PROJECT MANUAL - Volume 3 of 3

Wilmington Elementary School

320 Salem Street, Wilmington, Massachusetts, 01887

Design Development - March 20, 2026

Dore & Whittier Architects Inc. Project Number: 23-0847

Awarding Authority / Owner
Town of Wilmington, Wilmington Public Schools

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Dore & Whittier Architects Inc.

Geotechnical Consultant
Lahlaf Geotechnical Consulting

Civil Consultant
CDW Consultants, Inc.

Landscape Consultant
Terraink

Structural Consultant
Engineers Design Group

Plumbing and Fire Protection Consultant
Akal Engineering, Inc.

HVAC and Electrical Consultant
GGD Consulting Engineers, Inc.

Geoenvironmental Consultant
PEER Consultants, P.C.

Door Hardware Consultant
Allegion, PLC

Owner's Project Manager
LeftField Project Management

Construction Manager
Fontaine Brothers, Inc.

Sustainable Design Consultant
The Green Engineer

Environmental / HAZMAT Consultant
United Environmental Consultants

Technology Consultant
Edvance Technology Design

Acoustical Consultant
Acentech

Foodservice Consultant
Crabtree McGrath Associates, Inc.

Cost Estimating
PM&C

Traffic and Site Survey Consultant
Nitsch Engineering

DORE + WHITTIER

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Project Name: Wilmington Elementary School
Dore & Whittier Architects Inc. Project Number: 23-0847

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_____ _____

Donald M. Walter Date

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END OF SECTION

SECTION 21 00 01
FIRE PROTECTION TRADE BID SUMMARY

PART 1 GENERAL

1.01 FILING OF TRADE BIDS.

A. Trade Bids are required for work under this section in accordance with the provisions of the General Laws of the Commonwealth of Massachusetts, Chapter 149A, Sections 1-8, 10, and 11, as most recently amended.

B. Trade Bids shall be submitted to the Awarding Authority as set forth in the Invitation to Bids and the Instructions to Bidders, accompanied by the bid deposit specified therein.

C. Every Trade Bids for work under this section shall be on the form in this Project Manual furnished by the Awarding Authority.

1.02 GENERAL REQUIREMENTS

A. The General and Supplementary Conditions of the Contract, Construction Manager's Scoping Documents, and General Requirements of the Project Manual, including without exception all sections in Divisions 00 and 01, apply to the Fire Protection Trade Contractor, material suppliers, and all other persons furnishing labor and materials under this section.

B. Examine all project specifications and drawings for requirements which affect work of this section whether or not such work is specifically mentioned in this section.

C. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.

D. The following definitions apply to the drawings and specifications:

1. Furnish: The term "furnish" is used to mean "supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations".
2. Install: The term "install" is used to describe operations at the project site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
3. Provide: The term "provide" is used to mean "furnish and install, complete and ready for the intended use".
4. Installer: An "installer" is the subcontractor or an entity engaged by the subcontractor, either as an employee or sub-subcontractor for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.

E. When open-flame or spark producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the Construction Manager shall be notified not less than 24 hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant dedicated fire watch who is not otherwise employed as installation labor, where work is being performed, until it is completed.

1.03 DESCRIPTION

A. The work of this Trade Bid Section shall include delegated design of the system by the Trade Contractor's engineer, furnishing, and installing complete and operational automatic fire protection systems for the project, including all materials and labor, and required accessories identified within the specification sections referenced below, and necessarily to provide a complete installation

B. The work of this Trade Bid Section may be (but is not exclusively) shown on the drawings by the section number 21 00 01 or the abbreviation "SC-FPROT".

C. The work of this Trade Bid Section shall include the scope of each of the following sections in their entirety:
   1. Section 21 00 10 - Fire Protection.

D. The work of this Trade Bid Section shall include part of the scope of each of the following sections:
   1. Section 07 11 13 - Bituminous Dampproofing: for sealing penetrations at foundation walls that include dampproofing.
   2. Section 07 84 00 - Firestopping: For material and installation requirements related to firestopping by this Trade Contractor at penetrations of fire rated assemblies (floors, walls, and ceilings) by the work of this section.
   3. Section 08 31 00 - Access Doors and Panels: For material and installation requirements related to access doors and frames required to access concealed components of this section, to be furnished by this Subcontractor to Section 06 20 00 - Finish Carpentry for installation.
   4. Section 23 05 48 - Vibration and Seismic Controls for HVAC: For requirements related to seismic bracing of components provided by this Trade Contractor.

E. This Trade Contractor shall fully coordinate the execution of the work of this section with, and anticipate the requirements of the following sections:
   1. Section 01 91 13 - MEP Commissioning Requirements: For list of equipment to be commissioned and requirements for cooperation with the Commissioning Agent.
   2. Section 09 21 16 - Gypsum Board Assemblies: For gypsum board ceilings indicated to receive sprinklers.
   3. Section 09 51 00 - Acoustical Ceilings: Coordination of sprinklers with lay-in acoustical ceilings.
   4. Section 09 91 13 - Exterior Painting: For preparation of exposed exterior piping to be painted.
   5. Section 09 91 23 - Interior Painting: For preparation of exposed interior piping to be painted.
   6. Section 10 22 39 - Folding Panel Partitions: Coordination of above ceiling piping with supports and wall construction above folding partition locations.
   7. Section 11 40 00 - Foodservice Equipment: For hood suppression system to be furnished and installed by that contractor.
   8. Section 11 61 43 - Stage Curtains: Coordination of piping and sprinklers with theatrical draperies and support rigging.
   9. Section 11 66 23 - Gymnasium Equipment : Coordination of sprinkler head and piping locations with gymnasium equipment secured to roof structure.
   10. Section 11 95 13 - Kilns: Coordination with rooms requiring high temperature sprinkler heads.
   11. Section 26 00 10 - Electrical: For wiring of supervisory switches, electrical alarm, flow switches, and power wiring.
   12. Section 31 23 00 - Excavation and Fill for Utilities and Pavement.: For excavation and backfill of utilities.

F. Sub-Sub Bid Requirements: See Section 00 21 13 - Instructions to Bidders TRADE BIDS Paragraph, and Section 00 41 01 - Form for Trade Contractor Bid for instructions regarding "Paragraph E" Sub-Sub Bids.

G. Primary Drawings listed are those intended to indicate the scope of work for this trade.
   1. List of Primary Drawings: To be provided prior to the release of Bid Set.
   2. This Trade Contractor shall review all remaining drawings that may show additional information relating to specific installation conditions and information that may be required to

calculate exact quantities, determine specific installation requirements, or generally coordinate the work with other trades.

3. Additionally, this subcontractor must include in the List of Primary Drawings: To be provided prior to the release of Bid Set, Code Plans, Phasing Plans, Demolition Plans, and all project detail sheets for general and code-related information, installation or other conditions and instructions that directly affect their work.

H. Staging and Scaffolding: The work of this Trade Bid Section shall include the provision of staging and scaffolding (including design, engineering, erection, maintenance, and removal) where required to complete the work of this Trade Bid category.
   1. See Section 01 50 00 - Temporary Facilities and Controls for additional information.

I. Temporary Hoisting Equipment, Lifts, and Machinery: The work of this Trade Bid Section shall include all temporary hoisting equipment, lifts, and machinery required to complete the work of this Trade Bid category. All hoisting equipment, lifts, and machinery and operation shall comply in all respects to the governing laws and codes.
   1. See Section 01 50 00 - Temporary Facilities and Controls for additional information.

J. Cutting and Patching
   1. This Trade Contractor shall perform all cutting and coring required to complete the work of all sections listed as part of this Trade Bid category, except as specifically indicated in the respective Trade Contract sections. Where any of the sections listed as part of this Trade Bid indicate that cutting and coring shall be performed by parties other than the Fire Protection Trade Contractor, the cost of such cutting and coring necessary for the work of this section shall be borne by the Fire Protection Trade Contractor.
   2. All patching required to complete the work of all sections listed as part of this Trade Bid shall be performed by the appropriate trade, and the cost of such patching necessary for the work of this section shall be borne by this Trade Contractor.
   3. All cutting, coring, and patching shall be coordinated through and by the Construction Manager.
   4. Any and all cutting of structural members, including floor slabs, shall require approval of the project's Structural Engineer of Record; see Structural Drawings for typical penetrations and openings in structural members, including floor slabs. For any openings outside the parameters of those indicated on Structural Drawings, obtain approval from Structural Engineer of Record.

1.04 REFERENCE STANDARDS

1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

1.06 QUALITY ASSURANCE

A. See Section 01 40 00 - Quality Requirements for additional requirements.

B. Testing Agency Qualifications: Independent firm specializing in performing testing and inspections of the type specified in this section.

1.07 LEED REQUIREMENTS

A. This project is intended to be certified as a LEED for Schools v4/v4.1 building, with a rating of LEED "Silver". See Section 01 81 14 - LEED for Schools v4/v4.1 Project Scorecard for projected LEED credits. Some product and material selections, and some performance requirements of this section are required to achieve the credits listed.

B. Prior to any product submittals, the Fire Protection Trade Contractor shall assist the Construction Manager in the creation of a LEED action plan identifying products that will contribute toward LEED credits. The LEED Action Plan shall be submitted prior to any product submittals to assist the Architect in evaluating product submittals that must meet LEED criteria.

C. The Fire Protection Trade Contractor shall provide all documentation indicating applicability of all products of this section to potential LEED credits to the project LEED Administrator for submission to www.leedonline.com. See Section 01 81 13 - Sustainable Design Requirements for additional requirements.

1.08 WARRANTY

PART 2 PRODUCTS (SEE EACH INDIVIDUAL SPECIFICATION SECTION LISTED ABOVE FOR PRODUCT REQUIREMENTS)

PART 3 EXECUTION (SEE EACH INDIVIDUAL SPECIFICATION SECTION LISTED ABOVE FOR ADDITIONAL EXECUTION REQUIREMENTS)

3.01 CLEANING

A. Fire Protection Trade Contractor shall be responsible for cleaning up Fire Protection Trade Contractor's own work at the end of each day, and depositing waste and debris created by Fire Protection Trade Contractor's work in the appropriate dumpsters, separating eligible products for recycling, and depositing recycling in designated recycling containers. Dumpsters shall be provided and maintained (including payment of costs for legal disposal off-site) by the Construction Manager.

1. See the following for additional requirements:
   a. Section 01 50 00 - Temporary Facilities and Controls.
   b. Section 01 74 19 - Construction Waste Management and Disposal.

END OF SECTION

SECTION 21 05 00
COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - **GENERAL**

1.01 **TRADE CONTRACT REQUIREMENTS**

A. Work of this Section is part of the Fire Protection Trade Contract. Refer to Section 21 00 00 "Fire Protection Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 **RELATED DOCUMENTS**

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 **SUMMARY**

A. This Section includes the following:
1. Piping materials and installation instructions common to most piping systems.
2. Mechanical sleeve seals.
3. Sleeves.
4. Escutcheons.
5. Grout.
6. Equipment installation requirements common to equipment sections.
7. Painting and finishing.
8. Concrete bases.
9. Supports and anchorages.

B. Commissioning: Refer to Section 01 91 13 "MEP Commissioning Specifications" for scope of work and general requirements for the fire protection systems commissioning. The Fire Protection Subcontractor responsibilities shall include but not limited to:
1. Perform commissioning tests at the direction of the Commissioning Authority.
2. Attend construction phase controls coordination meetings.
3. Attend testing review and coordination meetings.
4. Participate in the electrical systems equipment and component maintenance orientation and inspection as directed by the Commissioning Authority.
5. Provide information requested by the Commissioning Authority for final commissioning documentation.
6. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.04 **LEED v4 GENERAL REQUIREMENTS**

A. The work of this Section is required to comply with general requirements and procedures for compliance with prerequisites and certain credits required for the Project to obtain a Certified rating based on USGBC's LEED v4 Reference Guide for Building Design and Construction and as outlined in Division 01 Section “Sustainable Design Requirements – LEED v4 BD+C: Schools” (LEED v4).

1. The Construction Manager is responsible to coordinate with the work of other Sections and comply with all LEED v4 requirements in accordance with the Contract Documents such that the work carried out by this Section does not compromise the achievement of any other LEED v4 prerequisites and credits applicable to the entire Project.

B. Related Sections for Sustainable Design Requirements:

1. Division 01 Section “Submittal Procedures” for LEED v4 submittal requirements.
2. Division 01 Section “Temporary Facilities and Controls” for requirements for temporary facilities.
3. Division 01 Section “Product Requirements” for product substitutions and additional LEED v4 submittal requirements.
4. Division 01 Section “Construction Waste Management and Disposal” for waste management, recycling and disposal.
5. Division 01 Section “Sustainable Design Requirements – LEED v4 BD+C: Schools” for general procedures for compliance with LEED v4 prerequisites and credits.
6. Division 01 Section “Indoor Air Quality Requirements” for material and procedure requirements.

1.05 QUALITY ASSURANCE

A. Provide Fire Protection piping and fitting throughout the facility which is compliant with applicable NFPA standards, Massachusetts State Building Code, local ordinances/regulations/standards, local Authorities Having Jurisdiction and Insurance Underwriter requirements.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. Electrical Characteristics for Fire protection Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

E. The substitution of products or methods provided/undertaken are the sole responsibility of this subcontract. The remedy correcting resulting detrimental effects due to substituted items will be borne as part of this subcontract, at no additional cost to the owner. The remedy to correct such deficiencies will be as determined by the Architect. Refer to specification section 01 30 00 Administrative Requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.07 Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire protection installations.
1. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
2. Coordinate requirements for access panels and doors for fire protection items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

PART 2 - **PRODUCTS**

2.01 **PIPE, TUBE, AND FITTINGS**

A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.02 **JOINING MATERIALS**

A. Refer to individual Division 21 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.03 **MECHANICAL SLEEVE SEALS**

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
1. Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.
   e. or Equal

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Composite material or carbon steel, include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.04 **SLEEVES**

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

E. For interior wall, floor and ceiling penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for fire rating, size, depth, and location of joint shall be shall be by CM under separate bid contract.

2.05 **ESCUTCHEONS**

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
1. Finish: Polished chrome-plated

D. One-Piece, Floor-Plate Type: Cast-iron floor plate.

2.06 **GROUT**

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000/pounds per square inch 28/day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - **EXECUTION**

3.01 **PIPING SYSTEMS - COMMON REQUIREMENTS**

A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Exposed piping in finished spaces (unless clearly indicated otherwise on the Contract Documents) will be installed as high as possible, tight to structure above. This exposed piping is to also be installed in a configuration as indicated on the Construction Documents. Fully coordinated Fabrication Drawings will be submitted to and approved by the Architect and Engineer prior to fabrication or installation. Non-conforming work will be made to conform to the Contract Documents and Architect's/Engineer's Fabrication Drawing comments by this Contractor at no additional cost to the Owner.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Install piping to permit valve servicing.

H. Install piping at a slope that will permit full drainage.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   2. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   3. Insulated Piping: One-piece, stamped-steel type with spring clips.
   4. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   5. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
   6. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   7. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
   8. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas two inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
    a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
    b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
    c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
        1) Seal space outside of sleeve fittings with grout.
4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

O. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than six inches in diameter.
2. Install cast-iron "wall pipes" for sleeves six inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.02 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

B. Refer to Division 03 Section "Cast-in-Place Concrete (or Miscellaneous Cast-in-Place Concrete.)" for concrete bases.

END OF SECTION

SECTION 21 05 16
EXPANSION FITTINGS AND LOOPS FOR FIRE SUPPRESSION PIPING

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Fire Protection Filed Sub-bid Contract. Refer to Section 21 00 01 "Fire Protection Filed Sub-Bid Summary" for additional information about this Filed Sub-Bid Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following:
   a. Flexible pipe connections.
   b. Expansion joints and compensators.
   c. Pipe loops, offsets, and swing joints
   d. Seismic restraints

B. Related Sections:
   1. Division 21 Section “Common Work Results for Fire Suppression” for codes, standards, and other general requirements.

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

B. LEED Submittals:
   1. Complete “Sustainable Materials Attributes Submittal Form” attached to Section 01 81 13 “Sustainable Design Requirements”.
   2. Provide supporting documentation for Materials and Resources and Low Emitting Materials, as required in Section 01 81 13, from manufacturer for materials attributes data submitted.
      1. Environmental Product Declaration: For each product.
      2. Chain-of-Custody Certificates: For FSC certified wood products. Include statement of costs and qualifications of manufacturers and vendors.
      3. Health Product Declaration: For each product.
      4. Laboratory Test Reports: Verify that the following products comply with the testing and product requirements of the California Department of Public Health's (CDPH) "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers", or South Coast Air Quality Management District (SCAQMD) Rule 1113:
         a. Sealants.

b. Paints and coatings.

5. Product Data: For the following, including VOC content:
   a. Sealants.
   b. Paints and coatings.
6. Statement of Volume: for wet-applied products installed in the field.
7. Verify that the following products comply with Ultra Low Emitting Formaldehyde and No Added Urea Formaldehyde (ULEF or NAUF) requirements:
   a. For composite wood products, verify that product contains no urea formaldehyde, as defined in the California Air Resources Board's (CARB) "Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products" or shall be made with no added formaldehyde.

C. Welding certificates.

PART 2 - PRODUCTS

2.01 PACKLESS EXPANSION FITTINGS

A. Flexible-Hose Packless Expansion Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Metraflex, Inc.
   b. Flex-Hose Co., In.c
   c. Flexicraft Industries.
   d. or Equal

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Potable water piping and components shall comply with NSF 14 and NSF 61.
4. Sanitary flexible expansion joints shall comply with IAPMO IGC 304.
5. Elbows: 304 Stainless Steel long radius 90 degree elbows.
6. Flexible Hose: 321 Stainless Steel hose, 304 Stainless Steel braid and interlocking liner.
7. Brass cleanout plugs two
8. Plus or minus 8 inches of movement.
9. 150 PSI working pressure at 70 degree Fahrenheit.
10. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
11. 304 Stainless Steel long radius 90° elbows.
12. Expansion Fittings for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.

    a. Bronze hoses and single-braid bronze sheaths with 450 pounds per square inch at 70 degree Fahrenheit and 340 pounds per square inch at 450 degree Fahrenheit ratings.

13. Expansion Fittings for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.

a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 pounds per square inch at 70 degree Fahrenheit and 225 pounds per square inch at 450 degree Fahrenheit ratings.

14. Expansion Fittings for Steel Piping NPS 2 and Smaller: Stainless-steel fittings with threaded end connection.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 pounds per square inch at 70 degree Fahrenheit and 325 pounds per square inch at 600 degree Fahrenheit ratings.

15. Expansion Fittings for Steel Piping NPS 2-1/2 and larger: Stainless-steel fittings with flanged end connections.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 pounds per square inch at 70 degree Fahrenheit and 145 pounds per square inch at 600 degree Fahrenheit ratings.

2.02 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Metraflex, Inc.
    b. Flex-Hose Co., Inc.
    c. Hyspan Precision Products, Inc.
    d. Adsco Manufacturing LLC.
    e. U.S. Bellows, Inc.
    Or equal

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, zinc-coated carbon steel.
    b. Expansion Plug: Zinc-coated steel.
    c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened Portland cement concrete, with tension and shear capacities appropriate for application.

a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
c. Washer and Nut: Zinc-coated steel.

2.03 SEISMIC RESTRAINTS

A. General

1. This section provides Seismic Control for the "equipment" as listed below.

2. It is the intent of this specification to provide restraint of non-structural building components. Restraint systems are intended to withstand the stipulated seismic accelerations applied through the component's center of gravity.

3. The work in this section includes the following:
   a. Seismic restraints for equipment.
   b. Seismic separation assemblies at seismic joints.
   c. Certification of seismic restraint designs and installation supervision.

4. Definitions

   a. The term EQUIPMENT will be used throughout this specification and it includes ALL non-structural components within the facility and/or serving this facility, such as equipment located in outbuildings or outside of the main structure on grade within five feet of the foundation wall. Equipment buried underground is excluded but entry of services through the foundation walls is included. Equipment referred to below is a partial list of equipment for reference. (Equipment not listed are still included in this specification)

   - Piping

5. Life safety systems defined

   a. All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks.
   b. All systems involved with and/or connected to emergency power supply including all circuits to fire protection systems.

6. Positive Attachment

   a. Positive attachment is defined as a support location with a cast-in or wedge type expansion anchor, a double sided beam clamp, a welded or through bolted connection to the structure.

7. Transverse Bracing

   a. Restraint(s) applied to limit motion perpendicular or angular to the centerline of the pipe, duct, or conduit.

8. Longitudinal Bracing

a. Restraint(s) applied to limit motion along the centerline of the pipe, duct, and conduit.

B. Submittal Data Requirements

1. Submittals

a. Catalog cuts or data sheets on specific restraints to be utilized detailing compliance with the specification. Reference "TYPE" as per "PRODUCTS" section of this specification.
b. An itemized list of all equipment. Detailed schedules showing seismic restraints proposed for each piece of equipment, referencing material and seismic calculation drawing numbers.

2. Shop Drawings

a. When walls and slabs are used as seismic restraint locations, details of acceptable methods must be included.
b. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
c. Coordinated or contract drawings shall be marked-up with the specific locations and types of restraints shown for all pipe. Rod bracing at various installation angles and assigned load at each restraint location shall be clearly delineated. Any and all tributary loads, Eg: Fire Protection pipe runouts shall be considered for proper restraint sizing.
d. For ceiling suspended equipment provide minimum/maximum installation angle allowed for restraint system as well as braced and unbraced rod lengths at each allowable installation condition.

C. Manufacturer’s Responsibility

1. Manufacturer of seismic control equipment shall have the following responsibilities:

a. Determine seismic restraint sizes and locations.
b. Provide equipment seismic restraints as specified.
c. Provide installation instructions, drawings and field supervision to insure proper installation and performance of systems.

D. Related Work

1. Housekeeping Pads

a. Housekeeping pad attachment shall be by the project structural engineer. Material and labor required for attachment and construction shall be by the Concrete section contractor.
b. Housekeeping pads shall be coordinated with the Seismic Restraint vendor and sized to provide a minimum edge distance of 10 bolt diameters of clearance all around the outermost anchor bolt to allow for the use of full anchor ratings.

2. Supplementary Support Steel

a. Contractor shall supply supplementary support steel and connections for all equipment.

3. Attachments

a. Contractor shall provide restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, in accordance with the requirements of the Seismic Restraint vendor.

TABLE A

"G" FORCES FOR VARIOUS CONDITIONS (SEISMIC ZONE 2 - AV > 0.1 ≤ 0.2)		
PIPE	RIGIDLY MOUNTED EQUIPMENT	ALL LIFE SAFETY EQUIPMENT
.25	.40	.60

E. Materials

1. Devices

a. All seismic restraint devices described in this section shall be the product of a single manufacturer. Mason Industries is the base manufacturer of these specifications; products of other manufacturers are acceptable provided their systems strictly comply with intent, structural design and performance of the Base Manufacturer.

2. Seismic Restraint Types

a. All seismic restraint devices shall be capable of accepting, without failure, the "G" forces as determined by the seismic certification and calculations as described in the "SUBMITTAL DATA REQUIREMENTS" section of these specifications.

b. All seismic restraint devices

(1) Shall maintain the equipment in a captive position.
(2) Shall have provisions for bolting and/or welding to the structure.

3. Seismic Restraint Types

a. TYPE I: Not Used

b. TYPE II: Not Used

c. TYPE III: Restraints for suspended systems

(1) Multiple seven x 19 strand galvanized cable rope.
Mason Industries Type SCB

(2) Structural steel strut type with approved fastening devices to equipment and structure.
Mason Industries Type SSB

(3) Steel angles (by contractor) shall be provided to prevent rod bending of hung equipment where indicated by the Seismic Restraint vendor's submittals. Steel angles shall be attached to the rods with a minimum of three ductile iron clamps at each restraint location. Welding of support rods to angles is not acceptable. Rod clamp assemblies shall have Anchorage Preapproval "R" number from California OSHPD.
Mason Ind. Model "SRC".

(4) Pipe clevis cross braces are required at all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the clevis cross bolt. Clevis cross braces shall have Anchorage Preapproval "R" number from California OSHPD.
Mason Ind. Model "CCB".

d. TYPE IV: Not Used

e. TYPE V: Rigid attachment to structure utilizing wedge type expansion anchors for bolting and steel plates, either cast-in or anchored with wedge type expansion bolts, for welding. Powder shots are not acceptable. Concrete anchor bolt spacing shall be in accordance with manufacturer's published standards.

F. Installation

1. Seismic restraint systems must be installed in strict accordance with the manufacturer's written instructions, all submittal data, and the approved seismic design certified by the qualified registered professional engineer.

2. Equipment Installation

a. Housekeeping pads for equipment in this section must be properly doweled or bolted, using wedge type expansion bolted to the structure to meet the acceleration criteria. Anchor equipment or isolators to housekeeping pads, see RELATED WORK.

3. Seismic Restraints

a. Installation

(1) All floor mounted equipment shall be snubbed, anchored, bolted or welded to the structure to comply with the required acceleration. Calculations that determine that equipment movement may be less than the operating clearance of snubbers (restraints) do not preclude the need for snubbers. All equipment must be positively attached to the structure.

(2) All suspended equipment shall be two or four point independently braced with TYPE III restraints. Rod bracing shall be installed as per approved submittals and shop drawings. Equipment less than 50 lbs. is excluded.

(3) All horizontally suspended pipe shall use RESTRAINT TYPE III. Spacing of seismic bracing shall be as per TABLE B at the end of this section.

(4) For all trapeze supported piping the individual pipes must be transversely and vertically restrained to the trapeze support at the designated restraint locations.

(5) For overhead supported equipment, over stress of the building structure must not occur. Bracing may occur from:

(a) Flanges of structural beams.
(b) Upper truss chords in bar joists.
(c) Cast in place inserts or drilled and shielded inserts in concrete structures.

(6) Pipe Risers

(a) Where pipes pass through cored holes, core diameters to be a maximum of two inches larger than pipe Outside Diameter for pipes less than three inch diameter and four inches larger than pipe Outside Diameter for pipes four inches and greater in diameter, including insulation. Cored holes must be packed with resilient material or fire stop as specified in other sections of this specification and/or state and local codes. No additional horizontal seismic bracing is required at these locations.

(b) An alternate method to (a) above is to install a flexible coupling 12 inches above and 24 inches below where the pipe penetrates a slab. Cored holes must be packed with resilient material or fire stop as specified in other sections of this specification and/or state and local codes.

(c) Pipe risers through cored holes require a riser clamp at each floor level on top of the slab attached in a seismically approved manner for vertical restraint.

(d) Pipe in pipe shafts require structural steel attached in a seismically approved manner at each floor level and a riser clamp at each floor level on top of, and fastened to the structural steel. The riser clamp and structural steel must be capable of withstanding all thermal, static and seismic loads.

(7) All floor or wall mounted equipment and tanks shall use RESTRAINT TYPE III or V.

(8) Where base anchoring of equipment is insufficient to resist seismic forces, restraint TYPE III shall be located above the unit’s center of gravity to suitably resist "G" forces specified.

(a) Vertically mounted tanks may require this additional restraint.

(9) A rigid piping system shall not be braced to dissimilar parts of a building or two dissimilar building systems that may respond in a different mode during an earthquake. Examples: Wall and roof; solid concrete wall and a metal deck with lightweight concrete fill or pipes crossing a building expansion joint.

(10) Piping that crosses a building expansion joint must be provided with a seismic separation assembly, regardless of size, in accordance with NFPA 13, 2013 Edition, Section 9.3.3. This can be in the form of a 6 ell expansion loop using flexible couplings as shown in NFPA 13, 2013 Edition, Section A-9.3.3(a) or a UL Listed seismic separation assembly equal to metraflex fire loop.

4. Exclusions for Seismic Bracing on Life Safety Equipment

a. Piping

(1) Fire protection standpipe, risers, and branches less than 2-1/2 inches in diameter unless required by Chapter 9 of NFPA 13, 2013 Edition.

G. Inspection

1. Upon completion of installation of all vibration isolation and seismic restraint devices, the owner may elect to contract and outside consultant at the owner's expense to review the installation. Any deficiencies in the installation will be corrected immediately at the contractor's expense.

TABLE B SEISMIC BRACING TABLE			
EQUIPMENT	ON CENTER SPACING (Max)		WITHIN EACH CHANGE OF DIRECTION (LARGER OF. . .)
	TRANSVERSE	LONGITUDINAL	
	(Mains regardless of size)		
PIPE (Threaded, Welded, Soldered or Grooved)			
To 16"	40 Feet	80 Feet	10 Feet or 15 Diameters

PART 3 - EXECUTION

3.01 EXPANSION FITTING INSTALLATION

A. Install flexible hose mechanical expansion joints and/or expansion loops in piping crossing building expansion joints. Coordinate locations with Architectural and Structural drawings.

B. Install expansion fittings of sizes matching sizes of piping in which they are installed.

3.02 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.

3.03 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion fitting not more than four pipe diameters from expansion joint.

C. Install second guide(s) at 10 to 14 pipe diameters from first guide. Install intermediate guides spaced at the following distances for the indicated pipe size:

1. 1 inch pipe: 11 feet
2. 1-1/4 inch pipe: 14 feet
3. 1-1/2 inch pipe: 17 feet
4. 2 inch pipe: 23 feet
5. 2-1/2 inch pipe: 27 feet
6. 3 inch pipe: 33 feet
7. 4 inch pipe: 37 feet

D. Attach guides to pipe and secure guides to building structure.

E. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

F. Anchor Attachments:

1. Anchor Attachment to Black Steel Pipe: Attach with pipe hangers. Use MSS SP-69, Type 42.
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

G. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer’s written instructions.

H. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 21 12 00
FIRE-SUPPRESSION STANDPIPES

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Fire Protection Trade Contract. Refer to Section 21 00 00 "Fire Protection Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. Section Includes:
1. Pipes, fittings, and specialties.
2. Fire-protection valves.
3. Hose connections.
4. Fire-department connections.
5. Alarm devices.
6. Pressure gages.
7. Recessed stainless steel fire department valve cabinets.

B. Related Sections:
1. Division 21 Section "Wet-Pipe Sprinkler Systems" for wet-pipe sprinkler piping.
2. Division 28 Section "Digital, Addressable Fire-Alarm System" for alarm devices not specified in this Section.

1.04 DEFINITIONS

A. Standard-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure 175 pounds per square inch maximum.

1.05 SYSTEM DESCRIPTIONS

A. Manual Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand.

1.06 PERFORMANCE REQUIREMENTS

A. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-pounds per square inch minimum working pressure.

B. Delegated Design: Design fire-suppression standpipes, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated. Perform hydrant flow test and use data for calculations.

C. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.
   1. Residual pressure at each hose-connection outlet is:
      a. 100 pounds per square inch.

D. Seismic Performance: Fire-suppression standpipes shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. Comply with requirements in Part 3 of this spec, "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.02 STEEL PIPE AND FITTINGS

A. Standard Weight, Black-Steel Pipe (Galvanized between the fire department connection and check valve): ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 10, Black-Steel Pipe (Galvanized between the fire department connection and check valve): ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

C. Standard-Weight, Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, seamless steel pipe with threaded ends.

D. Galvanized and Uncoated, Steel Couplings: ASTM A 865, threaded.

E. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

F. Malleable- or Ductile-Iron Unions: UL 860.

G. Cast-Iron Flanges: ASME B16.1, Class 125.

H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

I. Grooved-Joint, Steel-Pipe Appurtenances:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Inc.
      b. Tyco Fire & Building Products LP.
      c. Victaulic Company.
      Or equal
   2. Pressure Rating: 250 pounds per square inch minimum.
   3. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
   4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.03 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.
   1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
   2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.04 LISTED FIRE-PROTECTION VALVES

A. General Requirements:
   1. Valves shall be UL listed and FM approved.
   2. Minimum Pressure Rating for Standard-Pressure Piping: 175 pounds per square inch.
   3. Minimum Pressure Rating for High-Pressure Piping: 300 pounds per square inch.

B. Bronze Butterfly Valves (for sizes 2” and smaller):

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Fivalco Inc.
      b. Global Safety Products, Inc.
      c. Milwaukee Valve Company.
      Or equal
   2. Standard: UL 1091.
   3. Body Material: Bronze.
   4. End Connections: Threaded.

C. Iron Butterfly Valves (for sizes 2 ½ inches” and larger):
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Milwaukee Valve Company.
      b. Tyco Fire & Building Products LP.
      c. Victaulic Company.
      Or equal
   2. Standard: UL 1091.
   3. Body Material: Cast or ductile iron.
   4. End Connections: Grooved.

D. Check Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Globe Fire Sprinkler Corporation.
      b. Potter Roemer.
      c. Reliable Automatic Sprinkler Co., Inc.
      d. Tyco Fire & Building Products LP.
      e. Victaulic Company.
      f. Viking Corporation.
      Or equal
   2. Standard: UL 312.
   3. Type: Swing check.
   4. Body Material: Cast iron.

5. End Connections: Flanged or grooved.

E. Bronze OS&Y Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   Or equal
2. Standard: UL 262.
3. Body Material: Bronze.
4. End Connections: Threaded.

F. Iron OS&Y Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group.
   b. Tyco Fire & Building Products LP.
   c. Watts Water Technologies, Inc.
   Or equal
2. Standard: UL 262.
3. Body Material: Cast or ductile iron.
4. End Connections: Flanged or grooved.

G. Indicating-Type Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International, Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   Or equal
2. Standard: UL 1091.
3. Valves NPS 2 and Smaller:
   a. Valve Type: Ball or butterfly.
   b. Body Material: Bronze.
   c. End Connections: Threaded.
4. Valves NPS 2-1/2 and Larger:
   a. Valve Type: Butterfly.
   b. Body Material: Cast or ductile iron.
   c. End Connections: Flanged, grooved, or wafer.
5. Valve Operation: Integral electrical, 115-V ac, prewired, single or two-circuit, supervisory switch indicating device.

H. Non Rising Stem Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Clow Valve Company; a division of McWane, Inc.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. Mueller Co.; Water Products Division.
   d. Tyco Fire & Building Products LP.
   Or equal
2. Standard: UL 262.
3. Body Material: Cast iron with indicator post flange.
4. Stem: Non-rising.

5. End Connections: Flanged or grooved.

2.05 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating: 250 pounds per square inch minimum.

B. Angle Valves: Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Fire Protection Products, Inc.
2. United Brass Works, Inc.
3. NIBCI INC.
4. Potter Roemer
Or equal

C. Ball Valves: Subject to compliance with requirements, provide products by one of the following:
1. Conbraco Industries, Inc.; Apollo Valves.
2. NIBCO INC.
3. Potter Roemer.
4. Tyco Fire & Building Products LP.
5. Victaulic Company.
6. Watts Water Technologies, Inc.
Or equal

D. Globe Valves: Subject to compliance with requirements, provide products by one of the following:
1. Fire Protection Products, Inc.
2. United Brass Works, Inc.
3. NIBCO INC.
4. Potter Roemer
Or equal

E. Plug Valves: Subject to compliance with requirements, provide products of one of the following:
1. Southern Manufacturing Group.
2. Kennedy Valves
3. Flomatic Valves
Or Equal

2.06 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating:
   a. Standard-Pressure Piping Specialty Valves: 175 pounds per square inch minimum.
   b. High-Pressure Piping Specialty Valves: 250 pounds per square inch minimum.
3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AFAC Inc.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Tyco Fire & Building Products LP.
   Or equal
2. Standard: UL 1726.
3. Pressure Rating: 250 pounds per square inch minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

2.07 HOSE CONNECTIONS

A. Nonadjustable-Valve Hose Connections:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Fire-End & Croker Corporation.
   b. Fire Protection Products, Inc.
   c. Guardian Fire Equipment, Inc.
   d. Potter Roemer.
   e. Tyco Fire & Building Products LP.
   Or Equal
2. Standard: UL 668 hose valve for connecting fire hose.
3. Pressure Rating: 300 pounds per square inch minimum.
4. Material: Brass or bronze.
5. Size: NPS 2-1/2, as indicated.
6. Inlet: Female pipe threads.
7. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
8. Pattern: Angle.
9. Finish: Rough brass or bronze.

2.08 FIRE-DEPARTMENT CONNECTIONS

A. Flush-Type, Fire-Department Connection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elkhart Brass Mfg. Company, Inc.
   b. Guardian Fire Equipment, Inc.
   c. Potter Roemer.
   Or Equal
2. Standard: UL 405.
3. Type: Flush, for wall mounting.
4. Pressure Rating: 250 pounds per square inch minimum.
5. Body Material: Corrosion-resistant metal.
6. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
7. Caps: Chrome plated brass, lugged type, with gasket and chain.
8. Escutcheon Plate: Rectangular, chrome plated brass, wall type.

9. Outlet: With pipe threads.
10. Body Style: Horizontal
11. Number of Inlets: One.
12. Outlet Location: Back.
13. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."
14. Finish: Rough brass or bronze.
15. Outlet Size: NPS 6.
16. Outlet Connection: 5” STORZ connection as required by the local Fire Department.

B. ROOF MANIFOLD

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elkhart Brass Mfg. Company, Inc.
   b. Guardian Fire Equipment, Inc.
   c. Potter Roemer.
   Or Equal
2. Type: roof mounted free standing
3. Pressure rating: 250 pounds per square inch minimum
4. Body material: Cast brass
5. Inlets: Brass with threads matching local fire department
6. Number of inlets: Two
7. Provide two fire department valves for fore department use.

2.09 ALARM DEVICES

A. Electrically Operated Alarm Bell:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Fire-Lite Alarms, Inc.; a Honeywell company.
   b. Notifier; a Honeywell company.
   c. Potter Electric Signal Company.
   Or Equal
2. Standard: UL 464.
3. Type: Vibrating, metal alarm bell.
4. Size: Six-inch minimum diameter.
5. Finish: Red-enamel factory finish, suitable for outdoor use.

B. Water-Flow Indicators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. McDonnell & Miller; ITT Industries.
   b. Potter Electric Signal Company.
   c. System Sensor; a Honeywell company.
   d. Viking Corporation.
   Or Equal
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 250 pounds per square inch.

7. Design Installation: Horizontal or vertical.

C. Pressure Switches:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Potter Electric Signal Company.
   b. System Sensor; a Honeywell company.
   c. Tyco Fire & Building Products LP.
   d. Viking Corporation.
   Or Equal
2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

D. Valve Supervisory Switches:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Fire-Lite Alarms, Inc.; a Honeywell company.
   b. Kennedy Valve; a division of McWane, Inc.
   c. Potter Electric Signal Company.
   d. System Sensor; a Honeywell company.
   Or Equal
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

E. Indicator-Post Supervisory Switches:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Potter Electric Signal Company.
   b. Brooks Equipment
   c. System Sensor; a Honeywell company.
   Or Equal
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled indicator-post valve is in other than fully open position.

2.10 PRESSURE GAUGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK; U.S. Gauge Division.
2. Ashcroft Inc.
3. Brecco Corporation.
4. WIKA Instrument Corporation.
   Or Equal

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: 0 to 250 pounds per square inch minimum.

E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

F. Air System Piping Gage: Include "AIR" or "AIR/WATER" label on dial face.

2.11 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated finish with set-screws.

C. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.

D. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

E. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.12 SLEEVES

A. Cast-Iron Wall-Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.

E. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set-screws.

F. For interior wall, floor and ceiling penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for fire rating, size, depth, and location of joint shall be under division 078410 for Firestopping and Section 078440 for Fire Resistive Joint Sealants.

2.13 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Calpico, Inc.
2. Metraflex, Inc.
3. Pipeline Seal and Insulator, Inc.
Or Equal

B. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.14 GROUT

A. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink, and recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.15 FLOOR CONTROL STATIONS

A. Floor control valve stations to be located above acoustical tile ceiling as located on the plans

B. Provide lettering on floor control valves that state that each floor is a dual fed by two different floor control valve assemblies. Exact lettering to be approved by local fire department.

2.16 STAINLESS STEEL CABINETS

A. Recessed stainless steel cabinets shall be provided for fire department valve and floor control stations. Refer to drawings for fire department valve and floor control stations.

B. Door and frame shall be stainless steel and cabinets shall be recessed unit with square edges.

C. Cabinet shall be 20 gauge Box, 20 gauge Tubular steel door with 18 gauge Frame and a continuous steel hinge (brass pin); steel corner seams welded and ground smooth; recessed, mounted cabinets shall be furnished with .125” (0.31 cam) radiused frame.

D. The finish shall be coordinated with the architect.

E. Provide lettering on door approved by local F.D.

PART 3 - EXECUTION

3.01 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 14 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.03 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.

C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.

D. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install drain valves on standpipes. Extend drain piping to outside of building.

F. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or outside building.

G. Install alarm devices in piping systems.

H. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.

I. Install pressure gages on riser or feed main and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

J. Fill wet-type standpipe system piping with water.

K. Install pipe insulation on wet-type, fire-suppression standpipe piping in areas subject to freezing.

3.05 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14, Insurance Underwriter and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Install bypass check valve and retarding chamber drain-line connection.

3.06 HOSE-CONNECTION INSTALLATION

A. Install hose connections adjacent to standpipes.

B. Install freestanding hose connections for access and minimum passage restriction.

C. Install NPS 2-1/2 hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 reducer adapter and flow-restricting device. Coordinate the type of threads on the fire department valves with the fire department.

D. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Division 10 Section "Fire Extinguisher Cabinets."

3.07 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire-department connections.

B. Install automatic (ball drip) drain valve at each check valve for fire-department connection. Provide drain to exterior under fire department connection, 18 inches above grade.

END OF SECTION

SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 - **GENERAL**

1.01 **TRADE CONTRACTOR REQUIREMENTS**

A. Work of this Section is part of the Fire Protection Trade Contract. Refer to Section 21 00 00 “Fire Protection Trade Contractor Requirements” for additional information about this Trade Contract.

1.02 **RELATED DOCUMENTS**

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 **SUMMARY**

A. Section Includes:
1. Pipes, fittings, and specialties.
2. Fire-protection valves.
3. Sprinklers.
4. Alarm devices.
5. Pressure gages.
6. Backflow preventer.

B. Related Sections:
1. 21 05 00 Common Work Results.

1.04 **DEFINITIONS**

A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 pounds per square inch maximum.

1.05 **SYSTEM DESCRIPTIONS**

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included.

1.06 **PERFORMANCE REQUIREMENTS**

A. Standard-Pressure Piping System Component: Listed for 175-pounds per square inch minimum working pressure.

B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated on the drawing schedules and these specifications.

C. Sprinkler system design shall be approved by the Architect and authorities having jurisdiction prior to fabrication, order or installation. The contractor shall confirm the Sprinkler Occupancy Hazard Classifications, Sprinkler Densities and Sprinkler Spacing with authority having jurisdiction and the Owner's insurance underwriter prior to submitting Bid, to confirm that the classifications listed are still applicable or if more stringent requirements are to be used for the Project. Please note, the list below is standard NFPA 13 criteria, and Owner's Insurance Underwriter criteria will take precedence, if more stringent.

1. Margin of Safety for Available Water Flow and Pressure: 10 pounds per square inch, in addition to losses through water-service piping, valves, and backflow preventers.

2. Sprinkler Occupancy Hazard Classifications:
   a. Building Service Areas: Ordinary Hazard, Group 1.
   b. Electrical and Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
   c. General Storage Areas: Ordinary Hazard, Group 1.
   d. Libraries except Stack Areas: Light Hazard.
   e. Stage: Ordinary Hazard, Group 2.
   f. Science Laboratories: Ordinary Hazard, Group 1.
   g. Office, Classrooms, Cafeteria seating, Lobbies/Corridor, GYM and Public Areas: Light Hazard.
   h. Kitchen: Ordinary Hazard, Group 1.

3. Minimum Density for Automatic-Sprinkler Piping Design:

   a. Light-Hazard Occupancy: 0.10 gallons per minute over 1500-square feet area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gallons per minute over 1500-square feet area.
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gallons per minute over 1500-square feet area.

4. Maximum Protection Area per Sprinkler:
   a. Office & Classroom Spaces: 225 square feet
   b. Storage Areas: 130 square feet
   c. Mechanical and Electrical Equipment Rooms: 130 square feet
   d. Other Areas: According to NFPA 13 or Insurance Underwriter recommendations, whichever is more stringent.

5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
   a. Light-Hazard Occupancies: 100 gallons per minute
   b. Ordinary-Hazard Group 1 Occupancies: 250 gallons per minute
   c. Ordinary-Hazard Group 2 Occupancies: 250 gallons per minute

D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7-05 Category B.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

PART 2 - **PRODUCTS**

2.01 **PIPING MATERIALS**

A. Comply with requirements in “Piping Schedule” Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.02 **STEEL PIPE AND FITTINGS**

A. Schedule 40, Black-Steel Pipe for sizes 1-1/2 inches and smaller: ASTM A 53/A 53M. Pipe ends may be factory or field formed to match joining method.

B. Schedule 10, Black-Steel Pipe for sizes 2 inches and larger: ASTM A 135 or ASTM A 795/A 795M, Schedule 10

C. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.

D. Steel Couplings: ASTM A 865, threaded.

E. Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

F. Malleable- or Ductile-Iron Unions: UL 860.

G. Steel Flanges and Flanged Fittings: ASME B16.1, Class 150.

H. Grooved-Joint, Steel-Pipe Appurtenances:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International, Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   Or Equal
2. Pressure Rating: 175 pounds per square inch minimum.
3. Epoxy painted, Grooved-End Fittings for Steel Piping: ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
   a. In applicable sizes, fittings shall be short pattern, with flow equal to standard pattern fittings. Basis of Design: Victaulic FireLock.
   b. Installation-Ready™ fittings for sizes 1-¼ thru 2½ inches, consisting of a ductile iron housing with Installation-Ready™ ends, prelubricated Grade E EPDM Type ‘A’ gasket; and ASTM A449 electroplated steel bolts and nuts. UL listed for a working pressure of 300 pounds per square inch and FM approved for working pressure 365 pounds per square inch.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber center-leg gasket with pipe stop to ensure proper groove engagement, alignment, and pipe insertion depth, and ASTM A449 compliant bolts and nuts. Installation-Ready, for direct stab installation without field disassembly.
   a. Housings with fully defined metal-to-metal visual verification at the Install Indicators by locking into place preventing mis-assembly due to over shift of the slant pad surfaces; tooth and recessed shields gasket consisting of a pressure responsive center-leg, with One-Touch Tightening technology; no torque requirements required. Victaulic Firelock™ Installation-Ready™ Style 009V.

b. Flexible Type: For use in locations where vibration attenuation and stress relief are required. Victaulic Installation-Ready Style 177.

2.03 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick.
1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.04 LISTED FIRE-PROTECTION VALVES

A. General Requirements:
1. Valves shall be UL listed and FM approved.
2. Minimum Pressure Rating for Standard-Pressure Piping: 175 pounds per square inch.

B. Bronze Butterfly Valves (for sizes 2 inches and smaller):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Fivalco Inc.
b. Global Safety Products, Inc.
c. Milwaukee Valve Company.
d. Victaulic Company.
Or Equal
2. Standard: UL 1091.
3. Body Material: Bronze.
4. End Connections: Threaded.

C. Iron Butterfly Valves (for sizes 2 ½ inches and larger):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Milwaukee Valve Company.
b. Tyco Fire & Building Products LP.
c. Victaulic Company.
Or Equal
2. Standard: UL 1091.
3. Body Material: Cast or ductile iron.
4. End Connections: Grooved.
5. Seat: Pressure responsive elastomer.
6. Stem: Stainless steel, offset from the disc centerline to provide complete 360-degree circumferential seating.
7. Basis of Design: Victaulic Series 705.

D. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Potter Roemer.
b. Reliable Automatic Sprinkler Co., Inc.
c. Tyco Fire & Building Products LP.

Or Equal
2. Standard: UL 312.
3. Type: Swing or spring-assisted check. (Suitable for vertical or horizontal installation.)
4. Body Material: Cast ductile iron.
5. End Connections: Flanged or grooved.
6. Basis of Design: Victaulic Series 717.

E. Bronze OS&Y Gate Valves (2 inches and smaller):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   Or Equal
2. Standard: UL 262.
3. Body Material: Bronze.
4. End Connections: Threaded.

F. Iron OS&Y Gate Valves (2-1/2 inches and larger):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group.
   b. Tyco Fire & Building Products LP.
   c. Watts Water Technologies, Inc.
   Or Equal
2. Standard: UL 262.
3. Body Material: Cast or ductile iron.
4. End Connections: Flanged or grooved.
5. Basis of Design: Victaulic Series 771.

G. Indicating-Type Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International, Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   Or Equal
2. Standard: UL 1091.
3. Valves NPS 2 and Smaller:
   a. Valve Type: Ball or butterfly.
   b. Body Material: Bronze.
   c. End Connections: Threaded.
4. Valves NPS 2-1/2 and Larger:
   a. Valve Type: Butterfly.
   b. Body Material: Cast or ductile iron.
   c. End Connections: Flanged, grooved, or wafer.
   d. Seat: Pressure responsive elastomer.
   e. Stem: Stainless steel, offset from the disc centerline to provide complete 360-degree circumferential seating.
   f. Basis of Design: Victaulic Series 705.

5. Valve Operation: Weatherproof actuator housing with handwheel and factory installed integral electrical switches, 115 125-V ac, prewired, single or two-circuit, supervisory switch indicating device.

H. Non Rising Stem Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Clow Valve Company; a division of McWane, Inc.
   b. Mueller Co.; Water Products Division.
   c. Tyco Fire & Building Products LP.
   Or Equal
2. Standard: UL 262.
3. Body Material: Cast iron with indicator post flange.
4. Stem: Nonrising.
5. End Connections: Flanged or grooved.

2.05 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's Fire Protection Equipment Directory listing or Approval Guide, published by FM Global, listing.
2. Pressure Rating: 250 pounds per square inch minimum.

B. Angle Valves: Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Fire Protection Products, Inc.
2. United Brass Works, Inc.
3. NIBCO INC
   Or Equal

C. Ball Valves: Subject to compliance with requirements, provide products by one of the following:
1. Potter Roemer.
2. Tyco Fire & Building Products LP.
3. Victaulic Company.
   Or Equal

D. Globe Valves: Subject to compliance with requirements, provide products by one of the following:
1. Fire Protection Products, Inc.
2. United Brass Works, Inc.
3. NICBO INC
   Or Equal

E. Plug Valves: Subject to compliance with requirements, provide products of one of the following:
1. Southern Manufacturing Group.
2. Kennedy Valves
3. Flomatic Valves
   Or Equal

2.06 **SPECIALTY VALVES**

A. General Requirements:

1. Standard: UL's Fire Protection Equipment Directory listing and Approval Guide, published by FM Global, listing.
2. Pressure Rating:
   a. Standard-Pressure Piping Specialty Valves: 175 pounds per square inch minimum.
3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Alarm Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   Or Equal
2. Standard: UL 193.
3. Design: For vertical installation.
4. Valve internal components shall be replaceable without removal of valve from installed position.
5. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages and fill-line attachment with strainer.
6. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
7. Basis of Design: Victaulic Series 751.

C. Floor Control Valve Assembly (FCVA):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   Or Equal
2. Standard: UL 193.
3. Design: For horizontal installation.
4. Size: As indicated on Drawings.
5. Make: single pre-assembled unit.
6. Components:
   a. Supervised butterfly valve with Nylon-11 coated brass in accordance with ASTM A-536 and an EPDM encapsulated coated disc in accordance with ASTM A-536.
   b. Spring-loaded check valve with a straight flow design. Construction to be cast iron with a grooved one-piece bronze seat, 2 inches main drain port, and system side water pressure gauge. Clapper assembly shall be ductile iron casting with brass bushing assembly, EPDM rubber facing seal and stainless steel clamping ring. Valve body construction shall consist of gray iron per ASTM-A48 Class 30A.
   c. Single-handle, tri-position Test & Drain valve allowing both testing of the waterflow alarm and draining of a wet-pipe fire protection system. Test & Drain valve shall be provided with a pressure relief valve trim kit with 175 pounds per square inch rating.
   d. A vane type waterflow switch with non-corrosive insert for use on wet-pipe sprinkler systems utilizing two (2) single pole, double throw, snap action switches

and an adjustable, instantly recycling pneumatic retard. Waterflow switch to have an electrical rating of 10A @ 125/250 VAC / 2.5 A @ 24VDC.

7. Floor and Zone Control assemblies shall be ductile iron construction, incorporating a control valve (Victaulic Series 705), check valve, flow switch, test & drain assembly, adjustable relief valve, and system gauges in one compact body/footprint, and shall be manufactured for right and left-hand orientations. The test & drain assemble shall contain an adjustable relief valve, with a range of 175 to 310 pounds per square inch, and a universal test orifice of K2.8 [K4.2] [K5.6]; to provide testing capabilities of systems with k-factors ranging from K2.8 [K4.2] [K5.6] and larger. Universal manifold check valve shall be rated for use at the maximum service pressure of 300 pounds per square inch and shall be UL listed and FM approved. Victaulic Series UMC.

D. Automatic (Ball Drip) Drain Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AFAC Inc.
      b. Reliable Automatic Sprinkler Co., Inc.
      c. Tyco Fire & Building Products LP.
      Or Equal
   2. Standard: UL 1726.
   3. Pressure Rating: 175 pounds per square inch minimum.
   4. Type: Automatic draining, ball check.
   5. Size: NPS 3/4.
   6. End Connections: Threaded.
   7. Escutcheon Plate: Rectangular, brass, wall type.
   8. Outlet: With pipe threads.
   9. Body Style: Horizontal.
   10. Number of Inlets: Per Fire Department Standards
   11. Outlet Location: Per plans, and per wall cavity behind connection.
   12. Escutcheon Plate Marking: Similar to AUTO SPKR & STANDPIPE or AUTO SPKR, whichever is pertinent
   13. Finish: Rough brass or bronze.
   14. Outlet Size: Same size as piping indicated to it. Refer to plans for size(s).

2.07 **FIRE HOSE VALVES**

A. Nonadjustable-Valve Hose Connections:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Fire-End & Croker Corporation.
      b. Fire Protection Products, Inc.
      c. Guardian Fire Equipment, Inc.
      d. Potter Roemer.
      e. Tyco Fire & Building Products LP.
      Or Equal
   2. Standard: UL 668 hose valve for connecting fire hose.
   3. Pressure Rating: 300 pounds per square inch minimum.
   4. Material: Brass or bronze.
   5. Size: NPS 2-1/2, as indicated.
   6. Inlet: Female pipe threads.
   7. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
   8. Pattern: Angle.
   9. Finish: Rough brass or bronze.

B. Fire Hose Valve Cabinets
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Fire-End & Croker Corporation
      b. Larson's manufacturing.
      c. Guardian Fire Equipment, Inc.
      d. Potter Roemer.
      Or Equal
   2. Material: 20 Guage cold rolled steel.
   3. Finish: Steel door with white powder coat finish:

2.08 **FIRE-DEPARTMENT CONNECTIONS**

A. Flush-Type, Fire-Department Connection:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Elkhart Brass Mfg. Company, Inc.
      b. Guardian Fire Equipment, Inc.
      c. Potter Roemer.
      Or Equal
   2. Standard: UL 405.
   3. Type: Flush, for wall mounting.
   4. Pressure Rating: 250 pounds per square inch minimum.
   5. Body Material: Corrosion-resistant metal.
   6. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
   7. Caps: Chrome plated brass, lugged type, with gasket and chain.
   8. Escutcheon Plate: Rectangular, chrome plated brass, wall type.
   9. Outlet: With pipe threads.
   10. Body Style: Horizontal
   11. Number of Inlets: One.
   12. Outlet Location: Back.
   13. Escutcheon Plate Marking: Similar to AUTO SPKR & STANDPIPE.
   14. Finish: Rough brass or bronze.
   15. Outlet Size: NPS 6.
   16. Outlet Connection: STORZ connection as required by the local Fire Department.

B. ROOF MANIFOLD
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Elkhart Brass Mfg. Company, Inc.
      b. Guardian Fire Equipment, Inc.
      c. Potter Roemer.
      Or Equal
   2. Type: roof mounted free standing
   3. Pressure rating: 250 pounds per square inch minimum
   4. Body material: Cast brass
   5. Inlets: Brass with threads matching local fire department
   6. Number of inlets: Two
   7. Provide two fire department valves for fore department use.

2.09 **ALARM DEVICES**

A. Electrically Operated Alarm Bell:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Fire-Lite Alarms, Inc.; a Honeywell company.
   b. Notifier; a Honeywell company.
   c. Potter Electric Signal Company.
   Or Equal
2. Standard: UL 464.
3. Type: Vibrating, metal alarm bell.
4. Size: 6-inch minimum diameter.
5. Finish: Red-enamel factory finish, suitable for outdoor use.

B. Water-Flow Indicators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. McDonnell & Miller; ITT Industries.
   b. Potter Electric Signal Company.
   c. System Sensor; a Honeywell company.
   d. Viking Corporation.
   Or Equal
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 250 pounds per square inch.
7. Design Installation: Horizontal or vertical.

C. Pressure Switches:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Potter Electric Signal Company.
   b. System Sensor; a Honeywell company.
   c. Tyco Fire & Building Products LP.
   d. Viking Corporation.
   Or Equal
2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

D. Valve Supervisory Switches:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Fire-Lite Alarms, Inc.; a Honeywell company.
   b. Kennedy Valve; a division of McWane, Inc.
   c. Potter Electric Signal Company.
   d. System Sensor; a Honeywell company.
   Or Equal
2. Standard: UL 346.

3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

E. Indicator-Post Supervisory Switches:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Potter Electric Signal Company.
   b. Brooks Equipment
   c. System Sensor; a Honeywell company.
   Or Equal
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled indicator-post valve is in other than fully open position.

2.10 PRESSURE GAUGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK; U.S. Gauge Division.
2. Ashcroft Inc.
3. Brecco Corporation.
4. WIKA Instrument Corporation.
Or Equal

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: 0 to 250 pounds per square inch minimum.

E. Water System Piping Gage: Include WATER or AIR/WATER label on dial face.

F. Air System Piping Gage: Include AIRi or AIR/WATER label on dial face.

2.11 DENTIFICATION AND VALVE TAGS

A. All piping, except that piping which is within inaccessible chases, shall be identified with semi-rigid plastic identification markers equal to Seton Setmark pipe markers. Direction of flow arrows are to be included on each marker. Each marker background shall be appropriately color coded with a clearly printed legend to identify the contents of the pipe in conformance with the Scheme for the Identification of Piping Systems (ANSI A13.1-1981). Setmark snap-around markers shall be used for overall diameters up to six inches and strap-around markers shall be used above six inches overall diameter. Markers shall be located adjacent to each valve, at each branch, at each cap for future, at each riser take off, at each pipe passage through wall, at each pipe passage through floors, at each pipe passage to underground and on all vertical and horizontal piping at 20 foot intervals maximum.

B. All valves shall be designated by distinguishing numbers and letters carefully coordinated with a valve chart. Valve tags shall be 19 gauge polished brass, 1-1/2 inch diameter with stamped black filled letters similar to Seton Style No. 4522, or approved equal. Lettering shall be 1/4 inch high for type service and 1/2 inch for valve number. Tag shall be attached to valves with

approved brass S hooks, or brass jack chain. Whenever a valve is above a hung ceiling, the valve tag shall be located immediately above the hung ceiling.

C. Furnish a minimum of two typed valve lists to be framed under glass or Plexiglas. Each chart shall be enclosed in an approved .015 inch thick plastic closure for permanent protection. Valve numbers shall correspond to those indicated on the Record Drawings and on the printed valve lists. The printed list shall include the valve number, location and purpose of each valve. It shall state other necessary information such as the required opening or closing of another valve when one valve is to be opened or closed. Printed frame valve lists shall be displayed in each Mechanical Room or in a location designated by the Owner.

D. Equipment nameplates shall be 3/4 inch by 2-1/2 inch long .02 inch aluminum with a black enamel background with engraved natural aluminum letters similar to Seton Style 2065-20. Nameplate shall have pressure sensitive taped backing.

2.12 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated finish with set-screws.

C. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.

D. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

E. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.13 SLEEVES

A. Cast-Iron Wall-Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.

E. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set-screws.

F. For interior wall, floor and ceiling penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for fire rating, size, depth, and location of joint shall be under division 078410 for Firestopping and Section 078440 for Fire Resistive Joint Sealants.

2.14 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Calpico, Inc.
   2. Metraflex, Inc.
   3. Pipeline Seal and Insulator, Inc.
   Or Equal

B. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.15 GROUT

A. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink, and recommended for interior and exterior applications.

C. Design Mix: 5000-pounds per square inch, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.16 SPRINKLER SPECIALTY PIPE FITTINGS

A. Flow Detection and Test Assemblies:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Reliable Automatic Sprinkler Co., Inc.
      b. Tyco Fire & Building Products LP.
      c. Victaulic Company.
      Or Equal
   2. Standard: UL's Fire Protection Equipment Directory listing or Approval Guide, published by FM Global, listing.
   3. Pressure Rating: 175 pounds per square inch minimum.
   4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
   5. Size: Same as connected piping.
   6. Inlet and Outlet: Threaded.

B. Sprinkler Inspector's Test Fittings:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Tyco Fire & Building Products LP.
      b. Victaulic Company.
      c. Viking Corporation.

Or Equal

2. Standard: UL's Fire Protection Equipment Directory listing or Approval Guide, published by FM Global, listing.
3. Pressure Rating: 175 pounds per square inch minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

2.17 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Reliable Automatic Sprinkler Co., Inc.
2. Tyco Fire & Building Products LP.
3. Viking Corporation.
4. Victaulic Corporation
Or Equal

B. General Requirements:

1. Standard: UL's Fire Protection Equipment Directory listing or Approval Guide, published by FM Global, listing.
2. Pressure Rating for Automatic Sprinklers: 175 pounds per square inch minimum.

C. Automatic Sprinklers with Heat-Responsive Element:
1. Nonresidential Applications: UL 199.
2. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for Ordinary temperature classification rating unless otherwise indicated or required by application.
3. Provide quick response sprinkler heads.
4. Sprinklers shall be glass bulb type, with hex shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation.
5. Wrenches shall be provided by the sprinkler manufacturer that directly engage the wrench boss cast in the sprinkler body.

D. Sprinkler Finishes:
1. Gloss White Concealed Cover Plates (except as specifically noted otherwise)
2. Chrome plated.
3. Bronze.

E. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
1. Ceiling Mounting: Chrome-plated steel, one piece, flat or black.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

F. Sprinkler Guards:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Reliable Automatic Sprinkler Co., Inc.
b. Tyco Fire & Building Products LP.
c. Viking Corporation.
Or Equal
2. Standard: UL 199.

3. Type: Wire cage with fastening device for attaching to sprinkler.

G. Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.

H. In lieu of rigid pipe offsets or return bends for sprinkler drops, the Victaulic VicFlex™ Multiple-Use Flexible Stainless Steel Sprinkler Drop System [with captured coupling Style 108] may be used to locate sprinklers as required by final finished ceiling tiles and walls. The drop system shall consist of a braided type 304 stainless steel flexible tube, zinc plated steel Male threaded nipple or Victaulic FireLock IGS Groove Style 108 coupling for connection to branch-line piping, and a zinc plated steel reducer with a female thread for connection to the sprinkler head.
1. The drop shall include a UL approved Series AH1 with three inches bend radius; AH2 or AH2-CC braided hose with a bend radius to two inches to allow for proper installation in confined spaces.
2. Union joints shall be provided for ease of installation.
3. The flexible drop shall attach to the ceiling grid using a one-piece open gate Series AB1 or AB2 bracket. The bracket shall allow installation before the ceiling tile is in place.
4. The braided drop system is UL listed for sprinkler services to 175 pounds per square inch (1206 kPa) and FM Approved to 200 pounds per square inch (1380 kPa).

2.18 SPARE HEADS AND CABINETS

A. Provide where directed by the Designer, a metal cabinet in the building containing spare sprinkler heads and wrenches.

B. Cabinet shall have shelves for storing the spare sprinkler heads in an orderly manner. The shelf spaces shall be subdivided to segregate the sprinkler heads of each type and clearly identify them with approved markings. Cabinet shall have proper arrangements for hanging the wrenches. Wrenches shall be located so as to be readily accessible.

C. Cabinet shall be dust tight and red in color, enameled finish. The outside of the cabinet door shall have painted on it in legible and clear lettering Automatic Sprinklers - Reserve Supply, suitable standard instructions pertaining to the sprinkler systems and other necessary information shall be fastened onto the inside of the cabinet door.

D. Cabinet shall have shelves for storing the spare sprinkler heads in an orderly manner. The shelf spaces shall be subdivided to segregate the sprinkler heads of each type and clearly identify them with approved markings. Cabinet shall have proper arrangements for hanging the wrenches. Wrenches shall be located so as to be readily accessible.

E. The cabinet size and number of each type spare sprinkler head shall conform to the National Fire Protection Association Pamphlet No. 13.

2.19 BACKFLOW PREVENTER

A. Provide a UL Listed/FM approved, backflow preventer on the fire protection water service, where indicated on the drawings. The BFP shall be full line size. Where the service entry is specifically sized, the BFP shall be the same size.

B. The unit shall comply with State and Water Authority requirements.

C. Unit shall be Watts, Hersey, Beeco, Febco or equal, and be acceptable to the Water Authority and the Local Fire Department.

D. The inlet and outlet gate valves shall be equipped with tamper switches.

E. Spare Parts Kit: Furnish one spare parts kit.

F. Test Kit:
1. Furnish one Watts Model #TK-7 kit for use with double check type devices. Each kit shall be contained in its own carrying case.

G. Double check valve assembly shall be Watts Model #709, bronze body construction through 2 inches in size and epoxy coated cast iron for 2 ½ inches to 10 inches, removable bronze seats, stainless steel internal parts, bronze-bodied ball valve test cocks, OS & Y stem gate valves with union or flanged connections between the valves and the device itself. Size as indicated on the Drawings. DEP equals will be accepted with proof of state approval.

H. Where fire pumps are involved, the BFP shall be properly installed on the discharge.

I. A State certified BFP installation certificate is required for the BFP installer.

PART 3 - **EXECUTION**

3.01 **PREPARATION**

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in Quality Assurance Article.

B. Report test results promptly and in writing.

3.02 **PIPING INSTALLATION**

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.

C. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

G. Install Inspector's Test Connections in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

N. Fill sprinkler system piping with water.

O. Install pipe insulation on sprinkler piping in areas subject to freezing.

3.06 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14, Insurance Underwriter and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Install bypass check valve and retarding chamber drain-line connection.

3.07 HOSE-CONNECTION INSTALLATION

A. Install freestanding hose connections for access and minimum passage restriction.

B. Install NPS 2-1/2 hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 reducer adapter and flow-restricting device. Coordinate the type of threads on the fire department valves with the fire department.

C. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Division 10 Section Fire Extinguisher Cabinets.

3.08 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire-department connections.

B. Install automatic (ball drip) drain valve at each check valve for fire-department connection. Provide drain to exterior under fire department connection, 18 inches above grade.

3.09 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

B. Install in alignment in gypsum board ceilings and soffits.

C. Do not install sprinklers that have been dropped, damaged, show a visible loss of fluid, or a cracked bulb.

D. The sprinkler bulb protector shall be removable by hand, without tools or devices that may damage the bulb.

3.17 PIPING SCHEDULE

A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

B. Standard-pressure, wet-pipe sprinkler system, NPS 1-1/2 and smaller shall be one of the following:
   1. Standard-weight (schedule 40), black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and larger, shall be one of the following:
   1. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.18 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:
   1. Rooms without Ceilings: Upright sprinklers
   2. Rooms with Suspended Ceilings: Concealed sprinklers as indicated.
   3. Wall Mounting: Sidewall sprinklers.
   4. Spaces Subject to Freezing: Upright, sidewall or dry pendent sprinklers.
   5. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers where indicated.

B. Provide sprinkler types in subparagraphs below with finishes indicated.
   1. Concealed Sprinklers: Rough brass, with factory-painted gloss white cover plate.
   2. Flush Sprinklers: Bright chrome, with painted white escutcheon.
   3. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon
   4. Upright, Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view. Provide wire cages in gymnasium, mechanical, and storage rooms.

3.19 DRAINS AND AUXILIARY DRAINS

A. Provisions shall be made to properly drain all parts of the system. Follow requirements of NFPA 13, 2013 Section 8.16.2.4.

B. Provide splash block at the exterior discharge of each main drain.

C. Auxiliary drain connections shall be provided when a change in piping direction prevents drainage of sections of branch lines or mains through the main drain valve. Follow requirements of NFPA 13, 2013 Section 8.16.2.5.

D. Inspector's test and drain: Wet system test pipe shall not be less than 1 inch in diameter terminating in a smooth bore corrosion resistant orifice giving a flow equivalent to one sprinkler shall be provided for each system. Each test connection valve shall be ready accessible and labeled. The discharge shall be to the outside, to an open drain connection capable of accepting full flow under system pressure or to another location where water damage will not result.

3.20 TESTING

A. Testing and flushing of the fire protection systems shall be done at the expense of Fire protection subcontractor and with equipment furnished by him. Testing shall be done in the presence of duly authorized inspectors and representatives of the owner's project manager within forty-eight (48) hour notice given those authorities. Prior to testing, the system shall be thoroughly flushed with clean water.

B. The system shall be repaired and retested until made perfect, without additional expense to THE CONTRACT.

C. To test piping, subject it to a three-hour hydraulic test of 200 pounds per square inch, and as by N.F.P.A. and the User Agency's Insurance Underwriter. Piping shall be repaired until such tests show no leaks. Where required, and depending on the building timing and schedule, the system may be required to be tested without final swing elbows and heads installed. In this case, a second test will be required upon installation of swing elbows and heads.

D. Material and test certificates must be signed by fire protection contractor prior to and upon completion of testing. Final test reports must be approved in writing by local authorities.

E. Results of tests shall be recorded and submitted using the forms in NFPA #13 & #14, for review by the Engineer. The Material and Test Certificate shall also be sent to the Owners Project Manager and User Agency's Insurance Underwriter.

F. Fire protection subcontractor shall ensure that the underground piping from the street main and service entry piping has been tested to 200 pounds per square inch in accordance with NFPA 24 requirements. This shall be recorded separately from the interior piping. Coordinate this with the site water piping installer.

G. Provide all necessary and appropriate personnel to participate in and coordinate fire protection systems with all fire alarm testing, or other systems testing which may interface with fire protection system. Participation shall include all preliminary testing, walk-through testing prior to official walk-through testing and any re-testing if required.

H. Where Insurance Service Office (ISO) approval is required, the Sprinkler Contractor shall be sure that:

1. That plans and calculations are sent for review to ISO, 100 Newport Avenue, CS1700, Quincy, MA 022690, and that all required changes are made.
2. The certificate covering materials and tests is filed with ISO.
3. That ISO has been given the proper notification, and that they are present for the 2 inches main drain test.
4. That the underground test certificate is filed with ISO. Coordinate with the Site Contractor.

3.21 BACKFLOW PREVENTER PERMIT AND INSTALLATION

A. All backflow prevention devices shall be approved, permitted, installed, maintained and tested in accordance with the requirements of the State and the Local Water Authority. A full size brass discharge line shall be extended to the nearest floor drain.

B. Prior to installation, the Fire Protection subcontractor shall submit through the construction manager, a design data sheet, with plans showing the method of protecting the water system, and secure approval from the Local Water Authority, or its designee. This shall not be done until the Fire Protection Subcontractor has secured the permit for the work and shop drawings have been approved.

C. Immediately upon installation, the Fire protection Subcontractor shall have the backflow preventer tested by a Certified Backflow Prevention Device Tester, and the results recorded on the Local Water Authority's Inspection and Maintenance Report Forms. Within 14 days after the installation, the fire protection Subcontractor shall notify, through the Construction Manager, the reviewing authority to arrange inspection of the installation.

D. Three copies of each application and all subsequent correspondence, including the final permit, shall be forwarded to the Designer for record. Availability of final approvals or permits shall be prerequisite to scheduling a final inspection of the fire protection work.

3.22 COMMISSIONING

A. PRE-FUNCTIONAL CHECKLISTS
1. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.
2. The contractor will be provided with construction checklists from the CA for
3. completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with 019113.
4.
5. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

B. FUNCTIONAL PERFORMANCE TESTING
1. Intent of functional performance testing is to prove thru functional test procedures proper system operation.
2. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with 01 91 13.
3. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

C. PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PREFORMANCE TESTING
1. Pre-Functional Checklists and Functional performance testing procedures will be performed on the following system types. (Pre Functional and Functional performance

testing requirements are in addition to and do not replace any testing required elsewhere in Division 21 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.

2. Fire Protection System and related equipment/accessories

D. SAMPLE CHECKLISTS
   1. See Attached.
      Functional Test

FIRE PROTECTION SYSTEMS

1. Submittal / Approvals

Submittal. The above equipment and systems integral to them are complete and ready for functional testing. A Statement of Correction will be submitted upon completion of any outstanding areas. None of the outstanding items preclude safe and reliable functional tests being performed.

2. Prerequisite Checklist

a. All associated equipment/systems including piping and fire alarm system have been installed and are ready for functional testing.
b. All A/E punchlist items for this equipment corrected.
c. Safeties and operating ranges reviewed.
d. This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.
e. This checklist does not take the place of the Authority Having Jurisdiction's (AHJ) required tests under AHJ's supervision.
f. All fire protection systems are installed per the shop drawings.
g. The Engineer of record and the Owner's insurance underwriter has approved all fire protection shop drawings including hydraulic calculations.
h. Items that do not apply shall be noted with the reasons on this form (N/A = not applicable).
i. Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

Check if Okay. Enter comment or note number if deficient.

Check	
Zone Valves	
Sealed	
Locked	
Tamper Switches	
Position	
Operation	
Supervisory	
Alarm Valves	
Pressure gauges	
Main drain/test	
Trim piping per manufacturer's instructions	
Isolation valve	

Check if Okay. Enter comment or note number if deficient.

Check	
Backflow Prevention	
Reduced Pressure Backflow Preventer	
Reduced pressure Detectors Assembly	
Double Check Valve Assembly	
Double Check Detector Assembly	
Fire Department Connection	
Brass Finish	
Brass caps and chains	
Check valve	
Waterflow Alarms	
Tied into fire alarm control panel	
Provided at alarm valve riser	
Valves, Piping	
Isolation valves installed per drawings	
Pipe fittings complete and pipes properly supported	
Pipes properly labeled	
Piping system properly flushed	
No leaking apparent around fittings	
Valves properly labeled	
Risers clamps	
Test connections	
Instrumentation installed according to specification (pressure gages, test valves.)	
Clean up of equipment completed per contract documents	
Inspectors test connections provided at all zones with equivalent sprinkler orifice size	
Maintenance access acceptable for components	

The checklist items of Part 3 are all successfully completed for given trade ☐ *YES* ☐ *NO*

4. Operational Checks

Check if Okay. Enter comment or note number if deficient.

Check Equip Tag➔	Test Results Functional Y/N
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 1	
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 2	

Check if Okay. Enter comment or note number if deficient.

Check Equip Tag➔	Test Results Functional Y/N
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 3	
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 4	
Activation of tamper switch and automatic activation of alarm at fire alarm control panel at all valve locations	

The checklist items of Part 4 are all successfully completed for given trade ☐ *YES* ☐ *NO*

END OF SECTION

SECTION 22 00 01
PLUMBING TRADE BID SUMMARY

PART 1 GENERAL

1.01 FILING OF TRADE BIDS

A. Trade Bids are required for work under this section in accordance with the provisions of the General Laws of the Commonwealth of Massachusetts, Chapter 149A, Sections 1-8, 10, and 11, as most recently amended.

B. Trade Bids shall be submitted to the Awarding Authority as set forth in the Invitation to Bids and the Instructions to Bidders, accompanied by the bid deposit specified therein.

C. Every Trade Bid for work under this section shall be on the form in this Project Manual furnished by the Awarding Authority.

1.02 GENERAL REQUIREMENTS

A. The General and Supplementary Conditions of the Contract, Construction Manager's Scoping Documents, and General Requirements of the Project Manual, including without exception all sections in Divisions 00 and 01, apply to the Plumbing Trade Contractor, material suppliers, and all other persons furnishing labor and materials under this section.

B. Examine all project specifications and drawings for requirements which affect work of this section whether or not such work is specifically mentioned in this section.

C. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.

D. The following definitions apply to the drawings and specifications:

1. Furnish: The term "furnish" is used to mean "supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations".
2. Install: The term "install" is used to describe operations at the project site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
3. Provide: The term "provide" is used to mean "furnish and install, complete and ready for the intended use".
4. Installer: An "installer" is the subcontractor or an entity engaged by the subcontractor, either as an employee or sub-subcontractor for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.

E. When open-flame or spark producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the Construction Manager shall be notified not less than 24 hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant dedicated fire watch who is not otherwise employed as installation labor, where work is being performed, until it is completed.

1.03 DESCRIPTION

A. The work of this Trade Bid section shall include all furnishing and installation of complete plumbing systems for the project, as shown on drawings, as described in specifications, or as reasonably inferred from either, in the judgment of the Architect.

B. The work of this Trade Bid section may be (but is not exclusively) shown on the drawings by the section number 22 00 01 or the abbreviation "SC-PLUMB".

C. The work of this Trade Bid section shall include the scope of each of the following sections in their entirety:

1. Section 22 00 10 - Plumbing.

D. The work of this Sub-Bid section shall include part of the scope of each of the following sections:
   1. Section 07 84 00 - Firestopping: For material and installation requirements related to firestopping by this subcontractor at penetrations of fire rated assemblies (floors, walls, and ceilings) by the work provided by this section.
   2. Section 07 92 00 - Joint Sealants: For sealing by this subcontractor around plumbing fixtures at joints to adjacent surfaces.
   3. Section 08 31 00 - Access Doors and Panels: For material and installation requirements related to access doors and frames required to access concealed components of this section, to be furnished by this Trade Contractor to Section 06 20 00 - Finish Carpentry for installation.
   4. Section 11 30 13 - Appliances: For connection, by this subcontractor, of dishwashers, refrigerators, ice makers, clothes washers, and other appliances provided and installed by that section.
   5. Section 11 40 00 - Foodservice Equipment: For connection, by this subcontractor, of sinks, dishwashers, refrigerators, ice makers, and other equipment and components provided and set in place by that section.
   6. Section 12 31 00 - Manufactured Metal Casework: For connection, by this subcontractor, of sinks and other and other service fitting components provided and installed by that section.
   7. Section12 32 00 - Manufactured Wood Casework: For connection, by this subcontractor, of sinks, gas turrets, and other service fitting components provided and installed by that section.
   8. Section 23 00 10 - HVAC.
   9. Section 23 04 58.10: Vibration Control and Seismic Restraint: For requirements related to seismic bracing of components to be provided by this Trade Contractor.

E. This Trade Contractor shall fully coordinate the execution of the work of this section with, and anticipate the requirements of the following sections:
   1. Section 01 91 13 - MEP Commissioning Requirements: For list of equipment to be commissioned and requirements for cooperation with the Commissioning Agent.
   2. Section 03 30 00 - Cast-in-Place Concrete: For setting of floor and trench drains and floor sinks in concrete slab floors.
   3. Section 03 54 00 - Concrete Toppings: For coordination of floor drain elevations with floors sloped for drainage.
   4. Section 05 50 00 - Metal Fabrications: For formed metal trenches for utility piping.
   5. Section 05 53 05 - Metal Gratings and Floor Plates for trench covers for utility piping.
   6. Section 07 54 00 - Thermoplastic Membrane Roofing: for vents through roofing and coordination of flashing requirements.
   7. Section 09 30 00 - Tiling: for setting of floor drains and floor sinks in tile floors sloped for drainage.
   8. Section 09 91 13 - Exterior Painting: For preparation of exterior exposed piping scheduled and permitted by code to be painted.
   9. Section 09 91 23 - Interior Painting: For preparation of interior exposed piping scheduled and permitted by code to be painted.
   10. Section 10 21 13.19 - Plastic Toilet Compartments.
   11. Section 10 28 00 - Toilet, Bath, and Laundry Accessories.
   12. Section 12 36 00 - Countertops: For coordination of openings in counters to receive fixtures.

F. Sub-Sub Bid Requirements:

1. Each Trade Bidder shall list in Paragraph E of Section 00 41 01 - Form for Trade Contractor Bid the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the section of the specifications for that sub-trade requires such listing; provided that, in the absence of a contrary provision in the specifications, any sub-bidder may, without listing any bid price, list their own name in said Paragraph E for any such class of work or part thereof and perform that work with persons on sub-bidder's own payroll, if such sub-bidder, after sub-bid openings, establishes to the acceptance of the Awarding Authority that that sub-bidder does customarily perform such class or part thereof with persons on sub-bidder's own payroll and is qualified to do so. The following class(es) of work shall be listed in Paragraph E under the conditions indicated herein.
    a. Plumbing Piping Insulation as described in paragraph _____ of Section 22 00 10 - Plumbing.
2. See Section 00 21 13 - Instructions to Bidders TRADE BIDS Paragraph, and Section 00 41 01 - Form for Trade Contractor Bid for additional instructions regarding "Paragraph E" Sub-Sub Bids.

G. Primary Drawings listed are those intended to indicate the scope of work for this trade.
    1. List of Primary Drawings: To be provided prior to the release of Bid Set.
    2. This Trade Contractor shall review all remaining srawings that may show additional information relating to specific installation conditions and information that may be required to calculate exact quantities, determine specific installation requirements, or generally coordinate the work with other trades.
    3. Additionally, this subcontractor must include in the List of Primary Drawings: To be provided prior to the release of Bid Set, Code Plans, Phasing Plans, Demolition Plans, and all project detail sheets for general and code-related information, installation or other conditions and instructions that directly affect their work.
H. Staging and Scaffolding: The work of this Trade Bid section shall include the provision of staging and scaffolding (including design, engineering, erection, maintenance, and removal) where required to complete the work of this Trade Bid category. All staging or scaffolding provided shall include safety devices and meet all applicable laws and regulations.
    1. See Section 01 50 00 - Temporary Facilities and Controls for additional information.
I. Temporary Hoisting Equipment, Lifts, and Machinery: The work of this Trade Bid section shall include all temporary hoisting equipment, lifts, and machinery required to complete the work of this Trade Bid category. All temporary hoisting equipment, lifts, and machinery and operation shall comply in all respects to the governing laws and codes.
    1. See Section 01 50 00 - Temporary Facilities and Controls for additional information.
J. Cutting and Patching
    1. This Trade Contractor shall perform all cutting and coring required to complete the work of this Trade Bid category, except as specifically indicated in the respective technical sections. Where any of the sections listed as part of this Trade Bid indicate that cutting and coring shall be performed by parties other than the Plumbing Trade Contractor, the cost of such cutting and coring necessary for the work of this section shall be borne by the Plumbing Trade Contractor.
    2. All patching required to complete the work of this Trade Bid section shall be performed by the appropriate trade, and the cost of such patching necessary for the work of this section shall be borne by this Trade Contractor.
    3. All cutting, coring, and patching shall be coordinated through and by the Construction Manager.

4. Any and all cutting of structural members, including floor slabs, shall require approval of the Structural Engineer of Record; see Structural Drawings for typical penetrations and openings in structural members, including floor slabs. For any openings outside the parameters of those shown on Structural Drawings, obtain approval from Structural Engineer of Record.

1.04 REFERENCE STANDARDS

A. See each individual technical specification section listed above for Reference Standards.

1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. See each individual technical specification section listed above for required product information, samples, shop drawings, and other submittals required.

1.06 LEED REQUIREMENTS

A. This project is intended to be certified as a LEED for Schools v4/v4.1 building, with a rating of LEED "Silver". See Section 01 81 14 - LEED for Schools v4/v4.1 Project Scorecard for projected LEED credits. Some product and material selections, and some performance requirements of this section are required to achieve the credits listed.

B. Prior to any product submittals, the Plumbing Trade Contractor shall assist the Construction Manager in the creation of a LEED action plan identifying products that will contribute toward LEED credits. The LEED Action Plan shall be submitted prior to any product submittals to assist the Architect in evaluating product submittals that must meet LEED criteria.

C. The Plumbing Trade Contractor shall provide all documentation indicating applicability of all products of this section to potential LEED credits to the project LEED Administrator for submission to www.leedonline.com. See Section 01 81 13 - Sustainable Design Requirements for additional requirements.

1.07 QUALITY ASSURANCE

A. See each individual technical specification section listed above for quality assurance requirements.

B. See Section 01 40 00 - Quality Requirements for additional requirements.

C. Testing Agency Qualifications: Independent firm specializing in performing testing and inspections of the type(s) specified in sections assigned to this trade.

1.08 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. See each individual technical specification section listed above for specific warranties required.

PART 2 PRODUCTS (SEE EACH INDIVIDUAL SPECIFICATION SECTION LISTED ABOVE FOR PRODUCT REQUIREMENTS)

PART 3 EXECUTION (SEE EACH INDIVIDUAL SPECIFICATION SECTION LISTED ABOVE FOR EXECUTION REQUIREMENTS)

3.01 CLEANING

A. Plumbing Trade Contractor shall be responsible for cleaning up Plumbing Trade Contractor's own work at the end of each day, and depositing waste and debris created by Plumbing Trade Contractor's work in the appropriate dumpsters, separating eligible products for recycling, and depositing recycling in designated recycling containers. Dumpsters shall be provided and maintained (including payment of costs for legal disposal off-site) by the Construction Manager.

1. See Section 01 50 00 - Temporary Facilities and Controls.
2. See Section 01 74 19 - Construction Waste Management and Disposal.

END OF SECTION

SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following:
   a. Piping materials and installation instructions common to most piping systems.
   b. Transition fittings.
   c. Dielectric fittings.
   d. Mechanical sleeve seals.
   e. Sleeves.
   f. Escutcheons.
   g. Grout.
   h. Electric Heat Tracing

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.02 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.03 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8 inch maximum thickness unless thickness or specific material is indicated.
   2. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   3. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   4. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.04 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
   1. Manufacturers:
      a. Cascade Waterworks Mfg. Co.
      b. Dresser Industries, Inc.; DMD Div.
      c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
      d. JCM Industries.
      e. Smith-Blair, Inc
      f. Viking Johnson.
   2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
   3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
   4. Aboveground Pressure Piping: Pipe fitting.

B. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.
   1. Manufacturers:
   a. Cascade Waterworks Mfg. Co.
   b. Fernco, Inc.
   c. Mission Rubber Company.
   d. Plastic Oddities, Inc.

2.05 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250 pound per square inch gauge minimum working pressure at 180 degree F.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Eclipse, Inc.
      d. Epco Sales, Inc.
      e. Hart Industries, International, Inc.
      f. Watts Industries, Inc.; Water Products Div.
      g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150 or 300 pounds per square inch gauge minimum working pressure as required to suit system pressures.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Epco Sales, Inc.
      d. Watts Industries, Inc.; Water Products Div.

2.06 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.
   2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Composite, Include two for each sealing element.
   4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.07 SLEEVES

A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

B. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Underdeck Clamp: Clamping ring with set screws.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

E. For interior wall, floor and ceiling penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for fire rating, size, depth, and location of joint shall be under division 07 84 10 - Firestopping, 07 91 00 - Preformed Joint Seals, and 07 92 00 - Joint Sealants.

2.08 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated

D. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

2.09 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-pounds per square inch, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

2.10 VALVE TAGS, NAMEPLATES, AND CHARTS

A. Valves on pipes of every description shall have neat circular brass valve tags at least 1-1/2 inch in diameter attached with brass hook to each valve stem. Stamp on these valve tags, in letters as large as practical, the number of the valve and the service, such as "H.W., C.W., GAS", for hot water, cold water, and gas respectively. The numbers for each service shall be consecutive. Where valves are located above ACT ceilings, furnish and install valve finder ceiling tack, tack shall be minimum 7/8 in. diameter with 1/2 inch steel point, color as determined by Owner.

2.12 ELECTRIC HEAT TRACE:

A. Acceptable manufacturers:
   1. Raychem XL Trace Edge
   2. Thermon
   3. Delta Therm

3.01 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

END OF SECTION

SECTION 22 05 13
COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contractor. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.04 SUBMITTALS

A. Product Data: For the following:
1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
B. Comply with NEMA MG 1 unless otherwise indicated.
C. Comply with IEEE 841 for severe-duty motors.

2.02 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 degree C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.03 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Multispeed Motors: Variable torque or separate winding for each speed.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

D. Rotor: Random-wound, squirrel cage.

E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating.

G. Insulation: Class B for general purpose motors, Class F for high efficiency motors.

H. Code Letter Designation:
   1. Motors 15 horsepower and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 horsepower: Manufacturer's standard starting characteristic.

2.04 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 horsepower shall be one of the following, to suit starting torque and requirements of specific motor application:
   1. Permanent-split capacitor.
   2. Split phase.
   3. Capacitor start, inductor run.
   4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 horsepower and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 22 05 16
EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following:
   a. Flexible pipe connections.
   b. Expansion joints and compensators.
   c. Pipe loops, offsets, and swing joints

B. Related Sections:
   1. Division 22 Section “Common Work Results for Plumbing” for codes, standards, and other general requirements.
   2. Division 22 Section “Domestic Water Piping” for domestic water piping inside the building.
   3. Division 22 Section “Hangers and Supports for Plumbing Equipment and Piping”.

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

PART 2 - PRODUCTS

2.01 EXPANSION LOOPS JOINTS

A. Flexible-Hose Expansion Fittings:

   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

      a. Metraflex, Inc- “Metraloop”.
      b. Flex-Hose Co., In.c

c. Flexicraft Industries.
d. Or equal.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180 degreeree return bend or center section of flexible hose.
3. Potable water piping and components shall comply with NSF 14 and NSF 61.
4. Sanitary flexible expansion joints shall comply with IAPMO IGC 304.
5. Elbows: 304 Stainless Steel long radius 90 degreeree elbows.
6. Flexible Hose: 321 Stainless Steel hose, 304 Stainless Steel braid and interlocking liner.
7. Brass cleanout plugs (two)
8. +- 8 inch of movement.
9. 150 PSI working pressure at 70 degreeree F.
10. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
11. 304 Stainless Steel long radius 90 degreeree elbows.
12. Expansion Fittings for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.

    a. Bronze hoses and single-braid bronze sheaths with 450 pounds per square inch gauge at 70 degree F and 340 pounds per square inch gauge at 450 degree F ratings.

13. Expansion Fittings for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 pounds per square inch gauge at 70 degree F and 225 pounds per square inch gauge at 450 degree F ratings.

14. Expansion Fittings for Steel Piping NPS 2 and Smaller: Stainless-steel fittings with threaded end connection.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 pounds per square inch gauge at 70 degree F and 325 pounds per square inch gauge at 600 degree F ratings.

15. Expansion Fittings for Steel Piping NPS 2-1/2 to NPS 6: Stainless-steel fittings with flanged end connections.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 pounds per square inch gauge at 70 degree F and 145 pounds per square inch gauge at 600 degree F ratings.

2.02 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Metraflex, Inc.
    b. Flex-Hose Co., Inc.

c. Hyspan Precision Products, Inc.
d. Adsco Manufacturing LLC.
e. U.S. Bellows, Inc.
f. Or equal.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, with tension and shear capacities appropriate for application.

a. Stud: Threaded, zinc-coated carbon steel.
b. Expansion Plug: Zinc-coated steel.
c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened Portland cement concrete, with tension and shear capacities appropriate for application.

a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.01 EXPANSION FITTING INSTALLATION

A. Install mechanical expansion fittings at a minimum of every 100 feet on straight runs of piping and where specifically indicated on drawings.

B. Install flexible hose mechanical expansion joints and/or expansion loops in piping crossing building expansion joints. Coordinate locations with Architectural and Structural drawings.

C. Install expansion fittings of sizes matching sizes of piping in which they are installed.

3.02 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.

3.03 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion fitting not more than four pipe diameters from expansion joint.

C. Install second guide(s) at 10 to 14 pipe diameters from first guide. Install intermediate guides spaced at the following distances for the indicated pipe size:

1. 1 inch pipe: 11 feet
2. 1-1/4 inch pipe: 14 feet
3. 1-1/2 inch pipe: 17 feet
4. 2 inch pipe: 23 feet
5. 2-1/2 inch pipe: 27 feet
6. 3 inch pipe: 33 feet
7. 4 inch pipe: 37 feet

END OF SECTION

SECTION 22 05 19
METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. Section Includes:
1. Thermometers.
2. Gages.
3. Test plugs.
4. Water Meters and Sub-meters
5. Gas Sub Meters

B. Related Sections:
1. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.

1.04 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.05 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

PART 2 - PRODUCTS

2.01 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
1. Palmer - Wahl Instruments Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.
4. Or equal.

B. Case: Die-cast aluminum seven inches long.

C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass

F. Connector: Rigid, straight type

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus one percent of range or plus or minus one scale division to maximum of 1.5 percent of range.

2.02 DIRECT-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   1. Marsh Bellofram.
   2. Weiss Instruments, Inc.
   3. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter.

C. Element: Bourdon tube or other type of pressure element.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red metal.

G. Window: Glass

H. Ring: Metal

I. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device

J. Thermal System: Liquid-bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus one percent of range or plus or minus one scale division to maximum of 1.5 percent of range.

2.03 REMOTE-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
   2. Marsh Bellofram.
   3. Tel-Tru Manufacturing Company.

4. Weiss Instruments, Inc.
5. Or equal.

B. Case: Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter with holes for panel mounting.

C. Element: Bourdon tube or other type of pressure element.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red metal.

G. Window: Glass

H. Ring: Metal

I. Connector: Bottom union type.

J. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus one percent of range or plus or minus one scale division to maximum of 1.5 percent of range.

2.04 BIMETALLIC-ACTUATED DIAL THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
1. Eugene Ernst Products Co.
2. Marsh Bellofram.
3. Weiss Instruments, Inc.
4. Or equal.

B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

C. Case: Dry type, stainless steel with three inch diameter.

D. Element: Bimetal coil.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red metal.

G. Window: Glass

H. Ring: Stainless steel.

I. Connector: Adjustable angle type.

J. Stem: Metal, for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus one percent of range or plus or minus one scale division to maximum of 1.5 percent of range.

2.05 THERMOWELLS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
1. Ernst Gage Co.
2. Palmer - Wahl Instruments Inc.
3. Weiss Instruments, Inc.

B. Manufacturers: Same as manufacturer of thermometer being used.

C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.06 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
1. Ernst Gage Co.
2. Marsh Bellofram.
3. Weiss Instruments, Inc.
4. Or equal.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
1. Case: Dry type, drawn steel or cast aluminum, 4-1/2 inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass
8. Ring: Metal
9. Accuracy: Grade A, plus or minus one percent of middle half scale.
10. Vacuum-Pressure Range: 30 inches of mercury of vacuum to 15 pounds per square inch gauge of pressure
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:
1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.07 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
1. Flow Design, Inc.
2. Trerice, H. O. Co.
3. Watts Industries, Inc.; Water Products Div.
4. Or equal.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 pounds per square inch gauge at 200 degree F

D. Core Inserts: One or two self-sealing rubber valves.
   1. Insert material for water service at 20 to 200 degree F shall be CR.
   2. Insert material for water service at minus 30 to plus 275 degree F be EPDM.

E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer, and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
   1. Pressure Gage: Small bourdon-tube insertion type with two to three inch diameter dial and probe. Dial range shall be 0 to 200 pounds per square inch
   2. High-Range Thermometer: Small bimetallic insertion type with one to two inch diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 degree F
   3. Carrying case shall have formed instrument padding.

2.08 BUILDING WATER SERVICE METER

A. Manufacturers:
   1. Subject to compliance with requirements, provide products by the following or approved equal:
      a. Badger Meter, Inc.
      b. Mueller Company; Water Products Division.
      c. Schlumberger Limited; Water Division.
      d. Or equal.

B. Coordinate type of water meter and remote registration system with Local Water Department and Authority Having Jurisdiction.

C. Compound-Type Water Meters:
   1. Description:
      a. Standard: AWWA C702.
      b. Pressure Rating: 150-psig working pressure.
      c. Body Design: With integral mainline and bypass meters; totalization meter.
      d. Registration: In gallons or cubic feet as required by utility company.
      e. Case: Bronze.
      f. Pipe Connections: Flanged.

D. Shut-off valves shall be installed on both sides of the meter and a strainer shall be installed on the inlet side of the meter after the inlet shut-off valve. Provide bypass per local requirements

E. Remote Registration Systems: Specified water meter type, modified to include factory- or field-installed, self-contained, pulsing- type, generating system transmitter. Include low-voltage connecting wiring, totalizing device, and remote wall register.
   1. Encoder-Type, Remote-Registration System: AWWA C707; meter-mounted transmitter; totalizing device; two or three conductor connecting wire; weatherproof, outdoor, remote receptacle for automatic reading and billing; and conforming to utility standards.

F. Water meters are to include dry contacts and made compatible with the building BMS (Bacnet) system. Provide devices required for accurate meter remote reading/report to BMS (Bacnet) system.

2.09 ULTRA SONIC WATER SUB METERS (SM1, SM2, SM3, & SM4)

A. Manufacturers:
   1. Subject to compliance with requirements, provide products by the following or approved equal:
      a. Spire Metering, Inc 280W-CI
      b. SHENITECH STUF
      c. Dynasonics
      d. Or equal.

B. Refer to drawing P0.01 for sub meter application.

C. Provide water meter for flow measurement of potable water supply to the school facility and shall be capable to integrate with building control management system.

D. Design of the water meter shall use transit-time ultrasonic technology along with transducers to provide for flow totalizing (gallons used) and flow rate (gpm) in real time. The utrasonic water meter shall be consists of a flow-cell, a pair of ultrasonic flow transducers and an integrator.

E. Water meter (s) shall BE capable for + two percent accurate flow measurement of clean liquids, suitable for liquids that contain small amounts of suspended solids or particle in sizes smaller than 100 um in order to make a measurement. The meter shall be able to operate in temperatures ranging from 32 degree F to 212 degree F and come equipped with a device that emits pulse signals.

F. Indication for flow rate and flow accumulator shall be displayed in English (US) units.

G. The input/output interfaces and RD485 port to integrate with building management system.

H. Enclosure shall be weather-resistant, NEMA 4X or IP65. It shall be constructed of stainless steel

I. Water meters are to include dry contacts and made compatible with the building BMS (Bacnet) system. Provide devices required for accurate meter remote reading/report to BMS (Bacnet) system.

J. Shut-off valves shall be installed on both sides of the meter. Provide bypass with shut off valve around water sub meter.

PART 3 - EXECUTION

3.01 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers in the outlet of water heating equipment.

B. Install dry -case-type, vapor actuated dial thermometers at suction and discharge of pump.

C. Provide the following temperature ranges for thermometers:
   1. Domestic Hot Water: 30 to 180 degree F, with two degree scale divisions

3.02 GAGE APPLICATIONS

A. Install dry-case-type pressure gage on the incoming domestic water line as the water service enters the building.

B. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

C. Install dry-case-type pressure gages at the inlet and outlet of water heating equipment.

D. Install dry case-type pressure gages at suction and discharge of each pump.

END OF SECTION

SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. Section Includes:
1. Bronze ball valves.
2. Circuit Balancing Valves
3. Iron ball valves.
4. Iron, single-flange butterfly valves.
5. Bronze swing check valves.
6. Iron swing check valves.
7. Bronze gate valves.
8. Backwater valves.

B. Related Sections:
1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
3. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

1.04 DEFINITIONS

1. CWP: Cold working pressure.
2. EPDM: Ethylene propylene copolymer rubber.
3. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
4. NRS: Nonrising stem.
5. OS&Y: Outside screw and yoke.
6. RS: Rising stem.
7. SWP: Steam working pressure.

1.05 SUBMITTALS

A. Product Data: For each type of valve indicated.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valves in Insulated Piping: With two inch stem extensions and the following features:
1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

D. Valve-End Connections:
1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

E. Valve Bypass and Drain Connections: MSS SP-45.

2.02 BRONZE BALL VALVES

A. Three-Piece, Full-Port, Lead free, Bronze Ball Valves with Stainless-Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.; Apollo Valves.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
2. Description:
   a. Standard: MSS SP-110.
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Three piece.
   e. Body Material: Bronze.
   f. Ends: Threaded. (or solder for domestic water service, two inch and smaller)
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

2.03 CIRCUIT BALANCING VALVES

A. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Caleffi 1324
   b. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   c. NIBCO INC.
   d. ThermOmega Tech
   e. Or equal.

2. Description:
   a. SWP Rating: 150 psig.
   b. CWP Rating: 600 psig.
   c. Body Material: Copper alloy.
   d. Ends: Threaded.
   e. Seats: Ductile iron or copper alloy
   f. Stem: EPDM
   g. Ball: Teflon packing, brass packing nut, blowout proof stem, vented.
   h. Strainer: 20 mesh stainless steel

3. An option to standard balancing valves listed above are “Circuit Solver” (#CSUA) assemblies by ThermOmega Tech, complete with union and dual ball valves. Provide dielectric fittings upstream and downstream of device.

2.04 IRON BALL VALVES

A. Class 125, Iron Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.
      b. Conbraco Industries, Inc.; Apollo Valves.
      c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      d. Or equal
   2. Description:
      a. Standard: MSS SP-72.
      b. CWP Rating: 200 psig
      c. Body Design: Split body.
      d. Body Material: ASTM A 126, gray iron.
      e. Ends: Flanged.
      f. Seats: PTFE or TFE.
      g. Stem: Stainless steel.
      h. Ball: Stainless steel.
      i. Port: Full.

2.05 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.; Apollo Valves.
      b. NIBCO INC.
      c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      d. Or equal.
   2. Description:
      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 200 psig
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      e. Seat: EPDM.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Aluminum bronze.

2.06 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.
      b. Crane Co
      c. Milwaukee Valve Company.
      d. Or equal.
   2. Description:
      a. Standard: MSS SP-139.
      b. CWP Rating: 200 psig
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B 62, bronze.
      e. Ends: Threaded (or solder for domestic water service, sizes 2” and smaller).
      f. Disc: Bronze.

2.07 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co
      b. NIBCO INC.
      c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      d. Or equal.
   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. CWP Rating: 200 psig
      c. Body Design: Clear or full waterway.
      d. Body Material: ASTM A 126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Gasket: Asbestos free.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
B. Locate valves for easy access and provide separate support where necessary.
C. Install valves in horizontal piping with stem at or above center of pipe.
D. Install valves in position to allow full stem movement.
E. Install check valves for proper direction of flow and as follows:
    1. Swing Check Valves: In horizontal position with hinge pin level.

END OF SECTION

SECTION 22 05 29
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Pipe positioning systems.
   8. Equipment supports.

B. Related Sections include the following:
   1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.04 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.05 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.06 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Pipe positioning systems.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:
   1. B-Line Systems, Inc.; a division of Cooper Industries.
   2. Grinnell Corp.
   3. Tolco Inc.
   4. Or equal.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.03 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.04 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:
   1. B-Line Systems, Inc.; a division of Cooper Industries.
   2. Tolco Inc.
   3. Unistrut Corp.; Tyco International, Ltd.
   4. Or equal.

C. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.05 THERMAL-HANGER SHIELD INSERTS

A. Description: 100 pounds per square inch gauge minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:
1. Carpenter & Paterson, Inc.
2. Pipe Shields, Inc.
3. Rilco Manufacturing Company, Inc.
4. Or equal.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend two inches beyond sheet metal shield for piping operating below ambient air temperature.

2.06 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
1. Manufacturers:
    a. Hilti, Inc.
    b. ITW Ramset/Red Head.
    c. Masterset Fastening Systems, Inc.
    d. Or equal.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
1. Manufacturers:
    a. B-Line Systems, Inc.; a division of Cooper Industries.
    b. Hilti, Inc.
    c. ITW Ramset/Red Head.

2.07 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

1. Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.
   c. Or equal.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.
   1. Manufacturers:
      a. MIRO Industries.
      b. Or equal.

D. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
   2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
   3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
   4. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
   5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
   6. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 .
   7. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
   8. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
   9. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.

10. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
11. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
12. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
13. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
14. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
15. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.

c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

END OF SECTION

SECTION 22 05 53
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Valve tags.
   5. Warning tags.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Material and Thickness: Stainless steel, or Aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch
   3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   4. Fasteners: Stainless-steel rivets.
   5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2 by 11 inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where

equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
B. Letter Color: Black
C. Background Color: Yellow
D. Maximum Temperature: Able to withstand temperatures up to 160 degrees F
E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch
F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
G. Fasteners: Stainless-steel rivets.
H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.04 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2 by 11 inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.05 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately four by seven inches
   2. Fasteners: Brass grommet and wire
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.03 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
   8. In areas where exposed pipe will be painted, locate labels such that they will not be painted.

B. Pipe Label Color Schedule:
   1. Domestic Cold Water Piping:
      a. Letter Color: Black
      b. Background Color: Green
   2. Domestic Hot Water and Hot Water Return Piping:
      a. Letter Color: Black
      b. Background Color: Yellow
   3. Non Potable Water Piping:
      a. Letter Color: Black
      b. Background Color: Purple
   4. Sanitary Waste and Storm Drainage and Overflow Piping:

a. Letter Color: Black
b. Background Color: Green

5. Vent Piping:
   a. Letter Color: Black
   b. Background Color: Yellow
6. Special Waste Water Piping:
   a. Letter Color: Black
   b. Background Color: Orange

3.04 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape: Minimum 1-1/2 inches, round
   2. Valve-Tag Color: Natural
   3. Letter Color: Black

3.05 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

SECTION 22 07 00
PLUMBING INSULATION

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. Section Includes:
1. Insulation Materials for plumbing piping
2. Adhesives.
3. Mastics.
4. Sealants.
5. Factory-applied jackets.
6. Field-applied fabric-reinforcing mesh.
7. Field-applied cloths.
8. Field-applied jackets.
9. Tapes.
10. Securements.
11. Corner angles.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Cell-U-Foam Corporation; Ultra-CUF.
      b. Pittsburgh Corning Corporation; Foamglas Super K.
   2. Block Insulation: ASTM C 552, Type I.
   3. Special-Shaped Insulation: ASTM C 552, Type III.
   4. Board Insulation: ASTM C 552, Type IV.
   5. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
   6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Aeroflex USA Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

H. Mineral-Fiber, Preformed Pipe Insulation:
   1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Knauf Insulation; 1000 deg. Pipe Insulation.
      b. Manson Insulation Inc.; Alley-K.
      c. Owens Corning; Fiberglas Pipe Insulation.
   2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   3. Provide insulations with PVC covering for insulated systems located within mechanical room, piping in exposed ceiling area.

2.02 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      a. Childers Brand; H. B. Fuller Construction Products.
      b. Eagle Bridges - Marathon Industries.
      c. Foster Brand; H. B. Fuller Construction Products.
      d. Mon-Eco Industries, Inc.
      e. Or equal.

2. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of **80** g/L or less.
3. Adhesives and sealants shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. Phenolic Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees Fahrenheit .

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Caseway Products.
    d. Or equal.

2. Adhesive: As recommended by phenolic manufacturer and with a VOC content of [**50**] g/L or less.
3. Adhesives and sealants shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Eagle Bridges - Marathon Industries.
    c. Foster Brand; H. B. Fuller Construction Products.
    d. Mon-Eco Industries, Inc.
    e. Or equal.

2. Adhesives shall have a VOC content of **80** g/L or less.
3. Adhesives and sealants shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Dow Corning Corporation.
    b. Johns Manville; a Berkshire Hathaway company.
    c. P.I.C. Plastics, Inc.
    d. Speedline Corporation.
    e. Or equal.

2. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of **50** g/L or less.
3. Adhesives and sealants shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.03 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

   1. Mastics: As recommended by insulation manufacturer and with a VOC content of **50** g/L or less.
   2. Mastics shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.04 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   2. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
      a. Products: Subject to compliance with requirements, provide the following:
         1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film or approved equal..
   3. PVDC Jacket for Outdoor Applications and Entire Crawl Space: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
      a. Products: Subject to compliance with requirements, provide:
         1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film or approved equal.
   4. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
      a. Products: Subject to compliance with requirements, provide the following:
         1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film or approved equal.

2.05 SEALANTS

A. Joint Sealants for Cellular-Glass and Phenolic Products:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Eagle Bridges - Marathon Industries.
    c. Foster Brand; H. B. Fuller Construction Products.
    d. Mon-Eco Industries, Inc.
    e. Pittsburgh Corning Corporation.
    f. Or equal.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 degrees Fahrenheit.
5. Color: White or gray.
6. Sealant shall have a VOC content of **420** g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Eagle Bridges - Marathon Industries.
    c. Foster Brand; H. B. Fuller Construction Products.
    d. Mon-Eco Industries, Inc.
    e. Or equal.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees Fahrenheit.
5. Color: Aluminum.
6. Sealant shall have a VOC content of **420** g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Dow Corning.
    c. Amerimax Flash Mate.
    d. Or equal.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees Fahrenheit.
5. Color: White.
6. Sealant shall have a VOC content of **420** g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.06 FIELD-APPLIED JACKETS

A. Provide PVC jackets to all insulated piping systems in mechanical space areas.

B. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
      a. P.I.C. Plastics, Inc.; FG Series.
      b. Proto PVC Corporation; LoSmoke.
      c. Speedline Corporation; SmokeSafe.
   2. Adhesive: As recommended by jacket material manufacturer.
   3. Color: White
   4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      a. Shapes: 45 and 90 degree, short and long radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

      Factory-fabricated tank heads and tank side panels

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.

3.05 GENERAL PIPE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.

END OF SECTION

SECTION 22 11 16
DOMESTIC WATER PIPING

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. Section Includes:
1. Under-building slab, aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
2. Encasement for piping.
3. Specialty valves.
4. Flexible connectors.
5. Escutcheons.
6. Sleeves and sleeve seals.
7. Wall penetration systems.

1.04 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7.

1.05 SUBMITTALS

A. Product Data: For the following products:
1. Specialty valves.
2. Transition fittings.
3. Dielectric fittings.
4. Flexible connectors.
5. Water meters.
6. Backflow preventers and vacuum breakers.
7. Escutcheons.
8. Sleeves and sleeve seals.
9. Water penetration systems.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.02 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper and Type K for underground pipe.
   1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
   2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
   3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
   4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
   5. Grooved-Joint Copper-Tube Appurtenances:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following
         1) Anvil International.
         2) Shurjoint Piping Products.
         3) Victaulic Company.
      b. Copper Grooved-End Fittings: ASTM B 75 copper tube or ASTM B 584 bronze castings. Flaring of tube and fitting ends to IPS dimensions is not permitted.
      c. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, cast with offsetting, angle-pattern bolt pads and coated with copper-colored enamel; EPDM- synthetic rubber gaskets (UL classified and NSF-61), suitable for hot and cold water, and bolts and nuts.

B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper. ((for 1.5” and smaller piping below slab)
   1. Copper Brazed-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

2.03 DUCTILE-IRON PIPE AND FITTINGS (for 4 inch piping below slab)

A. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   1. Standard-Pattern, Push-on-Joint Fittings: AWWA C110, ductile or gray iron.
      a. Gaskets: AWWA C111, rubber.

2.04 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.05 SPECIALTY VALVES

A. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.

B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.06 TRANSITION FITTINGS

A. General Requirements:
   1. Same size as pipes to be joined.
   2. Pressure rating at least equal to pipes to be joined.
   3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2.07 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hart Industries International, Inc.
      b. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      c. Zurn Plumbing Products Group; Wilkins Water Control Products.
   2. Description:
      a. Pressure Rating: 150 psig at 180 degrees Fahrenheit.
      b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Capitol Manufacturing Company.
      b. EPCO Sales, Inc.
      c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      d. Or equal.
   2. Description:
      a. Factory-fabricated, bolted, companion-flange assembly.
      b. Pressure Rating: 150 psig minimum.
      c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Calpico, Inc.
      b. Lochinvar Corporation.
      c. Watts
      d. Or equal.

E. Dielectric Nipples (not allowed)

2.08 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
   1. Flexicraft Industries.
   2. Flex-Weld, Inc.
   3. Metraflex, Inc.
   4. Or equal.

2.09 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated finish with setscrews.

C. One Piece, Stamped Steel: Chrome-plated finish with setscrew or spring clips.

D. Split Casting, Cast Brass: Polished, chrome-plated or rough-brass finish with concealed hinge and setscrew.

E. Split Plate, Stamped Steel: Chrome-plated finish with concealed hinge, setscrew or spring clips.

F. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

G. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.10 SLEEVES

A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

E. For interior wall, floor and ceiling penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for fire rating, size, depth, and location of joint shall be under division 078400 for Firestopping, 079700 for Preformed Joint Seals, and 079200 for Joint Sealants.

2.11 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.

2. Calpico, Inc.
3. Metraflex, Inc.
4. Pipeline Seal and Insulator, Inc.
5. Or equal.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.12 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000 pounds per square inch, 28 day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.01 EARTHWORK

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.

H. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

J. Install seismic restraints on piping. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

K. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

L. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

M. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

N. Install piping adjacent to equipment and specialties to allow service and maintenance.

O. Install piping to permit valve servicing.

P. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

Q. Install piping free of sags and bends.

R. Install fittings for changes in direction and branch connections.

S. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

T. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

U. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.

V. Install thermometers on outlet piping from each water heater. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

END OF SECTION

SECTION 22 11 19
DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following domestic water piping specialties: Vacuum breakers.
   1. Backflow preventers.
   2. Water pressure-reducing valves.
   3. Balancing valves.
   4. Temperature-actuated water mixing valves.
   5. Strainers.
   6. Outlet boxes.
   7. Hose bibbs.
   8. Wall hydrants.
   9. Drain valves.
   10. Water hammer arresters.
   11. Air vents.
   12. Trap-seal primer systems.

B. Related Sections include the following:
   1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
   2. Division 22 Section "Domestic Water Piping" for water meters.

1.04 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.05 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.01 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   a. Jay R Smith, Inc.
   b. Watts Industries, Inc.; Water Products Div.
   c. Zurn Plumbing Products Group; Wilkins Div.
   d. Or equal
2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   a. Jay R Smith .
   b. Watts Industries, Inc.; Water Products Div.
   c. Zurn Plumbing Products Group; Light Commercial Operation.
   d. Or equal
2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Rough bronze.

2.02 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers (Water Service Entrance)
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   a. Watts Industries, Inc.- Watts 994
   b. Conbraco Industries, Inc.
   c. Ames Corporation.
   d. Or equal.
2. Standard: ASSE 1013.
3. Reduced pressure backflow preventers shall be lead-free construction and shall be stainless steel construction to provide long term corrosion resistance. The assembly shall consists of pressure differential relief valve located in a zone between two positive seating check valves. The main valve body shall be manufactured from 300 series stainless steel for corrosion resistance. The check valve shall be of thermoplastic construction with stainless steel hinge pins, cam arm, and cam bearing. The check valve shall be modular and shall seal to the main valve body by use of an O-ring. The differential relief valve shall be of stainless steel construction and shall utilize a rolling diaphragm and no sliding seats. The assembly shall include two resilient seated shutoff valves and four-ball type test cock. Gauges shall comply with requirements of ASSE Standard 1013
4. Coordinate the Model with local water department for approval.
5. Operation: Continuous-pressure applications.
6. Size: Refer to drawings
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
9. Valves: Ball type with threaded ends on inlet and outlet
10. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
11. Schedule: RPBP1 and RPBP2 – 4 inch in size. Refer to drawing P3.02 for location.

B. Reduced-Pressure-Principle Backflow Preventers (RPBP2,)
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Watts Industries, Inc.- Watts LF909
      b. Conbraco Industries, Inc.
      c. Flomatic Corporation.
      d. Or equal.

   2. Standard: ASSE 1013.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
   5. Size: Refer to drawings
   6. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
   7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   8. Configuration: Designed for horizontal, straight through flow.
   9. Accessories:
      a. Valves: Ball type with threaded ends on inlet and outlet
      b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Double-Check Backflow-Prevention Assemblies
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Conbraco Industries, Inc.
      b. FEBCO; SPX Valves & Controls.
      c. Watts Industries, Inc.; Water Products Div.
   2. Standard: ASSE 1015.
   3. Operation: Continuous-pressure applications, unless otherwise indicated.
   4. Pressure Loss: 5 pounds per square inch gauge maximum, through middle 1/3 of flow range.
   5. Size: Refer to drawings
   6. Configuration: Designed for horizontal, straight through flow.
   7. Accessories: Ball valves with threaded ends on inlet and outlet

D. Backflow-Preventer Test Kits and spare parts kits for each backflow preventer size are to be provided.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Conbraco Industries, Inc.
      b. FEBCO; SPX Valves & Controls.
      c. Watts Industries, Inc.; Water Products Div.
      d. Or equal.
   2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.03 WATER PRESSURE-REDUCING VALVES

A. Water Regulators
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Watts Industries
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. Or equal.

2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig
4. Size: Refer to drawings
5. Body: Bronze with chrome-plated finish for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3
6. Valves for Booster Heater Water Supply: Include integral bypass.
7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.
8. For 4 inch reduced port use flanged ANSI 150 automatic control valve with with low flow by-pass.

2.04 BALANCING VALVES

A. Balancing valves assembly
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Caleffi 1324
      b. Tacos.
      c. Bell and Gosset
      d. Or equal.

B. Install circuit balancing valves in each hot-water circulation return branch.

C. Lead-free flow calibrated brass balancing valve with built-in flow meter and sight gauge. Furnish with check valve to protect circuit thermos siphoning

2.05 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Electronic Master Water Mixing Valves (TM):
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Leonard Valve –Megatron NV-150-LF
      b. Armstrong International, Inc.
      c. Lawler Manufacturing Company, Inc.
      d. Or equal.
   2. Standard: ASSE 1017.
   3. Pressure Rating: 125 psig
   4. Type: Exposed-mounting thermostatically controlled water mixing valve.
   5. Material: Bronze body with corrosion-resistant interior components.
   6. Connections: Threaded inlets and outlet.
   7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
   8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.
   9. Tempered-Water Setting: Varies
   10. Valve Finish: Rough bronze.
   11. Piping Finish: Copper.
   12. Digital Display outlet temperature, Interface with BMS through BACnet IP
   13. Two GFI Recepticle

B. Thermostatic, Water Mixing Valves (TM2, TM3&TM3 Lab):
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Leonard Valve –TM-520BLF-DT
      b. Armstrong International, Inc.

c. Lawler Manufacturing Company, Inc.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig
4. Type: Exposed-mounting thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.
9. Tempered-Water Setting: Varies
10. Valve Finish: Rough bronze.
11. Piping Finish: Copper.

C. Thermostatic mixing valve for individual Emergency Showers (TM-ES). The shower shall ASSE 1071 certified and meet ANSI Z358.1-2009 requirement. The valve shall be equal to Guardian G6044 furnish in recessed stainless steel cabinet (minimum 18x16 size) and lockable latch. The valve shall be directly linked to control the hot and cold water intake and blend to deliver tepid water (75 degrees Fahrenheit adjustable). The valve shall be capable of supplying 3 to 34 gallons per minute of tepid water at maximum 20 pounds per square inch pressure drop. In event of restriction or failure of hot water supply, internal bypass shall allow valve to deliver cold water to emergency unit. In bypass mode, valve shall deliver 20 gallons per minute at 30 pounds per square inch drop. In event of loss of cold water supply, valve shall close and shall not deliver water

D. Thermostatic mixing valve for individual Emergency Eye Wash (TM-EE). The mixing valve shall ASSE 1071 certified and meet ANSI Z358.1-2009 requirement. The valve shall be equal to Guardian G6024 furnish in stainless steel cabinet and lockable latch. The valve shall be directly linked to control the hot and cold water intake and blend to deliver tepid water (75F adjustable). The valve shall be capable of supplying 2 to 6 gallons per minute of tepid water at maximum 20 pounds per square inch pressure drop. In event of restriction or failure of hot water supply, internal bypass shall allow valve to deliver cold water to emergency unit. In bypass mode, valve shall deliver 4 gallons per minute at 30 pounds per square inch drop. In event of loss of cold water supply, valve shall close and shall not deliver water

E. Point of use mixing valve for single or multi lavatory faucets: Lead free, Thermostatic Mixing Valves with bronze body, Thermostatic wax element design, locking temperature adjustment knob, integral check valves on inlets and ball shut off valve. Minimum flow 0.35 gallons per minute and maximum flow 4.6 gallons per minute. Mixing valve shall be equal to Chicago Faucets 131 ABNF / 131 CABNF or equal.

2.06 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
a. T&S Brass and Bronze Works, Inc.'s
b. NIBCO Inc.
c. Watts Industries, Inc.; Water Products Div.
d. Or equal
2. Pressure Rating: 125 psig minimum, unless otherwise indicated.
3. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and] for NPS 2-1/2 and larger.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
5. Screen: Stainless steel with round perforations, unless otherwise indicated.

6. Perforation Size:
   a. Strainers NPS 2 and Smaller: 0.020 inch
   b. Strainers NPS 2-1/2 to NPS 4, 0.045 inch
   c. Strainers NPS 5 and Larger: 0.10 inch
7. Drain: Pipe plug

2.07 OUTLET BOXES

A. Clothes Washer Outlet Boxes
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   a. Acorn Engineering Company.
   b. Watts Industries, Inc.; Water Products Div.
   c. Zurn Plumbing Products Group; Light Commercial Operation.
   d. Or equal.
2. Mounting: Recessed.
3. Material and Finish: Enameled-steel or epoxy-painted-steel box and faceplate.
4. Faucet: Combination, valved fitting or separate hot- and cold-water, valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
5. Supply Shutoff Fittings: NPS 1/2 gate, globe, or ball valves and NPS 1/2 copper, water tubing.
6. Drain: NPS 2 standpipe and P-trap for direct waste connection to drainage piping.

B. Ice Maker / Kitchen Valve:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   a. IPS Corp Guy Gray 88436
   b. Watts Industries, Inc.; Water Products Div.
   c. Sioux
   d. Or equal.
2. Furnish and install 3/8 inch icemaker outlet Box with CSA listed, ½ inch quarter turn, hammer arrester valve for pipe connection

2.08 HOSE BIBBS

A. Hose Bibbs (HB1&2)
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   a. Chicago faucets, a Geberit company
   b. T & S Brass
   c. Zurn Plumbing Products Group; Light Commercial Operation.
   d. Or equal
2. Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig
8. Vacuum Breaker: Integral, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Finish for Service Areas: Rough bronze.
11. Finish for Finished Rooms: Chrome or nickel plated.

12. Include operating key with each operating-key hose bibb.
13. Include integral wall flange with each chrome- or nickel-plated hose bibb.
14. Schedule: HB1 (Toilet Rooms) equal to Chicago Model 952-633OLCP.
    HB2 (Kitchen area) equal Chicago Model 387-E27CP.

2.09 WALL HYDRANTS (FPHB-1)

A. Vacuum Breaker Wall Hydrants
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Jay R Smith 5519.
      b. Zurn Plumbing
      c. Watts Industries, Inc.; Water Products Div.
      d. Or equal.

   2. Standard: ASSE 1019, Type A or Type B.
   3. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
   4. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
   5. Pressure Rating: 125 psig
   6. Operation: Loose key
   7. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
   8. Inlet: NPS 3/4 Outlet: Concealed with garden-hose, thread complying with ASME B1.20.7.

2.10 DRAIN VALVES

A. Stop-and-Waste Drain Valves
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Apollo valves Inc.
      b. NIBCO Inc.
      c. Watts Industries, Inc.; Water Products Div.
      d. Or equal
   2. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
   3. Pressure Rating: 200-psig minimum CWP or Class 125.
   4. Size: NPS 3/4
   5. Body: Copper alloy or ASTM B 62 bronze.
   6. Drain: NPS 1/8 side outlet with cap.

2.11 WATER HAMMER ARRESTERS

A. Water Hammer Arresters See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Josam Company.
      b. PPP Inc.
      c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      d. Or equal.
   2. Standard: ASSE 1010 or PDI-WH 201.
   3. Type: Metal bellows
   4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.12 AIR VENTS

A. Bolted-Construction Automatic Air Vents
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Zurn Plumbing Products Group; Wilkins Div.
      b. NIBCO Inc.
      c. Watts Industries, Inc.; Water Products Div.
      d. Or equal.
   2. Body: Bronze.
   3. Pressure Rating: 125-psig minimum pressure rating at 140 deg F
   4. Float: Replaceable, corrosion-resistant metal.
   5. Mechanism and Seat: Stainless steel.
   6. Size: NPS 1/2 minimum inlet.
   7. Inlet and Vent Outlet End Connections: Threaded.

2.13 TRAP-SEAL PRIMER SYSTEMS

A. Electronic Trap Primer (ETP) :
   1. Furnish and install trap primer units to serve one or two drains. Provide trap primers to floor drains as required by 248 CMR Plumbing code.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Precision Plumbing Product
      b. MiFAB
      c. Zurn
   3. Electronic Trap Primer for multiple floor drain shall be equal to Precision Plumbing Products Model PTS. The electronic Time Trap priming manifold (ETP) shall supply 2 oz water at 20 pasi at a preset 10 second every 24 hours. The manifold steel cabinet shall include , vacuum breaker, pre-set 24 hour time clock, manual override switch, 120V solenoid valve, 3 wire connection, NPS ¾ inlet connection, manifold, compression outlet fittings, inlet shut off valve
   4. Trap Cabinet: Wall recessed box with stainless steel cover.
   5. For one or two floor drains, the trap shall be Precision Plumbing Products, Inc. Model MP-500, ½ inch connections, Electronic automatic brass trap primer distribution unit which shall be by timer to active cold water line in which attached.
   6. Units shall meet Code and ASSE Standard #1018. Units shall be adjustable to line pressure and desired delivery amount. Units shall deliver a maximum of two ounces of water on a 15 second pressure drop and have corrosion resistant brass fittings with a copper reservoir with clear plastic inspection cover, and mounting brackets, “O” ring seals.
   7. Plumbing Subcontractor shall adjust units and cycle trap primers at least six times to insure proper activity.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
   3. Do not install bypass piping around backflow preventers.

C. Install water pressure reducing valves (PRV) with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

D. Install water control valves with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

E. Install balancing valves in locations where they can easily be accesses and adjusted.

F. Install temperature-actuated water mixing valves with check stops and shutoff valves on inlets and outlet.
   1. Install thermometers and water regulators if specified.
   2. Install cabinet-type units recessed in or surface mounted on wall as specified.

G. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve, and pump.

H. Install water hammer arresters in water piping according to PDI-WH 201.

I. Install air vents at high points of water piping.

J. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

K. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

END OF SECTION

SECTION 22 11 23
DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following bronze centrifugal pumps for domestic cold- and hot-water circulation:
   1. Close-coupled, in-line, seal-less centrifugal pumps.

1.04 SUBMITTALS

A. Product Data: For each type and size of domestic water pump specified on drawings. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified or approved equal.

2.02 CLOSE COUPLED, IN-LINE, SEALLESS CENTRIFUGAL PUMPS

A. Manufacturers:
   1. Bell & Gossett Domestic Pump; ITT Industries.
   2. Grundfos Pumps Corp.
   3. Taco, Inc.
   4. Or equal

B. Description: Factory-assembled and -tested, single-stage, close-coupled, in-line, sealless centrifugal pumps as defined in HI 5.1-5.6.
   1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge-type unit with motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
   2. Casing: Bronze, with threaded companion-flange connections.

3. Impeller: Corrosion-resistant material.
4. Motor: Single speed, unless otherwise indicated. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

2.04 Recirculation Pump Control

A. Aquastats: Electric; adjustable for control of hot-water circulation pump.
   1. Manufacturers:
      a. Honeywell International, Inc.
      b. Square D.
      c. White-Rodgers Div.; Emerson Electric Co.
   2. Type: Water-immersion sensor, for installation in hot-water circulation piping.
   3. Range: 50 to 125 degrees Fahrenheit
   4. Operation of Pump: On or off.
   5. Transformer: Provide if required.
   6. Power Requirement: 24 V, ac or 120 V, ac
   7. Settings: Start pump at 105 degrees Fahrenheit stop pump at 120 degrees Fahrenheit

2.05 BUILDING-AUTOMATION-SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
   1. On-off status of each pump.
   2. Turn pumps on and off on a 7 day programmable schedule.
   3. Alarm status.
   4. Pumps and contacts are to be compatible with BMS (Bacnet). Provide devices and/or pump options for full compatibility with Bacnet.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

END OF SECTION

SECTION 22 13 16
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following for soil, waste, and vent piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special Waste and Vent piping.

1.04 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.05 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   1. Soil, Waste, and Vent Piping: 10-foot head of water

1.06 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.02 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service Class and Extra Heavy.
B. Gaskets: ASTM C 564, rubber.
C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.03 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.
B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
   1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve, similar to husky SD 4000 or Clamp-All Hi-Torq 80.
C. Manufacturers:
   1. Clamp-All Corp.
   2. Husky
   3. Mission
   4. Tyler Pipe; Soil Pipe Div.
   5. Or equal.

2.04 COPPER TUBE AND FITTINGS (can be used for pipe sizes 2 ½ inch and smaller, shall not be used for urinal waste)

A. Hard Copper Tube: ASTM B 88, Types M, water tube, drawn temper.
   1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper DWV fittings if indicated.
   2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
   3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.05 SPECIAL WASTE PIPE AND FITTINGS

A. Piping and fittings shall be as manufactured by R.G. Sloane, Enfield, Orion or approved equal.

B. Polypropylene Plastic (PP) Drainage Pipe and Fittings: ASTM F 1412, pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions, from PP resin with fire-retardant additive complying with ASTM D 4101. Include fusion- and mechanical-joint ends.

C. 3 Joints Connections between polypropylene piping system and between piping and sinks under lab benches shall be made by means of MechanicalJoints. All other connections shall be made by heat fusion joints (FUSEAL II). Connections between polypropylene and other types of piping material shall be made with adapters according to manufacturer's recommendations

2.06 SLEEVES

A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

E. A. For interior wall, floor and ceiling penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for fire rating, size, depth, and location of joint shall be under division 078400 for Firestopping, 079100 for Preformed Joint Seals, and 079200 for Joint Sealants

2.07 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex, Inc.
   4. Pipeline Seal and Insulator, Inc.
   5. Or equal.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

PART 3 - EXECUTION

3.01 EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.02 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil and kitchen waste piping shall be the following:
   1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints, collective trademark of the CISPI.
   2. Urinals joint connection shall be service weight hub and spigot with lead and oakum joints
   3. Copper DWV tube, copper drainage fittings, and soldered joints.

C. Aboveground, vent piping shall be the following:
   1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
   2. Copper DWV tube, copper drainage fittings, and soldered joints.
      a. Option for Vent Piping, NPS 2-1/2 and smaller Hard copper tube, Type M; copper pressure fittings; and soldered joints.

D. Underground, soil, kitchen waste, and vent piping shall be the following:
   1. Service class, cast-iron soil piping; gaskets; and hub and spigot gasketed joints.
   2. Service weight cast iron soil pipe-coated bearing collective trademark of the Cast Iron Soil Pipe Institute (CISPI). Cleanouts and joints just prior to exiting the building shall be service weight hub and spigot with lead and oakum joints.

END OF SECTION

SECTION 22 13 19
SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS.

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contract Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
   1. Backwater valves.
   2. Cleanouts.
   3. Floor drains.
   4. Roof flashing assemblies.
   5. Through-penetration firestop assemblies.
   6. Miscellaneous sanitary drainage piping specialties.
   7. Flashing materials
   8. Waste Dilution Tank.

B. Related Sections include the following:
   1. Division 22 Section "Storm Drainage Piping Specialties" for trench drains for storm water.

1.04 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

1.05 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:
   1. Grease interceptors.

PART 2 - PRODUCTS

2.01 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Josam Company; Josam Div.
      b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
      c. Tyler Pipe; Wade Div.
      d. Or equal.

2. Standard: ASME A112.14.1.
3. Size: Same as connected piping.
4. Body: Cast iron.
5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: Hub and spigot or hubless
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed
8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.02 CLEANOUTS

A. Exposed Metal Cleanouts :
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Watts CO-1200-S
      b. Josam Company; Josam Div.- CO-100-S
      c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc. 55000-SS
      d. Or approved equal
   2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
   3. Size: Same as connected drainage piping
   4. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch or hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: Internal taper thread bronze plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size
   7. Square Top, Satin finish Bronze with additional leveling adjustment to finish floor.

B. Cast-Iron Wall Cleanouts
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Josam Company; Josam Div.
      b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      c. Zurn Plumbing Products Group; Specification Drainage Operation.
      d. Or equal.
   2. Standard: ASME A112.36.2M. Include wall access.
   3. Size: Same as connected drainage piping.
   4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: Satin Nikaloy cover with internal brass plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
   7. Wall Access: Round, nickel-bronze, copper-alloy, or stainless-steel material wall-installation frame and cover.

2.03 FLOOR DRAINS AND FLOOR SINKS

A. Cast-Iron Floor Drains:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Josam Company; Josam Div.
      b. Zurn
      c. Smith, Jay R. Mfg. Co.
      d. Or equal.

   2. Floor Drain Schedule:

a. Floor Drain (FD1- Finished Areas) shall be round grate, dura coated cast iron body with bottom outlet, combination invertible membrane clamp, adjustable collar, seepage slots, type BZ polished nickel bronze, light-duty, leveling strainer, trap primer connection. The floor drain shall be equal Jay R Smith Model 2005-A-P.

b. Floor Drain (FD2- Kitchen) Duco Cast iron flanged receptor and flashing collar with adjustable top, Nickel Bronze Grate and 6" Funnel. The floor drain shall be equal to Jay R. Smith Figure #3610-NB.

c. Floor Drain (FD3: Mechanical Room): Duco Cast Iron Body and Flashing Collar with Galvanized Cast iron Grate, Sediment Bucket, Trap primer connection. The floor drain shall be equal to Jay R. Smith Figure #2110.

d. Floor Drain (FD4): Floor Drain (Labs) shall be corrosion resistant floor drain manufactured from fire retardant polypropylene material conforming to ASTMD 4101, Grate, plug and covers made from fiber filled polypropylene for strength and durability. Floor drain shall be equal to Orion AWFDSTD.

e. Floor drain FD-5: Duco Cast Iron Body and Flashing Collar with Heavy Duty Grate, Sediment Bucket, Trap primer connection. The floor drain shall be equal to Jay R. Smith Figure #2340.

f. Floor Drain (FS1- Kitchen) shall be equal to Jay R. Smith Figure #3002-12 "square with grate and dome strainer. 14 gauge Type 304 SS Receptor Body with Seepage Control holes, Cast type 316 SS Ribbed non-tilt loose set grade w/ ½" holes. Provide floor drain w/ perforated SS dome bottom and trap primer connection. Coordinate and provide funnel or ¾" grate as required.

2.04 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Acorn Engineering Company; Elmdor/Stoneman Div.
      b. Thaler Metal Industries Ltd.
      c. FlashCo
      d. Or equal

B. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch- thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
   1. Open-Top Vent Cap: Without cap.
   2. Low-Silhouette Vent Cap: With vandal-proof vent cap.
   3. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.05 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies: All firestopping is done by Section 078413. Coordinate penetrations with the firestopping contractor.

2.06 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
2. Size: Same as connected waste piping

B. Floor-Drain, Trap-Seal Primer Fittings:
1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Air-Gap Fittings:
1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Sleeve Flashing Device:
1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

E. Stack Flashing Fittings:
1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

F. Vent Caps:
1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

G. Frost-Resistant Vent Terminals:
1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.
2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

2.07 WASTE DILUTATION TANK

A. The Waste Neutralization tank shall be constructed of virgin high density polyethylene conforming to ASTM , D1248 for polyolefin materials. Tank shall be equal to Orion Tank, exterior lining to consist of 1/8 inch reinforced fiberglass (FRP). Refer to drawing for tank size and capacity. Tank shall be self-supporting and rated for continuous operation temperature of 160 degrees Fahrenheit, and intermittent operation at 200 degrees Fahrenheit. Tank shall be provided with gasketed and bolted manhole with stainless steel nuts and bolts. Inlet/outlet/vent pipe fittings shall be made of polyethylene and fusion welded to tank. Tank shall be charged with limestone in accordance with manufacturer's recommendation prior to putting in service.

Chips or lumps shall be more than 90 percent calcium-carbonate content and 1 to 3 inch diameter. Refer to plan for tank capacity.

2.08 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Use: 4.0-lb/sq. ft. 0.0625-inch thickness.
   2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
   3. Burning: 6-lb/sq. ft. 0.0938-inch thickness.

B. Fasteners: Metal compatible with material and substrate being fastened.
C. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
D. Solder: ASTM B 32, lead-free alloy.
E. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.

D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
      a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than ¼ inch total depression.
      b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
      c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1 inch total depression.

3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

G. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

H. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

I. Assemble open drain fittings and install with top of hub 2 inches above floor.

J. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

K. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

L. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

M. Install vent caps on each vent pipe passing through roof.

N. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

O. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

P. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1 inch clearance between vent pipe and roof substrate.

Q. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.
1. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.
2. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

R. Install wood-blocking reinforcement for wall-mounting-type specialties.

S. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

T. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

END OF SECTION

SECTION 22 13 23
SANITARY WASTE INTERCEPTORS

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contract Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following types of interceptors outside the building:
   1. Grease interceptors.

1.04 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

B. HDPE: High-density polyethylene plastic.

C. PE: Polyethylene plastic.

D. PP: Polypropylene plastic.

1.05 SUBMITTALS

A. Product Data: For each type of metal interceptor indicated. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 GREASE INTERCEPTORS

A. Grease Interceptors GI-1:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Jay R Smith 8460.
      b. Rockford Sanitary Systems, Inc.
      c. Josam Company; Josam Div

d. Or equal.

2. Standard: ASME A112.14.3, for intercepting and retaining fats, oils, and greases from food-preparation wastewater.
3. Plumbing and Drainage Institute Seal: Required.
4. Body Material: Cast iron.
5. Interior Lining: Corrosion-resistant enamel.
6. Exterior Coating: Corrosion-resistant enamel
7. Extension Riser: For use below grade; sized to project requirements. Provide with 1 inch markers/ribs on riser and flanged bottom to interlock to frame. Installation components shall be supplied by manufacturer (outlet extension adaptors, seals and mechanical fasteners). Provide Pipe for handle extension.
8. The grease Interceptor shall be fully recessed with capacity of 100 GPM flow rate, 200 lbs capacity, 4" inlet & outlet. The steel interceptor shall furnish with integral extension, gray Duco coating (inside and outside) and Flow control fitting.
9. The grease trap shall bear the seal of approval from the Plumbing Drainage Institute and Mass approved product.

2.03 SOLID (PLASTER) INTERCEPTOR

A. Solid Interceptor (SI-1 and SI-2):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. MiFAB
b. Zurn
c. Josam Company; Josam Div.
d. Or equal.

B. Solid interceptor (SI-1) for fixtures P-5B amd as noteded on plan: MIFAB Series MI-SOLID-S sanitary powder epoxy coated inside and outside fabricated ten gauge steel solids interceptor. Interceptor shall include removable perforated sediment screen with bucket and a gasketed steel lid secured by a single recessed bolt. The interceptor shall adjacent casework to maintain accessibility clearance

C. Solid Interceptor (SI-2) for fixture P-4A: MIFAB Model MI-Solid-SA, large capacity side access type 304 14 gauge stainless steel solid interceptor with internal stainless steel perforated sediment bucket connected to removable and gasket side access latched lid. Interceptor shall be complete with 2 inch female threaded inlet, 2 inch female threaded outlet on each side right or left-hand installation and internal stainless steel flow control to maximum 35 gallons per minute.

2.04 OIL/ SAND INTERCEPTOR

A. Oil/ Sand Interceptors (OI-1):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Highland Tank Model 2556.
b. Park USA
c. Zurn
d. Or equal.
2. The Oil/ Sand Separator shall be constructed of Mild carbon steel and coated with heavy duty polyurethane.
3. The tank shall be rated for 50 gpm and structurally analyzed in accordance with the requirement of ASCE/ SEI 7 for direct burial.

4. Provide cover with water/ gas tight seal fitting.

PART 3 - EXECUTION

3.01 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 32 Section "Earth Moving."

3.02 INSTALLATION

A. Install interceptor inlets and outlets at elevations indicated.

B. Install precast concrete interceptors according to ASTM C 891. Set level and plumb.

C. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.

D. Set tops of manhole frames and covers flush with finished surface in pavements. Set tops 3 inches above finish surface elsewhere, unless otherwise indicated. Provide extensions to floor/grade as required.

E. Set tops of grating frames and grates flush with finished surface.

F. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

G. Clean and prepare metal surfaces to be field painted according to SSPC- PA 1. Paint the following metal surfaces according to SSPC-PA 1 and SSPC-Paint 16:
   1. Metal Interceptors: surfaces except baskets, screens, and strainers.
   2. Metal Manhole Frames and Covers (Including Grates): surfaces.
   3. Do not paint metal surfaces with factory-applied, corrosion-resistant coating.

H. Set metal interceptors level and plumb.

I. Prepare and paint metal components, to be field painted, according to SSPC-Paint 16.

J. Repair and restore protective coatings to original condition.

END OF SECTION

SECTION 22 14 13
FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following storm drainage piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.
   3. Encasement for underground metal piping.

1.04 DEFINITIONS

1.05 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
   1. Storm Drainage Piping: ten-foot head of water

1.06 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.02 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.03 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.
   1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve, similar to husky SD 4000 or Clamp-All Hi-Torq 80.

B. Manufacturers:
   1. Clamp-All Corp.
   2. Husky
   3. Tyler Pipe; Soil Pipe Div.
   4. Or equal.

2.04 SLEEVES

A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

E. A. For interior wall, floor and ceiling penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for fire rating, size, depth, and location of joint shall be under division 078410 for Firestopping and Section 078440 for Fire Resistive Joint Sealants

2.05 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex, Inc.
   4. Pipeline Seal and Insulator, Inc.
   5. Or equal.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

PART 3 - EXECUTION

3.01 EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.02 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground storm drainage piping shall be the following:
   1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and coupled joints.

C. Underground, soil, waste, and vent piping shall be the following:
   1. Service class, cast-iron soil piping; gaskets; and gasketed joints.

3.03 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialties."

C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

D. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

E. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

F. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

G. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
   1. Building Storm Drain: ¼ inch per foot slope downward in direction of flow for piping NPS 3 and smaller; 1/8 inch per foot slope downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Storm-Drainage Piping: ¼ inch per foot slope downward in direction of flow for piping NPS 3 and smaller; 1/8 inch per foot slope downward in direction of flow for piping NPS 4 and larger.

H. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

I. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

END OF SECTION

SECTION 22 14 23

STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following storm drainage piping specialties:
   1. Backwater valves.
   2. Cleanouts.
   3. Through-penetration firestop assemblies.
   4. Roof drains.
   5. Miscellaneous storm drainage piping specialties.
   6. Flashing materials.

B. Related Sections include the following:
   1. Division 22 Section "Sanitary Waste Piping Specialties" for backwater valves, floor drains, trench drains and channel drainage systems connected to sanitary sewer, air admittance valves, grease interceptors, oil interceptors and solid interceptors.
   2. Division 7 Section “Thermal and Moisture Protection” for flashing.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.01 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Josam Company; Josam Div.
      b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
      c. Zurn Plumbing Products Group; Specification Drainage Operation.
      d. Or equal.
   2. Standard: ASME A112.14.1.
   3. Size: Same as connected piping.
   4. Body: Cast iron.

5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: Hub and spigot or hubless
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed
8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.02 CLEANOUTS

A. Exposed Metal Cleanouts :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Josam Company; Josam Div.
   b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   c. Zurn Plumbing Products Group; Specification Drainage Operation.
   d. Or equal

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch or hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Wall Cleanouts
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Josam Company; Josam Div.
   b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   c. Zurn Plumbing Products Group; Specification Drainage Operation.
   d. Or equal.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
8. Wall Access: Round, nickel-bronze, copper-alloy, or stainless-steel material wall-installation frame and cover.

2.03 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies: All firestopping is done by Section 078413. Coordinate penetrations with the firestopping contractor.

2.04 ROOF DRAINS

A. Metal Roof Drains with overflow:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Zurn
   b. Jay R Smith
   c. Josam Company; Josam Div.
   d. Watts.

e. Or Equal.
2. Standard: ASME A112.21.2M.
3. Pattern: Canopy, Roof or Scupper drain.
4. Body Material: Cast iron

B. Schedules
1. RD-1: Roof drain shall be equal to Zurn Froet 100C_ Bi Functional Roof drain. Refer to roof plan for drain size. The drain shall be bi-functional body, Secured cast-iron dome, adjustable extension, overflow strainer, sump receiver, underdeck clamp, no-hub adaptor.

2. DSN-1 Overflow Corrosion-resistant stainless steel downspout nozzle spout with a perforated hinged strainer. The nozzle to be equal to Z199-DC or equal.

3. RD-2: Roof drain shall be equal to Zurn Z165, 8 inch Diameter combination main rood and overflow drain with low silhouette domes and double top-set deck plate, static extension, top set plate, sump receiver, underdeck clamp, no-hub adaptor.

2.05 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Expansion Joints:
1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected piping.

2.06 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft. thickness.

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04 inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

C. Fasteners: Metal compatible with material and substrate being fastened.

D. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

E. Solder: ASTM B 32, lead-free alloy.

F. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.
1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Position roof drains for easy access and maintenance.

F. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

G. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

H. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

END OF SECTION

SECTION 22 14 29
SUMP PUMPS

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following sump pumps and accessories, inside the building, for building storm drainage systems:
   1. Submersible sump pumps.

1.04 SUBMITTALS

A. Product Data: For each type and size of sump pump specified. Include certified performance curves with operating points plotted on curves, and rated capacities of selected models, furnished specialties, and accessories.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
   2. Refer to Schedule Sheet for Capacities and Characteristics.

2.02 SUMP PUMP (SP-1 & 2)

A. Manufacturers:

   1. Zoeller Pump Co
   2. Liberty Pumps.
   3. Bell & Gossets -ITT Industries.
   4. Or equal.

B. Description: Factory-assembled and -tested, simplex, single-stage, centrifugal, end-suction, submersible, direct-connected sump pumps complying with UL 778.

C. Casing: Cast iron; with cast-iron inlet strainer, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.

D. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, semi open non-clog design, overhung, single suction, keyed and secured to shaft.

E. Pump and Motor Shaft: Factory-sealed, grease-lubricated ball bearings and double-mechanical seals.

F. Motor: Hermetically sealed, induction motor with external magnetic contactor with overload protection; three-conductor waterproof power cable of length required, and with grounding plug and cable-sealing assembly for connection at pump. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

G. Pump Discharge Piping: Factory or field fabricated, ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe.

H. Controls: Three-phase simplex control panel NEMA 4X enclosure, pedestal mounted unless wall mounting is indicated; with three mechanical float or micropressure switches in NEMA 250, Type 6 enclosures; mounting rod; and electric cables.
   1. Float Guide: Pipe or other restraint for floats and rods in basins.
   2. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical float or micropressure -switch alarm matching control and electric bell; with transformer and contacts for remote alarm bell.

I. Building Automation System Interface
   1. Provide auxiliary contacts/relays at pump controllers for interface to building automation system. Include the following:
   2. On-off status of each pump.
   3. Alarm status.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

3.02 SUMP PUMP INSTALLATION

A. Install sump pumps according to applicable requirements in HI 1.4.

B. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.

C. Set submersible sump pumps on basin or pit floor. Make direct connections to storm drainage piping.

D. Support piping so weight of piping is not supported by pumps.

END OF SECTION

SECTION 22 33 00
ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. This Section includes the following fuel-fired water heaters:
   1. Expansion tanks.
   2. Water heater accessories.

1.04 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

PART 2 – PRODUCTS

2.01 Commercial Electrical Water Heater (EWH-1,2 &3)

A. The heater shall be a glass-lined, heavy duty commercial electric water heater and constructed in accordance with ASME Code, shall bear appropriate symbol and be listed with the state plumbing board. Th size and capacity are shown on the drawing schedule.

B. Manufacturers
   1. A.O Smith
   2. American Standard
   3. Ruud
   4. Or approved equal

C. Comply with UL 174 for household, storage electric water heaters, Factory-Installed Storage-Tank, Comply insulation with current t ASHRAE/IESNA 90.1.

D. Heater shall be listed with Underwriters' Laboratories and classified to The National Sanitation Foundation Standard No. 5.

E. Internal surfaces of the tank shall be glass-lined with an alkaline borosilicate composition that has been fused-to-steel by firing at a temperature of 1600 degrees Fahrenheit. Tank shall be

cathodically protected with a combination of sacrificial and powered anodes. The entire vessel is to be enclosed in a round steel enclosure with baked enamel finish.

F. Water heater shall have an electronic control with large LCD displaying current water heater status; provide real time element status and sensing, low water cutoff and economy mode operation. Shall have 120 volt control circuit transformer, transformer fusing, magnetic contactor(s), element fusing per N.E.C., and commercial grade Incoloy elements.

G. Temperature controls include limiting switch which will require resetting manually in the event the temperature reaches 202 degrees Fahrenheit.

H. Foam insulation shall meet the thermal efficiency and/or standby loss requirements of the U. S. Department of Energy and current edition of ASHRAE/IES 90.1.

I. Heater shall include a CSA Certified and ASME Rated T&P relief valve and a drain valve.

J. Water heater units(s) shall be compatible with building management systems using Modbus or BACnet with optional ICC interface.

2.02 Electrical Booster Water Heater in Kitchen(EH-#).

A. Tankless Water Heater
   1. Manufacturers:
      a. Stiebel Eltron
      b. Chronomite
      c. EeMax,
      d. or approved equal

B. Unit shall have ABS-UL 94 5VA rated cover. Unit shall have 0.5 GPM turn on. Unit shall allow mounting in vertical or horizontal directions. Element shall be replaceable cartridge insert. Unit shall have replaceable filter in the inlet connector. Element shall be iron free, Nickel Chrome material.

C. Tankless water heater shall utilize complex algorithm, actively managing power application to real time system demand. Integrated flow meter, along with inlet and outlet temperature sensors provide data which allows the unit to instantly adapt to variations in input parameters

D. Heater shall be fitted with 3/8 inch compression fittings to eliminate need for soldering. Maximum operating pressure of 150 pounds per square inch. Accessible diagnostic features to include error/fault display. Hot water storage tanks prohibited

E. Tankless water heater user interface must have the following capabilities:
   1. Selectable display including Celsius /Fahrenheit, setpoint, flow rate, inlet temperature outlet temperature, power factor
   2. Capable of displaying flow rate in gallons per minute & liters per minute
   3. Diagnostic features to include error/fault display
   4. Control board must maintain error/fault history of 5 events

F. Refer to Water Heater Schedule for water heater capacity required.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install water heaters as recommended by manufacturer. Provide final connections as required. Coordinate water heater location with other Contractors.

B. Warranty on electrical components against defects in workmanship and material for a period of one year from date of start-up, and the heating chamber for a full five years from date of start-up, provided that the unit is started within three months of date of shipment. Fabrication and assembly shall be performed in the U.S.A.

C. Initial start-up shall be provided by representative of manufacturer.

END OF SECTION

SECTION 22 40 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.01 TRADE CONTRACT REQUIREMENTS

A. Work of this Section is part of the Plumbing Trade Contract. Refer to Section 22 00 00 "Plumbing Trade Contractor Requirements" for additional information about this Trade Contract.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUMMARY

A. In general, the work of this section shall include, but not be limited to:
1. Plumbing fixtures and trim.
2. Water Coolers/Bottle Fill Stations
3. Faucets and flushometers.
4. Stops and supplies.
5. Traps and tailpieces.
6. Drain outlets.
7. Mixing valves.
8. Flow controls.
9. Carriers and supports.
10. Lavatory insulators.

B. Related Sections include the following:
1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
2. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.04 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.05 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

PART 2 - PRODUCTS

2.01 FIXTURES AND TRIM

A. Acceptable Manufacturers: Submit manufacturers not listed below for review and approval as specified for substitutions in this Section.
1. Vitreous China: Bradley, American Standard, Crane, Kohler or equal.
2. Faucets: Chicago Faucet Co., Kohler or T & S Brass or equal.
3. Self Closing Faucets: Chicago Faucet Co., Sloan, Kohler, Symmons or equal.
4. Sensor Faucets: Chicago Faucet Co., Hydrotek, Sloan or equal.
5. Stainless Steel Sinks: Elkay, Just Manufacturing, Metcraft Inc or equal.
6. Mop Service Basins: Crane, Fiat , Stern Williams or equal.
7. Carriers and Supports: Jay R. Smith, Wade, Josam Company or equal.
8. Thermostatic Mixing Valves: Leonard Valve Co., Powers Process Controls, Symmons, Chicago Faucets or equal.
9. Pressure Regulating Mixing Valves: Lawler Manufacturing, Leonard Valve Co Symmons or equal.
10. Emergency Eye Wash: Guardian, Haws, Speakman or equal
11. Water Cooler: Haws, Halsey Taylor, Filtrine or equal.
12. Flush Valves: Sloan, American Standards, Hydrotek or equal.
13. Stops and Supplies: Chicago Faucet Co., Kohler or McGuire, or equal.
14. P-Traps: McGuire, Sanitary-Dash, or Jameco, or equal.
15. Handicap Lavatory Insulation: McGuire, TCI Products or Truebro, or equal.

B. Fixture Trim and Accessories:
1. Provide fixtures complete with floor mounted fixture carrier supports; faucets, flushometers; drain outlets, tailpieces, P-traps and stops and supplies.
   a. Color and Finish: Trim exposed to view shall be polished chrome plated, and fixtures and toilet seats shall be white unless specified otherwise.
   b. Drain Outlets: Provide drain outlet of the same manufacturer as the fixture or faucet trim with chrome plated 17 gauge minimum weight tailpiece.
   c. Provide 1-1/4 inch tailpiece on lavatories.
   d. Provide 1-1/2 inch tailpiece on sinks.
   e. Provide offset drain outlets on handicapped use lavatories and sinks.
   f. P-Traps: Cast brass adjustable P-trap with cleanout plug, ground joint and 17 gage minimum weight extension with escutcheon.
   g. Provide McGuire No. 8090 1-1/4 inch by 1-1/2 inch on lavatories.
   h. Provide McGuire No. 8089 1-1/2 inch by 1-1/2 inch on sinks.
   i. Stops and Supplies: Provide stops and supplies of the same manufacturer as the fixture or faucet trim, or provide McGuire Model 170-LK loose key angle stop with 5

inch long 2 inch nominal copper sweat extension, bell escutcheon, and 3/8 inch O.D. by 12 inch flexible riser.

C. Sinks: Seamlessly drawn, self-rimming minimum 18 gauge, type 302 (18-8) nickel bearing stainless steel with 1-3/4 inch minimum rounded corners, satin finish, and fully undercoated.

D. Sink Faucets: Chrome plated cast brass with stainless steel seats and monel stems. Gooseneck spouts shall be interchangeable and convertible rigid/swing type. Handles shall be interchangeable with square handle broachings.

E. Flushometers: Diaphragm operated cast-brass body, brass or copper pipe or tubing inlet with wall flange and tailpiece with spud, screwdriver check stop, vacuum breaker. The flush valve shall be electric sensor operated with true manual override feature.

F. Water Conservation: Provide water conserving fixtures (Water sense labeled) and trim incompliance with the following maximum water use requirements. Provide Omni or equal variable pressure flow controls on sinks, and lavatory faucets.
1. Public lavatories: 0.35 gpm
2. Sinks: 1.0 gpm
3. Water Closets: 1.1 gallons per flush.
4. Shower : 1.5 gpm
5. Urinals : 0.125 gallons per flush.

G. Fixture Supports: Provide floor mounted fixture support carriers for wall mounted fixtures including but not limited to: water closets, lavatories, scrub sinks, urinals, and clinical sinks.
1. Fixture carriers shall support at least 250 pounds on the front rim of the fixture for 5 minutes.
   a. Water Closets: Jay R. Smith Series 200-Y
   b. Urinals: Jay R. Smith 637.
   c. Lavatories: Jay R. Smith 700-M31.
   d. Wheel Chair Lavatories: Jay R. Smith 700-27-M31.
2. Toilet Seats: Provide extra heavy-duty, commercial/industrial type, elongated, open front, solid white injection molded plastic with integral bumpers; and self-sustaining stainless steel check hinges.
   a. Acceptable Manufacturers: Bemis, Beneke, or Church, or equal.
3. Handicap Lavatory and Sink Insulation: Shall be provided on water supplies and waste piping below handicapped use lavatories and sinks. Acceptable Manufacturers: McGuire, TCI Products or Truebro, or equal.

2.02 FIXTURE DESCRIPTIONS

A. **P-1:** HET Water Closet, Equal to American Standard Model Afwall Millenium 2859.11. Vitreous china wall hung, white, elongated wall outlet water closet, 1.1 GPF, 1-1/2 inch top spud. Toilet flush valve to be water sense labeled, Electrical override, Battery infrared, 1.28 gpf flushometer. Equal to Sloan ECOS 8111-BT-1.28. Provide combination drainage fitting and chair carrier to suit. Extra heavy duty solid plastic seat with check hinges (open front). Water closet shall be in compliance to the applicable section of ASME A112.19.2/ CSA B45.1. Refer to architectural drawing for mounting height requirement.

B. **P-1A:** Water Closet (Barrier Free) Same as P-1, except mounting height to be 17 inch in accordance with architectural barriers board.

D. **P-2:** Wall hung, 0.125 gpf vitreous china, top spud urinal equal to American Standard model Washbrook Universal 6590.001. The Flush valve to be water sense labeled, Electrical

Override, Battery, 0.125 gpf equal to Sloan ECOS 8186 BT-.125. Refer to architectural drawing A210 for mounting height requirement. Refer to architectural drawing and ADA mounting requirements.

E. **P-2A:** Urinal (Barrier Free) Same as P-2, except mounting per architectural drawing.

F. **P-3A** (Barrier Free)**:** American Standard Murro Universal Design 0954.00 wall hung lavatory, ASME A112.19.2; vitreous china, wall hung wheel chair lavatory, 22 inch deep x 21.25 inch wide with 4 inch center faucet hole, Bowl size 15.5 inch x13.5 inch x 5 inch, concealed arm brackets. Deck Mounted 4 inch fixed centers metering faucet, (lead free), 0.35 gpm aerator. Faucet to be water sense labeled, Solar powered with battery backup, equal to Sloan EAF-275-SOL-CP-0.35, Provide Trim Plates, Chrome Plated brass grid strainer w/ 1 ¼ outlet tube. Mounting height in accordance with architectural elevation drawing. Provide point of use thermostatic mixing valve. Provide knee guard insulation kit for trap and supplies. Coordinate mounting height with architectural elevation drawing.

G. **P-4:** American Standard Studio 0614.30 under counter lavatory, ASME A112.19.2; vitreous china, Bowl size 21.25 inch wide x 14 inch front to back, 6 inch deep with 4 inch center faucet hole, Deck Mounted 4 inch fixed centers metering faucet, (lead free), 0.35 gpm aerator. Faucet to be water sense labeled, Solar powered with battery backup, equal to Sloan EAF-275-SOL-CP-0.35. Provide Trim Plates, Chrome Plated brass grid strainer w/ 1 ¼ outlet tube. Mounting height in accordance with architectural elevation drawing. Provide knee guard insulation kit for trap and supplies. Coordinate mounting height with architectural elevation drawing.

H. **P-5A:** Countertop Sinks: Stainless Steel Sink (Barrier Free) Elkay Manufacturing Co. Model LRAD-25216, 25 inch x 21 inch x 6 inch deep ledge type, 18 gauge, type 304 18-8 stainless steel. Interior and top surfaces polished to polished finish, sound deadened with self-rimming feature. Rear outlet strainer, lead free, 4 inch center, deck mounted sink faucet equal to Chicago No. 786-GR2AE35V317AB, ADA lever handles, 1 gpm E35 aerator, flow control fittings. McGuire mfg. 1151 AWC pre-wrapped 1 1/2 offset tailpiece with 151 stainless steel basket strainer, rear center drain. McGuire mfg. 165LK loose key stops with supplies McGuire 8089 CP 1 ½ inch x 1 ½ inch cast brass “P” trap with cleanout. McGuire 2127 CP IPS nipple to cast set screw flange 2127. Provide point of use thermostatic mixing valve.

I. **P-5B**: Stainless Steel Sink (Barrier Free) Elkay Manufacturing Co. Model LRAD-221965, 22 inch x 19.5 inch x 6 inch deep ledge type, 18 gauge, type 304 18-8 stainless steel. Interior and top surfaces polished to polished finish, sound deadened with self-rimming feature. Chicago No. 786-GR2AE35V317AB, ADA lever handles, 1.0 gpm E35 aerator, flow control fittings. McGuire mfg. 1151 AWC pre-wrapped 1 1/2 offset tailpiece with 151 stainless steel basket strainer offset rear. McGuire mfg. 165LK loose key stops with supplies McGuire 8089 CP 1 ½ inch x 1 ½ inch cast brass “P” trap with cleanout. McGuire 2127 CP IPS nipple to cast set screw flange 2127. Provide point of use thermostatic mixing valve.

J. **P-6:** Hi-Lo Electric Water Cooler Halsey Taylor Barrier-Free Water Cooler, Model HTHBWF-OVLSER-I with Bi level ADA cooler and Bottle filling station. The water cooler shall include filter, and certified NDF/ANSI 42 and 53 for lead free chiller unit and Platinum Vinyl finish. Cooler shall provide 8 gph of 50 degree F water at 90 degree F inlet water. Shall have vandal resistant bubbler and front pushbutton activation. Shall comply with ADA standards, U.L listed and be certified to lead free compliance including NSF/ ANSI 61. The Bottle filling Station shall be sensor activated for no touch activation with 20 second shut off timer. The bottle filler shall provide 1.5 gpm of laminar flow and consists of components to prevent mold and mildew. Provide drain with 1 1/2 P-trap and mounting bracket. Refer to architectural drawings for mounting heights. Provide cane touch apron where indicated on drawing. Provide two spare

filters. Station shall be provided with a shut-off diverting valve to prevent the bubbler portion of the fountain from operating yet allow the bottle fill portion to operate with full functionality.

K. **P-7:** Floor Service Sink: Mop Receptor Fiat precast terrazzo mop basin, 24 inch x 24 inch x 12 inch with 6 inch drop front, stainless steel threshold, flange on wall sides. Fiat Model TSB-3010. Chicago 897 wall mounted service sink faucet w/ vacuum breaker spout. Wall hook, 24 inch long mop hanger with 3 spring clips. Provide 6 foot stainless steel braded water supply hose with pressure bleeder device and dual vented check valve (ASSE1055B approved) for secondary back flow preventer to soap dispenser connection. Installation shall be as per the plumbing code requirement.

L. **P-8:** Stainless Steel Sink - Stainless steel counter with backsplash equal to Just Manufacturing Company, Model NSFB, 160 -12.5, one compartment, 30 inch high, 14 gauge, type 304 stainless steel, 18 gauge 304 stainless steel, supported on 4-16 stainless steel tubular legs with fully enclosed gussets and adjustable bullet feet.. Conforms to ASME/ANSI A112.3 , IPC. Backsplash mounted faucet equal to Just JS-47_TGSA with gooseneck spout and water-saving aerator (1.5 gpm) flow control fittings. Just J-35-FD chrome plated brass drain, 2" center outlet continuous waste to the suspended soild interceptor. Provide faucet connection supplies. Provide point of use thermostatic mixing valve.

M. **P-8A:** Art room stainless steel counter with backsplash equal to Just Manufacturing Company, NSFB, 160 -12.5, one compartment, 30 inch high, 14 gauge, type 304 stainless steel, 18 gauge 304 stainless steel, supported on 4-16 stainless steel tubular legs with fully enclosed gussets and adjustable bullet feet.. Conforms to ASME/ANSI A112.3 , IPC. Backsplash mounted faucet equal to Just JS-47_TGSA with gooseneck spout and water-saving aerator (1.5 gpm) flow control fittings. Just J-35-FD chrome plated brass drain, 2 inch center outlet continuous waste to the suspended soild interceptor. Provide faucet connection supplies. Provide solids interceptor SI-2 as specified in section 22 13 23.

N. **P-8B:** Wall Hung Service Sink: Equal to American Standard Model # 7695.018, Enameled cast iron, 24 inch X 20-½ inch complete with rim guard, drilled back on 8 inch centers and #7798.176 P-trap, 3 inch outlet, floor support with strainer. Faucet shall be equal Chicago Model 956-RCP with #369 lever handle, 8 inch centers with vacuum breaker.

O. **P-9:** Combination Eyewash / Emergency Shower – Equal to Guardian GBF1994 combination eyewash/emergency shower. 8 inch diameter shower head. Chrome-plated brass stay-open ball valve activated by stainless steel triangular pull handle.1 ¼ inch galvanized steel pipe stanchion painted safety green. Eye and face wash has round stainless steel receptor and twin aerated spray heads. Chrome-plated brass stay-open ball valve. Provide a thermostatic mixing TM2A valve as follows:

1. The mixing valve shall ASSE 1071 certified and meet ANSI Z358.1-2009 requirement. The valve shall be equal to Guardian G3700LF furnish in stainless steel cabinet and lockable latch. The valve shall be directly linked to control the hot and cold-water intake and blend to deliver tepid water (75F adjustable). The valve shall be capable of supplying 3 to 34 gpm of tepid water at maximum 20 psi pressure drop. In the event of restriction or failure of hot water supply, internal bypass shall allow valve to deliver cold water to emergency unit. In bypass mode, the valve shall deliver 20 gpm at 30 psi drop. In the event of loss of cold-water supply, the valve shall close and shall not deliver water.

P. **P-9A:** Pedestal mounted eyewash with ABS plastic bowl, Schedule 40 galvanized pipe and fittings, ½" U.S. made chrome-plated stay-open ball valve, powder-coated cast aluminum flag handle and floor flange. Unit shall have (2) polypropylene GS-Plus™ spray heads with integral "flip-top" dust covers, filters and 1.6 GPM flow control orifices mounted on a chrome-plated brass eyewash assembly. Unit shall include Thermostatic Mixing Valve (TM2A) as specified in

2.18 paragraph. ANSI compliant sign. Unit shall be hydrostatically tested to meet or exceed ANSI Z358.1 – 2014. Product shall be equal to Guardian Equipment G1825P.

Q. **P-11:** Laundry box shall be PPP Model MM-500 MLB (Fire rated) ½ inch sweat connections, hammer arrester and 2 inch drain connection. Other acceptable manufacturer LSP Products, Symmons Laundry or approved equal

R. **P-11A:** Furnish and install Fire-rated icemaker outlet Box with CSA listed, ½ inch quarter-turn brass valve for pipe connection. The valve box shall be recessed, mini stainless steel, The valve shall meet NSF-61 requirements and be equal to model from IPS Corp, Water Tite, Guy Gray or approved equal.

S. **P-11B:** Furnish and install Fire-Rated Refrigerator icemaker outlet Box with CSA listed, ½ inch quarter-turn brass valve for pipe connection with hammer arrestor. The valve box shall be recessed, mini stainless steel, the valve shall meet NSF-61 requirements and be equal to model from IPS Corp, Water Tite, Guy Gray, or approved equal.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

3.02 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
1. Exception: Use ball valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

N. Install toilet seats on water closets.

O. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

Q. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

R. Install shower flow-control fittings with specified maximum flow rates in shower arms.

S. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

V. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

W. Set shower receptors and service basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."

END OF SECTION

SECTION 23 00 01
HVAC TRADE BID SUMMARY

PART 1 GENERAL

1.01 FILING OF TRADE BIDS

A. Trade Bids are required for work under this section in accordance with the provisions of the General Laws of the Commonwealth of Massachusetts, Chapter 149A, Sections 1 through 8, 10, and 11, as most recently amended.

B. Trade Bids shall be submitted to the Awarding Authority as set forth in the Invitation to Bids and the Instructions to Bidders, accompanied by the bid deposit specified therein.

C. Every Trade Bid for work under this section shall be on the form in this Project Manual furnished by the Awarding Authority.

1.02 GENERAL REQUIREMENTS

A. The General and Supplementary Conditions of the Contract, Construction Manager's Scoping Documents, and General Requirements of the Project Manual, including without exception all sections in Divisions 00 and 01, apply to the HVAC Trade Contractor, material suppliers, and all other persons furnishing labor and materials under this section.

B. Examine all project specifications and drawings for requirements which affect work of this section whether or not such work is specifically mentioned in this section.

C. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.

D. The following definitions apply to drawings and specifications:

1. Furnish: The term "furnish" is used to mean "supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations".
2. Install: The term "install" is used to describe operations at the project site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
3. Provide: The term "provide" is used to mean "furnish and install, complete and ready for the intended use".
4. Installer: An "installer" is the subcontractor or an entity engaged by the subcontractor, either as an employee, or sub-subcontractor for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.

E. When open-flame or spark producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the Construction Manager shall be notified not less than 24 hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant dedicated fire watch who is not otherwise employed as installation labor, where work is being performed, until it is completed.

1.03 DESCRIPTION

A. The work of this Trade Bid Section shall include all furnishing and installation of complete HVAC systems for the project, as shown on drawings, as described in specifications, or as reasonably inferred from either, in the judgment of the Architect.

B. The work of this Trade Bid Section may be (but is not exclusively) shown on the drawings by the section number 23 00 01 or the abbreviation "SC-HVAC".

C. The work of this Trade Bid Section shall include the scope of each of the following sections in their entirety:

1. Section 23 00 10 - HVAC.

D. The work of this Trade Bid Section shall include part of the scope of each of the following sections:
   1. Section 07 84 00 - Firestopping: For materials and requirements for this Trade Contractor to install firestopping at all penetrations, through rated assemblies ((floors, walls, and ceilings), by the work of this section.
   2. Section 08 31 00 - Access Doors and Panels: For material and installation requirements related to access doors and panels required to access concealed components of this Section to be supplied for installation to Section 06 20 00 - Finish Carpentry for installation.
   3. Section 11 40 00 - Foodservice Equipment: For connection, by this Trade Contractor, of hoods, dishwasher vents, and other components provided and installed by that section.
   4. Section 12 32 00 - Manufactured Wood Casework: For connection, by this Trade Contractor, of vented storage cabinets and other components provided and installed in casework by that section.
   5. Section 23 04 58.10 - Vibration Control and Seismic Restraint: For requirements related to seismic bracing of components by this sub.

E. This Trade Contractor shall fully coordinate the execution of the work of this section with, and anticipate the requirements of the following sections:
   1. Section 01 91 13 - MEP Commissioning Requirements: For list of equipment to be commissioned and requirements for cooperation with the Commissioning Agent.
   2. Section 03 45 00 - Precast Architectural Concrete: For penetrations and duct openings.
   3. Section 04 20 00 - Unit Masonry: For penetrations and duct openings.
   4. Section 04 72 00 - Cast Stone Masonry: For penetrations and duct openings.
   5. Section 09 21 16 - Gypsum Board Assemblies: for penetrations, duct openings, diffusers, and grilles in gypsum board assemblies.
   6. Section 09 91 13 - Exterior Painting: for preparation of exterior exposed piping to be painted.
   7. Section 09 91 23 - Interior Painting: for preparation of interior exposed piping to be painted.
   8. Section 11 95 13 - Kilns: for coordination with rooms requiring heat rejection hoods and associated exhaust fans.

F. Sub-Sub Bid Requirements:
   1. The Trade Bidder's attention is directed to Massachusetts General Law Chapter 149A, Section 8, which provides in part as follows:
      a. A Trade Contractor bid form shall require, without limitation, a listing of price, addenda, and alternates, if any, for the trade work; certification that the Trade Contractor will perform the complete trade work with employees on sub-bidder's own payroll, except for work customarily performed by sub-trade subcontractors within the trade; and the names of all sub-trade subcontractors to be used if awarded the trade contract and each sub-trade contract sum. This section requires that the following class(es) of work shall be listed on 00 41 01 - Form for Trade Contractor Bid under the conditions indicated herein:
         1) Duct and Piping Insulation: as described in paragraphs ____ of Section 23 00 10.
         2) Ductwork and Duct Accessories: as described in paragraphs ____ of Section 23 00 10.
         3) HVAC - Automatic Temperature Controls as described in paragraphs ____ of Section 23 00 10.
         4) HVAC System Balancing: As described in paragraph ____ of Section 23 00 10.

b. See Section 00 21 13 - Instructions to Bidders TRADE BIDS Paragraph, and Section 00 41 01 - Form for Trade Contractor Bid for additional instructions regarding "Paragraph E" Sub-Sub Bids.

G. Primary Drawings listed are those intended to indicate the scope of work for this trade.
   1. List of Primary Drawings: To be provided prior to the release of Bid Set.
   2. This Trade Contractor shall review all remaining drawings that may show additional information relating to specific installation conditions and information that may be required to calculate exact quantities, determine specific installation requirements, or generally coordinate the work with other trades.
   3. Additionally, this subcontractor must include in the List of Primary Drawings: To be provided prior to the release of Bid Set, Code Plans, Phasing Plans, Demolition Plans, and all project detail sheets for general and code-related information, installation or other conditions and instructions that directly affect their work.

H. Staging and Scaffolding: The work of this Trade Bid Section shall include all Staging and Scaffolding (including design, engineering, erection, maintenance, and removal) required to complete the work of this Trade Bid category. See Section 01 50 00 - Temporary Facilities and Controls for additional information.
   1. See 01 50 00 - Temporary Facilities and Controls for additional information.

I. Temporary Hoisting Equipment, Lifts, and Machinery: The work of this Trade Bid Section shall include all temporary hoisting equipment, lifts, and machinery required to complete the work of this Trade Bid category. All hoisting equipment, lifts, and machinery and operation shall comply in all respects to the governing laws and codes.
   1. See 01 50 00 - Temporary Facilities and Controls for additional information.

J. Cutting and Patching
   1. This Trade Contractor shall perform all cutting and coring required to complete the work of this Trade Bid category, except as specifically indicated in the respective Trade Contract sections. Where any of the sections listed as part of this Trade Bid indicate that cutting and coring shall be performed by others, the cost of such cutting and coring necessary for the work of this section shall be borne by this Trade Contractor.
   2. All patching required to complete the work of this Trade Bid section shall be performed by the appropriate trade, and the cost of such patching necessary for the work of this section shall be borne by this Trade Contractor.
   3. All cutting, coring, and patching shall be coordinated through and by the Construction Manager.
   4. Any and all cutting of structural members, including floor slabs, shall require approval of the Structural Engineer of Record; see Structural Drawings for typical penetrations and openings in structural members, including floor slabs. For any openings outside the parameters of those shown on Structural Drawings, obtain approval from Structural Engineer of Record.

1.04 REFERENCE STANDARDS

A. See individual technical specification sections listed above for Reference Standards.

1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. See each individual technical specification section listed above for required product information, samples, shop drawings, and other submittals required.

1.06 LEED REQUIREMENTS

A. This project is intended to be certified as a LEED for Schools v4/v4.1 building, with a rating of LEED "Silver". See 01 81 14 - LEED for Schools v4/v4.1 Project Scorecard for projected LEED

credits. Some product and material selections, and some performance requirements of this section are required to achieve the credits listed.

B. Prior to any product submittals, the HVAC Trade Contractor shall assist the Construction Manager in the creation of a LEED action plan identifying products that will contribute toward LEED credits. The LEED Action Plan shall be submitted prior to any product submittals to assist the Architect in evaluating product submittals that must meet LEED criteria.

C. The HVAC Trade Contractor shall provide all documentation indicating applicability of all products of this section to potential LEED credits to the project LEED Administrator for submission to www.leedonline.com. See Section 01 81 13 - Sustainable Design Requirements for additional requirements.

1.07 QUALITY ASSURANCE

A. See each individual technical specification section listed above for requirements.

B. See Section 01 40 00 - Quality Requirements for additional requirements.

C. Testing Agency Qualifications: Independent firm specializing in performing testing and inspections of the type specified in this section.

1.08 WARRANTY

A. See Sections 01 70 00 - Execution and Closeout Requirements and 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. See each individual technical specification section listed above for specific warranties required.

PART 2 PRODUCTS (SEE EACH INDIVIDUAL SPECIFICATION SECTION LISTED ABOVE FOR PRODUCT REQUIREMENTS)

PART 3 EXECUTION (SEE EACH INDIVIDUAL SPECIFICATION SECTION LISTED ABOVE FOR ADDITIONAL EXECUTION REQUIREMENTS)

3.01 CLEANING

A. HVAC Trade Contractor shall be responsible for cleaning up HVAC Trade Contractor's work at the end of each day, and depositing waste and debris created by HVAC Trade Contractor's work in the appropriate dumpsters, separating eligible products for recycling, and depositing recycling in designated recycling containers. Dumpsters shall be provided and maintained (including payment of costs for legal disposal off-site) by the Construction Manager.

1. See Section 01 50 00 - Temporary Facilities and Controls.
2. See Section 01 74 19 - Construction Waste Management and Disposal.

END OF SECTION

Section 23 00 10
HVAC
(Filed Sub-Bid Required)

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END OF INDEX

Section 23 00 10
HVAC

(Filed Sub-Bid Required)

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

A. Refer to Section 230000 HEATING, VENTILATION AND AIR CONDITIONING for filed sub-bid requirements.

1.02 RELATED DOCUMENTS

A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.03 DESCRIPTION OF WORK

A. The work described herein shall be interpreted as work to be done by the HVAC Trade Contractor. Work to be performed by other trades will always be specifically referenced to that trade.

B. Furnish all staging, rigging, temporary support, labor, materials, and perform all operations in connection with the installation of the HVAC work. Refer to Division 00 for more information regarding responsibilities for staging and scaffolding.

C. Without limiting the generality thereof, the work to be performed under this Section includes complete new HVAC systems with the following major sub systems:
   1. Low Pressure Water Piping, Insulation and accessories
   2. Refrigeration Piping
   3. Ductwork With Insulation, Diffusers, Registers And Grilles
   4. Rooftop Air Handling Units
   5. Exhaust Fans, and Kitchen Grease exhaust Systems
   6. Air Source Heat Pump Heat Recovery Chillers
   7. Electric Boilers
   8. Hydronic Accessories
   9. Pumps
   10. VAV Terminal Boxes
   11. Terminal Heating & Cooling Units
   12. Chilled Water/Hot Water Radiant Cooling/Heating
   13. Hot Water Radiation
   14. Ductless Cooling Unit Systems
   15. Equipment Energy Monitoring
   16. Direct Digital Automatic Temperature Controls
   17. Vibration Isolation and Control
   18. Water Chemical Treatment

D. Refer to section 23 05 48 “Vibration Control and Seismic Restraint” for additional work to be provided under this Section 23 00 01.

E. Refer to Section 07 84 00 “Firestopping” for additional work to be provided under this Section 23 00 01.

F. It shall be the responsibility of this Section 23 00 01 to provide all personnel to fully coordinate with the commissioning agent. The hours of training and instruction outlined in this Section 23 00 01 and the Testing requirements shall be in addition to those tests and requirements outlined in Division 01 and required to fulfill Section 01 91 13 - General Commissioning Requirements obligations.

G. Include the following work as needed to perform the work of this section.
   1. Core drilling in accordance with Section 01 70 00 – Execution and Closeout Requirements.
   2. Cutting through non masonry construction in accordance with Section 01 73 00 – Execution.
   3. Temporary facilities, including but not limited to stairs and ladders, staging, scaffolding, chutes and hoisting in accordance with Section 01 50 00 – Temporary Facilities and Controls.
   4. Fire stop systems in accordance with Section 07 84 00 –Firestopping.
   5. Furnish access doors and frames in accordance with Section 083113 – Access Doors and Frames.

H. For LEED requirements refer to Section 01 81 13 – SUSTAINABILITY DESIGN REQUIREMENTS for Division 23.

I. Section 01 91 13 - General Commissioning Requirements is included as work of this Section.

J. Change all air handling unit (RTU, AHU, MAU, DCU) filters per Section 01 81 19 Indoor Air Quality Requirements Building flush out procedures and adhere to IAQ Management Procedures referenced in Section 01 81 19.

K. Sustainable Design Intent: Comply with project requirements intended to achieve sustainable design, measured and documented according to the LEED Green Building Rating System, of the US Green Building Council. Refer to Section 01 81 13, SUSTAINABILITY REQUIREMENTS SUMMARY for certification level and certification requirements.
   1. Refer to LEED Reporting Form for material, procedure, and documentation submittal requirements.
   2. High efficiency filters – Install MERV-14 filters in all HVAC equipment requiring filtration media immediately prior to occupancy.
   3. Air intake location – Locate outside air intake openings a minimum of 25 feet from any hazard or noxious contaminants such as chimneys, plumbing vents, streets, alleys, parking lots, and loading docks. The distance between exhaust air or vent outlets and air intakes should be the greater of 25 feet or the distance as determined by MA State Building Code Equation 2801.2.2.2. Exception, when locating an air intake within 25 feet of a contaminant source is unavoidable, such opening shall be a minimum of 2 feet below the contaminant source and ten feet horizontally from the nearest edge of the air intake to the nearest edge of the contaminant source. All intakes must be 6 feet above landscaped grade including soil, lawn, shrubs, or any plant life within 1.5 feet horizontally of intake.
   4. All air conditioning equipment provided under this project shall meet or exceed mechanical equipment efficiency requirements outlined by the Utility Company Incentive Program. Refer to Utility Company Incentive Program requirements for efficiency values. If mechanical equipment efficiencies specifically listed on the drawings are higher than the Utility Company Incentive Program Requirements, the higher efficiency equipment must be provided.

L. Refer to Construction Manager Procurement and Contract Requirements.

M. Contractor shall provide an extended bond for five years to guarantee the workmanship for all soldered/brazed/welded piping system joints. Each leakage incident that occurs shall have a maximum exposure limit of $10,000 per event in order to cover expenses for loss of glycol, piping repairs, and damages to finishes. The maximum aggregate exposure shall be $50,000 over the five year period. This extended bond time period shall commence after the project Warranty period has expired.

N. Provide all HVAC and ATC/BMS requirements for HVAC Project in accordance with Specification Section 00 21 15, Workforce Diversity.
   1. The Project consists of the following HVAC equipment and systems: Air source water to water heat recovery heat pump chillers, connected chilled water, hot water piping, piping and equipment insulation, pumps, valves, air separators, expansion tanks, buffer tanks, accessories, rooftop air handling units, ductwork, ductwork accessories, ductwork insulation, dampers, air distribution devices, and controls.
   2. HVAC Systems that are not included in the Hydronic Scope include the following HVAC equipment sand systems that are not connected to the Heat Pump system as defined above: Exhaust air fans (including General Exhaust, Kitchen exhaust, other Specialty Exhaust) systems and associated exhaust ductwork and controls, electric boiler, electric resistance heating equipment, Air source or air cooled split system AC or heat pump units and related refrigerant, condensate piping, accessories and controls, miscellaneous ATC control points.

1.04 DEFINITIONS

A. Most terms used within the documents are industry standard. Certain words or phrases shall be understood to have specific meanings as follows:
   1. Provide: Furnish and install completely connected up and in operable condition.
   2. Furnish: Purchase and deliver to a specific location within the building or site.
   3. Install: With respect to equipment furnished by others, install means to receive, unpack, move into position, mount and connect, including removal of packaging materials.
   4. Conduit: Raceways of the metallic type which are not flexible.
   5. Connect: To duct, pipe or wire up, including all branch ductwork, piping, and/or circuitry, control and disconnection devices so item is complete and ready for operation.

6. Subject to Mechanical Damage: Equipment, ductwork, piping and raceways installed exposed and less than eight feet above finished floor in mechanical rooms or other areas where heavy equipment may be in use or moved.
7. General Contractor (GC) and Construction Manager (CM) are one in the same.
8. HVAC Contractor and Mechanical Contractor are one in the same.
9. References to HVAC Drawings and Specifications and Mechanical Drawings and Specifications are one in the same.
10. References to ATC Contractor, BAS Contractor, and BMS Contractor are one in the same Contractor.
11. ATC, BAS, BMS are one in the same, whereas ATC equal Automatic Temperature Controls, BAS equal Building Automation System and BMS equal Building Management System.
12. A/E, Architect and Engineer

1.05 RELATED WORK UNDER OTHER SECTIONS

A. The following work is included in other sections. Coordinate the work of this section with listed section.
B. Cutting beyond the requirements as stated herein, and patching of all openings regardless of size, is specified in the respective Sections of the trade responsible for furnishing and installing similar new materials.
C. For temporary controls refer to Division 00. Refer to Division 01 50 00 and Division 00 for Temporary Heating Requirements
D. For flashing of vents through roof and setting of roof curbs and flashing of such, refer to Section 07 54 00 & 07 62 00.
E. For power wiring of mechanical equipment refer to Section 26 00 01.
F. For excavation and backfill of below grade mechanical and related systems refer to Section 31 23 00.
G. For structural steel refer to Section 05 12 00.
H. For fire stopping not called for in this Section refer to Section 07 84 13.
I. For finished painting of mechanical systems not called for in this Section refer to Section 09 91 23.
J. For Food Service Equipment refer to Section 11 40 00.
K. For interior concrete work relating to this Section refer to Section 03 30 00.
L. For exterior concrete work relating to this Section refer to Section 03 30 00.
M. Installation of access doors and frames refer to Section 08 31 00 – Access Doors and Frames.
N. For LEED requirements refer to Section 01 81 13.00 – Sustainable Design Requirements.
O. Division 01 Section “LEED Systems Manual Requirements” for additional LEED requirements.
P. Section 01 91 13 – General Commissioning Requirements.
Q. Change all air handling unit (RTU, AHU, FCU, DCU) filters by Section 01 81 19 Indoor Air Quality Requirements flush out procedures and adhere to IAQ Management Procedures referenced in Section 01 81 19.
R. Sustainable Design:
    1. Section 01 74 19 – Construction Waste Management and Disposal.
    2. Section 01 81 13 – Sustainable Design Requirement
    3. Section 01 81 19 – Indoor Air Quality Requirements.
    4. Definitions: Refer to Section 01 81 13.23 “Sustainable Design Requirements “ 1.02.B for definitions of terms used in this section.
S. Refer to Ground Source Well field drawings and Specifications for reference and coordination with Wellfield Contractor requirements.
T. Refer to Specification Section 00 21 15, Workforce Diversity.

1.06 CODES, ORDINANCES, AND PERMITS

A. Perform all work in accordance with the requirements of Wilmington Building Department, State of Massachusetts Building Code (Latest Adopted Edition), and applicable State and Federal Laws. Give all requisite notices, file all requisite plans, and obtain all permits required to perform HVAC Work.
B. HVAC Subcontractor is responsible for obtaining all permits and Construction Manager is responsible for paying all permit and inspection fees.
C. All HVAC equipment shall be installed to meet all State, Local and Federal sound ordinances.
D. All HVAC Equipment shall operate within local sound ordinance levels.
E. Refer to 1.08.A Codes and Standards for additional requirements.

1.07 WELDING QUALIFICATIONS

A. Piping shall be welded in accordance with qualifications procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC IX. Welding procedures qualified by other standards, and welders and welding operations qualified by another employer may be accepted as permitted by ASME B31.1. The Owner's Representative shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practicable. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Division 01.

B. When open-flame or spark producing tools such as welding equipment, and the like are required in the process of executing the work, the Construction Manager shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant fire watch/fire detail (by the Wilmington Fire Department) where work is being performed and until it is completed. The HVAC Subcontractor shall be responsible for obtaining required permit and paying all permit fees and Firewatch detail expenses.

C. Refer to Division 1 and CM Supplemental Instructions for additional fire watch requirements.

1.08 QUALITY ASSURANCE

A. Codes and Standards:
   1. HI Compliance: Design, manufacture, and install HVAC pumps in accordance with HI Hydraulic Institute Standards".
   2. UL Compliance: Design, manufacture, and install HVAC pumps in accordance with UL 779 "Motor Operated Water Pumps".
   3. ANSI Standards: Comply with ANSI A13.1 for pipe, valve, and equipment identification.
   4. FM Compliance: Provide control devices and control sequences in accordance with requirements of Factory Mutual System (FM).
   5. IRI Compliance: Provided control devices and control sequences in accordance with requirements of Industrial Risk Insurance (IRI).
   6. AMCA Compliance: Test and rate air handling units in accordance with AMCA standards.
   7. ARI Compliance: Test and rate air handling units in accordance with ARI 430 "Standard for Central-Station Air Handling Units", display certification symbol on units of certified models.
   8. ASHRAE Compliance: Construct and install refrigerant coils in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration" and ASHRAE Standard 34 "Designation and Safety Classification of Refrigerants" (Latest adopted and referenced editions).
   9. NFPA Compliance: Provide air handling unit internal insulation having flame spread rating not over 25 and smoke developed rating no higher than 50; and complying with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".
   10. UL and NEMA Compliance: Provide electrical components required as part of air handling units, which have been listed and labeled by UL and comply with NEMA standards.
   11. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of air handling units.
   12. LEED: Install all HVAC systems in accordance with all current requirements. Refer to Sustainable Design specification section for requirements.

B. MSS Standard Practices: Comply with the following standards for valves:
   1. MSS SP-45: Bypass and Drain Connection Standard
   2. MSS SP-67: Butterfly Valves
   3. MSS SP-70: Cast Iron Gate Valves, Flanged and Threaded Ends
   4. MSS SP-71: Cast Iron Swing Check Valves, Flanged
   5. MSS SP-72: Ball Valves with Flanged or Butt-Welding Ends for General Service
   6. MSS SP-78: Cast Iron Plug Valves, Flanged and Threaded Ends
   7. MSS SP-80: Bronze Gate, Glove Angle and Check Valves
   8. MSS SP-84: Steel Valves - Socket Welding and Threaded Ends
   9. MSS SP-85: Cast Iron Globe and Angle Valves, Flanged with Threaded Ends
   10. MSS SP-92: MSS Valve User Guide

C. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
   1. All castings used for couplings housings, fittings, or valve and specialty bodies shall be date stamped for quality assurance and traceability.

D. Automatic Temperature Control Contractor Qualifications: Building automation and energy management systems Sub-contractor specializing in installation of HVAC control system.
   1. Codes and Standards:
      a. Electrical Standards: Provide electrical components of control systems which have been UL-listed and labeled, and comply with NEMA standards.
      b. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

1.09 DISCREPANCIES IN DOCUMENTS

A. Where Drawings or Specifications conflict or are unclear, advise Architect in writing before Award of Contract. Refer to general conditions.
B. Where Drawings or Specifications do not coincide with manufacturers recommendations, or with applicable codes and standards, alert Architect in writing before installation.
C. If the required material, installation, or work can be interpreted differently from drawing to drawing, for between drawings and specs, The HVAC Subcontractor shall provide that material, installation, or work which is of the more stringent.
D. It is the intent of these contract documents to have the HVAC Sub-contractor provide systems and components that are fully complete and operational and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a system. In cases such as this, where the HVAC Sub-contractor has failed to notify the Architect of the situation in accordance with Paragraph (A) above, the HVAC Sub-contractor shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner.

1.10 CONTRACT DRAWINGS

A. All work shown on the Drawings is intended to be approximately correct to scale, but shall be taken in a sense as diagrammatic. Sizes of ductwork and pipes and general method of running them are shown, but it is not intended to show every offset and fitting. To carry out the true intent and purpose of the plans, furnish all necessary parts to make complete working systems ready for use.
B. The HVAC Drawings and Specifications are intended to supplement each other so that any details shown on the Drawings and not mentioned in the Specifications, or vice-versa, shall be executed the same as if mentioned in the Specifications and shown on the Drawings.
C. Refer to the Architectural, Structural, and other Mechanical and Electrical Drawings which indicate the construction in which this work shall be installed. Locations shown on the plans shall be checked against the general and detailed Drawings of the construction proper. All measurements must be taken at the building.

1.11 COORDINATION DRAWINGS

A. Coordination requirements specific to the Work of this Section include the following:
   1. Before materials are purchased or work is begun, the respective Subcontractor shall prepare and submit to the Architect Coordination Drawings showing the size, elevation and location of his equipment, fixtures, ductwork, conduit, and piping lines relevant to the complete system. He shall ensure that these drawings are compatible and correctly annotated and cross-referenced at their interfaces.
   2. Coordination drawings are for the Contractor's and the Architect's use during construction and shall not be construed as replacing any shop or record drawings required elsewhere in the Contract Drawings.
   3. All coordination drawings shall be prepared in a large enough scale to accurately identify work of each trade and in addition to each sub-contractors systems, shall also show architectural floor plan, reflected ceiling plan, and structural framing with grid identification.
   4. The coordination drawing shall be prepared in REVIT (version 2019 or later) or alternate approved BIM Modeling Software and shall be started by the sheet metal sub-contractor and after applying all ductwork, the drawing shall be submitted for ductwork approval by the engineer. After approval, the drawing shall be circulated to the remaining sub-contractors for application of their work.
   5. During coordination drawing preparation the sub-contractors shall meet periodically to discuss overall coordination of all sub systems, and shall adjust their systems accordingly. When all drawings are complete the Construction Manager shall submit to the architect and engineers for review.

6. Areas of conflict that cannot be resolved between the sub-contractor must be flagged on the drawings with adequate information to assist the architect and engineer in resolving noted issues.

B. Refer to Section 01 31 00 of these Contract Documents for general requirements and additional procedures relative to the preparation of Coordination Drawings.
C. Refer to CM Supplemental Instructions for BIM Execution Plan and additional requirements

1.12 ACCESSIBILITY

A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.
B. Extend all grease fittings to an accessible location.

1.13 ROUGH IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

1.14 PHASING

A. The mechanical subcontractor shall construct the subject project in phases as directed by the Construction Manager and Architect to suit the project progress schedule, as well as the completion date of the project.
B. For additional information related to phasing, review the General Conditions and Supplementary Conditions and the Architectural drawings.

1.15 HAZARDOUS MATERIALS

A. The HVAC Trade Contractor shall be responsible for removing and legally disposing of any and all hazardous waste associated with HVAC systems, including but not limited to:
   1. Glycol in heating and cooling systems.
   2. All chemical treatment used in flushing out HVAC piping systems.
   3. Un-used excess material such as adhesives used in ductwork and piping installations.
   4. Refrigerant in all AC systems to be removed and/or demolished.
   5. Items specifically noted on drawings.

1.16 NOTIFICATION OF RELATED TRADES

A. Notify all other trades responsible for installing chases, inserts, sleeves, anchors, and louvers when ready for such installation and for final checking immediately before concrete is placed. Cooperate with such trades to obtain proper installation.
B. Leave openings in walls for pipes, and ducts for mechanical and electrical work as shown on Drawings or required by layout of mechanical or electrical systems.

1.17 MECHANICAL INSTALLATIONS

A. Coordinate mechanical equipment and materials installation with other building components.
B. Verify all dimensions by field measurements.
C. Arrange for chases, slots, and opening in other building components to allow for mechanical installations.
D. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.
E. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.
F. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials.
G. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.
H. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
I. Coordinate connection of mechanical system with overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

1.18 CUTTING AND PATCHING

A. Penetrations through construction for the Work of this Section:
   1. Coring/Cutting: Perform all coring for required work up to and including 12 inch in diameter or equivalent in area of 12 inch square. Coring beyond 12 inch or cutting beyond the equivalent of 12 inch square will be performed by the Construction Manager.
   2. Notify Masonry Sub-Contractor of exact locations and sizes for openings required in masonry, to be executed under Division 04, utilizing lintels furnished per Section 05 50 00 – Metal Fabrications.
   3. Cut openings in new and existing non-masonry construction where required for penetrations. All cutting shall conform to the requirements of Section 01 70 00 – Execution and Closeout Requirements, and 02 41 16 – Structure Demolition, 02 41 19 – Selective Demolition.
   4. Refer to Section 02 41 16 – Structure Demolition, 02 41 00 –Demolition for restrictions on all alterations to structural elements.

B. Patching at penetrations through construction for the Work of this Section:
   1. Notify Masonry Sub-Contractor when HVAC work is complete at penetrations through masonry construction, and ready for patching under Division 04.
   2. Notify appropriate Sub-Contractors when HVAC work is complete at penetrations through non-masonry construction, and ready for patching under Sections in Division 09 - FINISHES.

C. Drilling, coring, and cutting of new and existing structures (through walls, floors, ceiling) where the largest dimension does not exceed 12 inch diameter for drilling/coring or the equivalent of an area equal to or less than 12 inch square shall be by the HVAC Trade Contractor.

D. Throughout the performance of the cutting and coring work, ensure that the structural integrity of the existing walls, floors, overhead structure, and other structural components, which are to remain, is maintained until permanent work is installed. Prior to any coring or cutting verify all locations of same with the Construction Manager. All cutting and coring is to be performed in accordance with approved coordination drawings. All cutting or coring of structural must receive approval of the Architect prior to proceeding.

E. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective, or non-conforming installations.

F. Patching of surfaces shall be by the trade responsible for the surface penetrated.

G. Refer to related architectural sections including Section 01 77 00 for additional reference.

1.19 SUBMITTALS

A. General: Refer to Section 01 30 00 – Administrative Requirements for general requirements for submittal of product data, shop drawings and other materials for review by the Architect and their Consultants. The following paragraphs supplement the requirements of Section 01 30 00.

B. Submittal of Shop Drawings, product data, and samples will be accepted only when submitted by the Construction Manager. Data submitted by Sub-contractors and material suppliers directly to the Architect/Engineer will not be processed.

C. Submittal requirements specific to the Work of this Section include the following:
   1. Valves
   2. Meters and Gages
   3. Hangers and Attachments
   4. Mechanical Identification
   5. Mechanical Insulation
   6. Hydronic Piping
   7. Refrigeration Piping
   8. Rooftop and Indoor Air Handling Units
   9. Water Source Heat Pump Heat Recovery Chillers
   10. Boilers
   11. Pumps
   12. VAV Terminal Boxes
   13. Terminal Heating and Cooling Units
   14. Unit Heaters
   15. Hot Water Radiant Heating
   16. Ductless Cooling Unit Systems
   17. Power and Gravity Ventilators
   18. Split system air source air conditioning and heat pump systems
   19. Electric resistance heating equipment

20. Metal Ductwork
21. Ductwork Accessories
22. Air Outlets and Inlets
23. Sound Attenuators and Sound Lining
24. Condensate Discharge Pumps
25. Access Panels
26. Elevator, Audio Visual and Theatrical Equipment for cooling load coordination.
27. Automatic Temperature Controls
28. Testing, Adjusting, Balancing, and Commissioning
29. Steel opening coordination drawing and/or sketches: submit to Construction Manager as early as possible size and orientation of all openings required under this section referenced from column centerlines. Sketches are to include dunnage for support of HVAC equipment including (but not limited to) future cooling tower, RTUs, remote condensing units, and water source heat pump chillers. Drawings and/or sketches will be used as the basis of establishing openings with the steel fabricator.
30. Coordination Drawings: Submit a layout of the main mechanical room including all HVAC equipment in BIM 3-D Model and CAD format.

D. The TAB Contractor shall submit a project-specific TAB Submittal six weeks prior to starting TAB work. This plan will be developed after the TAB Contractor has some familiarity with the systems and associated control systems. The Submittal shall address each system and component, and shall include but not be limited to:
    1. TAB Contractor's certifications and credentials to perform the contracted work.
    2. Certification that the TAB has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.
    3. The identification and types of measurement instruments to be used and their most recent calibration date.
    4. An explanation of the intended use of the building control system for review and comment on feasibility by the BAS contractor and Commissioning Agent.
    5. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data to be gathered for each.
    6. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
    7. Final test report forms to be used.
    8. Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / sub-main proportioning, total flow calculations, rechecking, diversity issues, and potential expected problems and solutions. Criteria for using air flow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
    9. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
    10. Details of how total flow will be determined.
        a. Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
        b. Water: pump curves, circuit setter, flow station, ultrasonic meter, and/or flow sensors.
    11. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.
    12. Confirmation that TAB contractor understands the outside air ventilation criteria under all conditions.
        a. Details of whether and how minimum outside air cfm will be verified and set, and for what level (total building, floor, zone, space, and/or rooms.).
        b. Details of how any CO2-based demand controlled ventilation airflow rates will be verified at various CO2 levels.
        c. Details of verification for any unoccupied setbacks from maximum required ventilation rate (based on both number of occupants and square feet per ASHRAE Standard 62.1, for example) to minimum required ventilation rate (based on square feet only per ASHRAE Standard 62.1)
    13. Details of how building static and exhaust fan / relief damper capacity will be checked. Proposed selection points for sound measurements and sound measurement methods.

14. Details of methods for making any specified coil or other system plant capacity measurements. Details of any TAB work to be done in phases (by floor, zone, space, and/or rooms.), or of areas to be built out later.
15. Phasing plan for performing TAB work by floor or area, and details regarding specified deferred or seasonal TAB work.
16. Details of any specified false loading of systems to complete TAB work.
17. Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
18. Procedures for verifying required room pressure differentials.
19. Details of any required interstitial cavity differential pressure measurements and calculations.
20. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
21. Plan for formal progress reports (scope, frequency and distribution list).
22. Plan for formal deficiency reports (scope, frequency and distribution list).
23. Procedures for addressing partial build-out, diversity, and part load issues including false loading or other approaches where allowed.
24. Methods to make all specified coil and system capacity measurements.
25. Specific procedures to ensure both water and air distribution systems operate at the lowest possible pressures and the methods to verify and document this.

E. If a Shop Drawing is not accepted after two submissions, a third submission from the same manufacturer will not be considered.
F. Check Shop Drawings and other submittals to assure compliance with contract documents before submittal to A/E.
G. Review of Shop Drawings is final and no further changes shall be considered without written application. Shop Drawings review does not apply to quantities, nor relieve The HVAC Subcontractor of his responsibility for furnishing materials or performing his work in full compliance with these Contract Drawings and Specifications. Review of these shop drawings shall not be considered a guarantee of the measurements of this building or the conditions encountered.
H. Sustainability Data: For each Sustainability Focus Material in accordance with Section 01 81 13 “Sustainable Design Requirements.”

1.20 SUBSTITUTIONS

A. Refer to, Section 01 30 00 for Administrative Requirements in requesting substitutions. The following paragraphs supplement the requirements of Section 01 33 00.
B. If materials or equipment are substituted for basis of design specified items that alter the systems shown or its physical characteristics, or which have different operating characteristics, clearly note the alterations or difference and call it to the attention of the Architect/Engineer. Contractor shall be responsible for coordinating dimensional fit of equipment that varies from basis of design equipment. Under no circumstances shall substitutions be made unless material or equipment has been successfully operated for at least three consecutive years.
C. Any modifications to the design, as a result of approving a substitution from the basis of design equipment, shall be the responsibility of The HVAC Subcontractor. Any additional cost to The HVAC Subcontractor or any other contractor, directly or indirectly, as a result of such substitutions, shall be the responsibility of The HVAC Subcontractor.

1.21 PRODUCT LISTING

A. Prepare listing of major mechanical equipment and materials for the project.
B. Provide all necessary information.
C. Submit to the A/E through the Construction Manager, within twenty days of signing contract, this listing indicating all equipment and manufacturers, as a part of the submittal requirement. If the product list is not submitted, it will be the responsibility of the sub-contractor to submit one of the three named equal manufacturers.
D. When two or more items of same material or equipment are required they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in work, except as otherwise indicated.
E. Provide products, which are compatible within systems and other connected items.

1.22 NAMEPLATE DATA

A. Provide permanent operational data nameplate on each item of power operated mechanical equipment, indicating manufacturer, product name, mode, number, serial number, capacity, operating, and power characteristics labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

1.23 DELIVERY, STORAGE AND HANDLING

A. Refer to Section General Conditions for delivery, storage, and handling of equipment. The following paragraphs supplement the requirements of Section General Conditions.

B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

C. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.

D. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

1.24 RECORD DOCUMENTS

A. General: Refer to Section 01 70 00 – Execution and Closeout Requirements, for general requirements for maintaining as-built drawings and submitting final reproducible record documents. The following paragraphs supplement the above.

B. Record Drawings for the Work of this Section shall include the following: Provide electronic AutoCAD drawings to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column line; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located.

1.25 OPERATION AND MAINTENANCE DATA

A. General: Refer to Section 01 70 00 – Execution and Closeout Requirements for general requirements for submittal of operations and maintenance manuals, training of personnel and related closeout procedures. The following paragraphs supplement the requirements of Section 07 70 00.

B. In addition to the information required by Section 01 70 00 for maintenance data, Closeout procedures specific to the Work of this Section include the following:

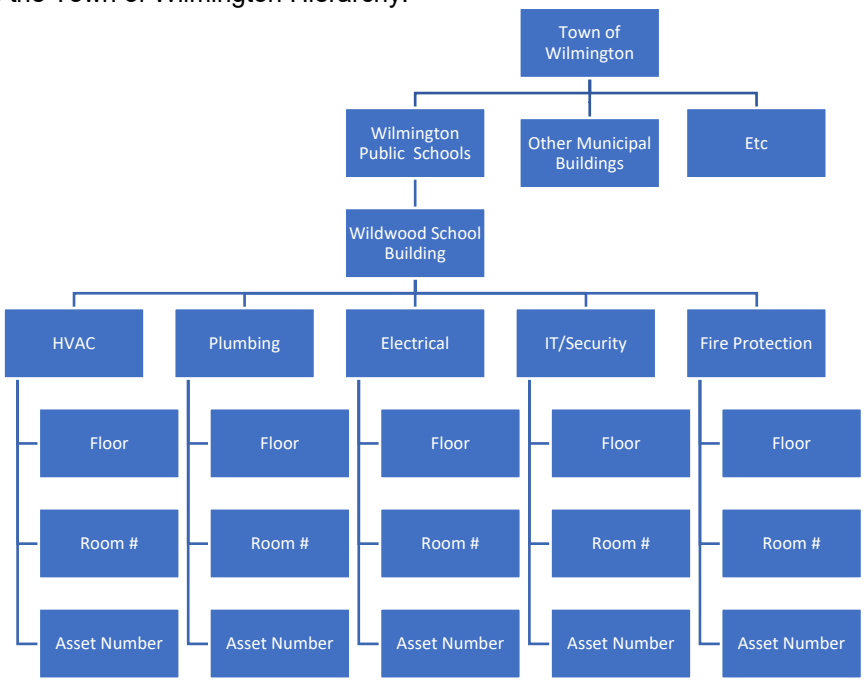
1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and user summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and trouble-shooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.
5. Provide start-up reports for all major HVAC systems and equipment, including but not limited to, water source heat pump chillers, all air handling equipment, ductless cooling unit systems, pumps and fans.
6. Provide video recording of operation and maintenance training sessions and include as part of O & M Manual submittal. Training session video recording shall be performed by a professional videographer. Provide indexed table of contents of recording. Submit six USB thumb drives of recording. Final approved recordings and electronic version of O&M manuals shall be stored on a Facility Maintenance Webpage with file links by the ATC/BAS Contractor. HVAC Trade Contractor shall coordinate with ATC/BAS contractor to provide all required training video files and O&M electronic files.
7. The HVAC and ATC contractors shall provide follow up Owner training sessions that occur throughout the warranty period. The HVAC Contractor shall coordinate the follow up training dates with the Owner and ATC Contractors, and shall keep a log of training sessions for record keeping purposes. These training sessions shall occur around the same time as the ATC seasonal testing dates. Refer to ATC seasonal testing requirements.

8. Cooperate with Commissioning agent to complete system and equipment start-up reports and testing. Refer to Section 01 91 13.
9. Provide an excel spreadsheet in the O&M manuals that includes the following, at a minimum:
10. All required equipment filter types, sizes and models, designated by equipment tag.
    a. All required fan belt types, sizes and models designated by equipment tag.
    b. All required lubricants, with suggested manufacturer and type, designated by equipment tag.
    c. Provide a manufacturer's recommended preventive maintenance schedule and routine and task list for each HVAC equipment/system type.
    d. Three copies of O&M Manuals are required for Owner's use. Include one electronic .pdf format of all final O&M materials on flash drive for Owner's Use.

C. Contractor shall provide computerized maintenance management system information in format compatible with School Dude (Excel spreadsheet) for Mechanical equipment. The preventative maintenance program includes the following minimum fields: Below is a sample format and city hierarchy. Submit all known fields as part of shop drawing and submit final fields prior to commissioning. Coordinate PM Software requirements with Owner.

D. Submittals shall be confirmed by Town hired staff who will utilize Contractor provided data.

E. Below is the Town of Wilmington Hierarchy:



F. Sample of Data Fields:

Location	Category	Asset Name	Sequential Number	Serial Number	Received Date	Installation Date	Warranty Date
	HVAC	Rooftop Units (RTU)					
	HVAC	Air Handling Units (AHU)					
	HVAC	Boilers (B)					
	HVAC	Water Source Heat Recovery Heat Pump Chiller (HRC)					
	HVAC	Pumps (P)					
	HVAC	Exhaust Fans (EF)					
	HVAC	Unit Heater (UH)					

Location	Category	Asset Name	Sequential Number	Serial Number	Received Date	Installation Date	Warranty Date
	HVAC	Fan Coil Units (FC)					
	HVAC	Radiant Cooling/Heating Panels (RP)					
	HVAC	Exhaust Fans (EF)					
	HVAC	Kitchen Exhaust Fan (KEF)					
	HVAC	VAV Boxes (VAV)					
	HVAC	Expansion Tanks (ET)					
	HVAC	Air/Separators (AS)					
	HVAC	Ductless AC Units (DCU)					
	ATC	BMS					
	HVAC	Wall Radiation (FTR)					
	HVAC	Glycol Make up Unit (GF)					
	HVAC	Air Handling Units (AHU)					
	HVAC	Make Up Air Unit (MAU)					
	HVAC	Hot, Chilled, Comp Chilled, Condenser Water Pumps (P-)					
	HVAC	VAV Boxes					
	HVAC	Cabinet Unit Heaters					
Asset Numbering Convention							
Location	Category	Asset Name	Sequential Number				
Task numbering Convention							
Model#, Frequency, Task Number							
Model is equipment model number							
WK - Weekly							
MO - Monthly							
SA - Semi-Annual							
AN-Annually							
EX - Every x number of years							

FIELDS CONTINUED:

Original Cost		Weight	Rating	Capacity	Model	Manufacturer	Supplier	PM Task	PM Frequency

1.26 WARRANTIES

A. The HVAC Sub-contractor shall provide a minimum one year minimum warrantee on all product (unless more stringent requirements are otherwise stated in the General conditions specifications, or specifications for a specific product) and labor for work under this section. Refer to general conditions and HVAC specifications for additional warranty requirements.

B. Refer to Section General Conditions and Section 01 70 00 – Execution and Closeout Requirements for additional procedures and submittal requirements for warranties.

C. In addition to the one year warranty period against component or workmanship defects, ATC Contractor shall provide the following: 40 hours of training, 120 hours of extra programming (as it relates to the control system to confirm, verify and modify as required the sequence and/or programming of each piece of equipment to ensure the system is functioning as required and per the sequence of operations), and 64 hours of seasonal testing. The ATC sub-contractor shall provide 16 labor hours per season (four times within a year, total of 64 hours). During each visit they shall, for each piece of equipment confirm operation and functionality, modify and/or repair any control related issues and/or programming and provide training as requested by the owner. This requirement will ensure the equipment/building is operating properly and efficiently as it cycles through each season. These site visits shall begin the following season after substantial completion of the project is issued. Upon substantial completion the ATC Sub-Contractor shall schedule the seasonal site visit dates with the Owner. Attendee Signatures and time logs shall be kept by the ATC contractor and shall be distributed to the CM, Owner and A/E team to record the dates of the seasonal site visits.

1.27 SUSTAINABLE DESIGN INTENT

A. SUMMARY

1. The Owner has established that this Project shall minimize the detrimental impacts on Indoor Air Quality (IAQ) resulting from construction activities. Factors that negatively impact indoor air, such as the use of adhesives, sealants, paints and coatings which exceed the minimum levels detailed in Section (Volatile Organic Compound Limits) shall not be permitted. Use of ductwork as a temporary means of distributing air prior to Substantial Completion will require cleaning of same by a company that performs this service on a regular basis and use of air handling and ductwork system shall be maintained with filter changes provided in accordance with SMACNA IAQ During Construction Guidelines and SMACNA Duct Cleanliness for New Construction Guidelines.

B. REFERENCE STANDARDS

1. SMACNA IAQ: Guidelines for Occupied Buildings Under Construction, 2nd Edition 2007, ANSI/SMACNA 008-2008 (Chapter 3): The Steel Metal and Air Conditioner National Contractors Association.
2. SMACNA Duct Cleanliness Advanced Levels for New Construction Guidelines, latest Edition.
3. ANSI / ASHRAE 52.2-2007, “Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size”.
4. United States Environmental Protection Agency, “Compendium of Methods for the Determination of Air Pollutants in Indoor Air”
5. The United States Green Building Council “Green Building Design and Construction” V4

C. LEED FOCUS MATERIALS

1. LEED Focus Materials for Division 23
   a. VOC Products
   b. Composite Wood and assemblies containing composite wood
   c. Solid wood products and assemblies containing solid wood

D. LEED ACTION SUBMITTALS

1. Refer to Section 01 81 13., SUSTAINABILITY DESIGN REQUIREMENTS and LEED V4 Checklist for detailed descriptions of the submittal documents listed below.
2. LEED Reporting Form (LRF): Submit a completed LRF for the materials included in Sections from Division 23 per Section LEED Reporting Form. Provide only the following information:

a. The Volatile Organic Compound (VOC) content for all field-applied interior adhesives, sealants, paints and coatings used.
b. Material Costs for all Wood Based Materials (solid wood and Composite Wood).
c. If the VOC Budget Method has been selected as the LEED compliance path for Credit IEQ Low Emitting Materials provide the Material Costs and VOC Volumes used for applicable adhesives, sealants, paints and coatings.

3. Validation: Provide validation according to the Action Submittals requirements of Section 01 81 13 Sustainable Design Requirements.
   a. VOC Content
   b. FSC Certified Wood:
   c. Composite Wood
   d. Laminating Adhesives
4. Submittal Package: LEED submittal information shall be assembled into one package per Section or sub-contractor. Incomplete or inaccurate submittals may be used as the basis for rejecting the submitted products or assemblies.

E. LEED QUALITY ASSURANCE
1. Field-applied adhesives, sealants, paints and coatings used for interior applications which meet the volatile organic compound (VOC) and chemical component limitations defined in Section "Volatile Organic Compound Limits". This includes products both specified and products not specified but required to complete the work of this section.
2. Composite Wood products that:
   a. Do not contain added urea-formaldehyde resins.
   b. Do not use laminating adhesive containing urea-formaldehyde
3. Wood Based Products (solid wood and composite wood) that are certified by the Forrest Stewardship Council (FSC).

F. INDOOR AIR QUALITY MANAGEMENT
1. Carry out indoor air quality management measures and activities as required in Section 01 81 09 – Testing for Indoor Air Quality.

G. CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL
1. Carry out construction waste management and disposal measures and activities as required in Section 01 74 19 – Construction Waste Management and Disposal.

H. Comply with project requirements intended to achieve measured and documented credits according to the project LEED checklist. Project scores will be verified by a third party certifier.
1. Refer to section 01 81 13 – Sustainable Design Requirements and LEED V4 Checklist, for material, procedure, and documentation submittal requirements.
2. The project intends to apply for the following credits. The project HVAC Subcontractor shall perform all required work for the following credits as outlined in the LEED Reference Guides Version 4:

Energy and Atmosphere		
Item	**Title/Description**	**HVAC Trade Contractor Responsibility**
Prerequisite Fundamental Commissioning and Verification	Provide effective and complete training and documentation on the operation and maintenance of the building systems identified in the commissioning report.	Provide Operating and Maintenance manuals for all HVAC/ATC systems and equipment. Provide owner training and video tape training sessions for all HVAC/ATC systems. Coordinate training with CM.
Prerequisite Minimum Energy Performance	**(A, B, or C). Energy Efficiency Standard:** Design a school that performs significantly better than schools built to current standard practice by designing **6 percent or more above the ASHRAE 90.1 – 20ten standard** using A) the prescriptive criteria established by	Provide equipment meeting or exceeding energy efficiency design requirements; submit shop drawings indicating equipment efficiencies.

Energy and Atmosphere		
Item	**Title/Description**	**HVAC Trade Contractor Responsibility**
	the New Buildings Institute's main resource guide: *Benchmark: Energy Benchmark for High Performance Buildings*, B) the prescriptive approach outlined in the ASHRAE standards, or C) the Total Building Approach outlined in the ASHRAE standards.	
Optimize Energy Performance	Demonstrate superior energy performance (6 percent-50 percent reduction).	Provide equipment meeting or exceeding energy efficiency design requirements; submit shop drawings indicating equipment efficiencies.
Prerequisite Building-Level Energy Metering	Install energy management system.	Install ATC/EMS system meeting design requirements and to monitor energy use.
Fundamental Refrigerant Management	Zero use of CFC-based refrigerants in HVAC equipment.	Provide equipment without CFC-based refrigerants.
Advanced Energy Metering	Install energy management system.	Install ATC/EMS system meeting design requirements and to monitor energy use.

Indoor Environmental Quality		
Item	**Title/Description**	**HVAC Trade Contractor Responsibility**
Prerequisite Minimum Indoor Air Quality	Design ventilation systems to ASHRAE Standard 62.1-20ten: Ventilation for Acceptable Indoor Air Quality.	Install and Balance systems per Design requirements.
Prerequisite Minimum Acoustical Performance	Ensure that all classrooms meet the acoustic standards of ANSI 12.60-2010.	Comply with Acoustical Consultant's report recommendation; install equipment meeting specified sound data. Refer to Vibration isolation specifications for additional requirements.
Construction Indoor Air Quality Management Plan	If the building or a portion of the building is to be occupied during construction, meet or exceed the Recommended Design Approaches of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) *IAQ Guideline for Occupied Buildings Under Construction,* 2007, and SMACNA Duct Cleanliness for New Construction Guidelines.	Follow SMACNA Guidelines; coordinate with CM. ATC Contractor shall modify sequences as needed for this credit & return the sequences back to the requirements of the contract documents. Provide required filter changes as required.

Indoor Environmental Quality		
Item	**Title/Description**	**HVAC Trade Contractor Responsibility**
Indoor Air Quality Assessment	Construction management – provide ventilation	Provide unit start-up with CM to provide required flush-out. Provide required filter changes.
Indoor Air Quality Assessment	Construction management – post construction IAQ provide building flushout.	Provide flush-out calculation and coordinate unit start-up with CM to provide required flush-out. Provide temporary heating for areas served by air handling units which are not designed to heat 100 percent O.A. (i.e. re-circ RTUs if flushout occurs during winter heating season to maintain minimum 60 degrees Fahrenheit space temp).
Acoustical Performance	Ensure that all classrooms meet the acoustic standards of ANSI 12.60-2010. Achieve a maximum background noise level from HVAC systems in classrooms and other core learning spaces of 35 dBA.	Comply with Acoustical Consultant's report recommendation; install equipment meeting specified sound data. Refer to Vibration isolation specifications for additional requirements.
Enhanced Indoor Air Quality Strategies	Install dedicated exhaust for pollutant source control.	Install exhaust air systems as designed.
Enhanced indoor Air Quality Strategies	Ensure that permanently installed filtration media have a Minimum Efficiency Reporting Value (MERV) of at least 14.	Provide MERV-14 filters.
Thermal Comfort	Design HVAC systems and building envelope to meet the requirements of ASHRAE Standard 55-2010, Thermal Environmental Conditions for Human Occupancy. Provide individual comfort controls for 50 percent (min.) of the building occupants to enable adjustments to meet individual needs and preferences. Provide comfort system controls for all shared multi-occupant spaces to enable adjustments to meet group needs and preferences.	Install mechanical systems as designed. Install temperature sensors and systems per Design requirements.

1.28 ENERGY REBATE PROGRAM

A. This project has been designed to incorporate equipment approved for energy rebate such as water source heat pump chillers, high efficiency air source heat pumps, high efficiency motors, VFDs, and rooftop air handling units. Contractor shall review Utility Company requirements prior to submitting shop drawing to ascertain that submittal meets program guidelines. All submitted equipment shall meet utility company rebate program efficiency requirements. Contractor shall furnish equipment submittals, related equipment/system pricing data and all required rebate application information and forms to utility company. Contractor shall not participate in any "upstream" equipment vendor based rebate or incentive programs that apply discount to Contractor equipment costs.

1.29 HOISTING EQUIPMENT AND MACHINERY

A. Hoisting Equipment and Machinery: Unless otherwise specified, all hoisting equipment and machinery required for the proper and expeditious prosecution and progress of the work shall be furnished, installed, operated and maintained in safe condition by the individual Non Trade and Trade Contractors and is so stated in each appropriately related Section of the Specifications. All costs for hoisting operating services shall be borne by the Non Trade and Trade Contractors unless specifically excepted in the Contract Documents.
   1. A licensed equipment manufacturer's representative shall be present at all times, to witness the erection and dismantling of all hoisting equipment and machinery, whenever such equipment is being erected or dismantled. No such work will be performed without the presence of such representative.
   2. Hoisting equipment and machinery erection and dismantling shall be performed only by trained, certified, and experienced riggers qualified to perform such work.

1.30 STAGING AND SCAFFOLDING

A. Staging and scaffolding shall be of engineered design adequate and suitable for the intended purpose and loading and in compliance with all applicable Federal, State and local laws and regulations, shall have all accident prevention devices and other features required by Federal, State and local laws and regulations, and shall be erected, maintained and removed by experienced scaffolding/staging builders.

B. Each Trade Contractor entering upon the Work shall furnish, erect and maintain all staging and scaffolding required for work under his subcontract. Each Trade Contractor shall provide access to staging and scaffolding for all inspections by the CM, Owner, OPM, Commissioning Agent or Inspection *Agency*. Each Trade Contractor shall dismantle and remove such staging and scaffolding on completion of his work and at other times as necessary to accommodate and facilitate orderly progress of the Work including work by other trades.

1.31 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 01 91 13 – MEP Commissioning Requirements.

B. Complete installation and startup checks and functional tests according to Section 01 91 13 and manufacturers written instructions.

C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of section 01 91 13 and manufacturers written instructions/requirements.

1.32 TRADE RESPONSIBILITY COORDINATION MATRIX

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke Detectors (Area type)	26 00 01	26 00 01	26 00 01	23 00 01 (ATC)	26 00 01	
Smoke Detectors (Duct mounted)	26 00 01	23 00 01	26 00 01	23 00 01 (ATC)	26 00 01	

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke & Fire/Smoke Dampers	23 00 01	23 00 01	N/A	N/A	N/A	
Smoke & Fire/Smoke Damper Actuators	23 00 01	23 00 01	26 00 01 & 23 00 01 (ATC)	23 00 01 (ATC)	26 00 01	2
Fire Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
VAV Boxes	23 00 00	23 00 00	26 00 00	23 00 00 (ATC)	N/A	2
VAV Box Damper Actuator	23 00 00 (ATC)	Box Mfr	23 00 00 (ATC)	23 00 00 (ATC)	N/A	2
VAV Box DDC Controller	23 00 00 (ATC)	Box Mfr	23 00 00 (ATC)	23 00 00 (ATC)	N/A	2
Hydronic Control Valves	23 00 00 (ATC)	23 00 00	N/A	23 00 00 (ATC)	N/A	1
Hydronic Control Valve Actuator	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Sheet Metal Damper	23 00 00	23 00 00	N/A	N/A	N/A	1
Sheet Metal Damper Actuators	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Electrical Energy Meters	26 00 00	26 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3, 5
Domestic Water Submeters	23 00 00	22 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3, 5
HVAC Hydronic Energy Meters	23 00 00	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3, 5
RTU/AHU Outdoor Air Airflow Measuring Stations	23 00 00 (RTU Manuf.)	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	N/A	6
RTU/AHU Fan Airflow Measuring Stations	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	N/A	6
VFDs at Outdoor RTU/AHU Fans	23 00 00 (RTU/AHU Manufacturer)	23 00 00 (RTU/AHU Manufacturer)	26 00 00	23 00 00 (ATC)	N/A	7
VFDs at Indoor RTU/AHU Fans	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	23 00 00 (ATC)	N/A	7
VFDs at RTU/AHU Energy Recovery Wheels	23 00 00 (RTU/AHU Manufacturer)	23 00 00 (RTU/AHU Manufacturer)	26 00 00	23 00 00 (ATC)	N/A	7
VFDs at Outdoor RTU Energy Recovery Wheels	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	23 00 00 (ATC)	N/A	7
Duct Mounted Airflow Measuring Stations	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
DDC Panels	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	4
EFs, Pumps with VFDs	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	23 00 00 (ATC)	N/A	
KEF-1 VFDs	Food Service Contractor	Food Service Contractor	26 00 00	23 00 00 (ATC)	N/A	
Kitchen Energy Management System	Food Service Contractor	Food Service Contractor	26 00 00	23 00 00 (ATC)	26 00 00	
Electric DHW	22 00 01	22 00 01	26 00 00	N/A	N/A	-
Emergency Shower Flow Switch	22 00 01	22 00 01	26 00 00	23 00 00 (ATC)	N/A	8

Notes:

1. Section 23 00 01 and Section 23 00 01 (ATC) Contractors shall fully coordinate all airflow damper and hydronic valves sizes and quantities.
2. Smoke Damper and VAV Box power wiring shall be provided by Section 26 00 01 to junction box locations shown on electrical drawings; Section 23 00 01 (ATC) Contractor shall provide final power wiring from junction box to end device location.
3. Section 26 00 01 Contractor shall provide all line-voltage power wiring required for meters; Section 23 00 01 (ATC) Contractor shall provide all low-voltage power wiring required for meters.
4. Section 26 00 01 shall provide power at main DDC Panel and Junction Box locations throughout the building as indicated on Electrical Plans. Section 23 00 01 (ATC) shall provide power to all other DDC Panels and Control Devices.
5. Wiring from meters to Building Dashboard System shall be BACNet/IP and provided by ATC Contractor.
6. Outdoor airflow and fan airflow measuring station programming and integration into ATC/BMS shall be provided by ATC contractor.
7. VFDs for Outdoor AHU/RTU fans and ERW units shall be provided by RTU/AHU Manufacturer. VFDs for indoor AHU units fans and ERW shall be provided by ATC Contractor with internal Power wiring for Fans and ERW within AHU, casing shall be provided by Unit Manufacturer and terminated to a disconnect for connection to field provided VFD, and power wiring for VFDs shall be provided by Electrical Contractor.
8. Section 26 00 00 Contractor shall provide all line-voltage power wiring required; Section 23 00 01 (ATC) Contractor shall provide all low-voltage power wiring required connecting to the BMS.

PART 2 - PRODUCTS

2.01 ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT (Refer to section 01 91 13 - Commissioning for additional contract requirements)

A. Pursuant to Massachusetts General Laws Chapter 141, a Massachusetts Licensed electrician shall install all low voltage wiring required by this section.

B. General: The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. All motors for all mechanical equipment shall be NEMA premium efficiency matching the following:

	HP	RPM	Efficiency
a.	1	1800	85.5 percent
b.	1.5	1800	86.5 percent
c.	2	1800	86.5 percent
d.	3	1800	89.5 percent
e.	5	1800	89.5 percent

f. 7.5 1800 91.0 percent
g. 10 1800 91.7 percent
h. 15 1800 93.0 percent
i. 20 1800 93.0 percent
j. 25 1800 93.6 percent
k. 30 1800 94.1 percent
l. 40 1800 94.1 percent
m. 50 1800 94.5 percent

2. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
3. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
4. Temperature Rating: Rated for 40 deg. C. environment with maximum 50 deg. C temperature rise for continuous duty at full load (Class F Insulation). All ratings shall be for inverter duty applications.
5. Starting Capability: Frequency of starts by automatic control system, and not less than 5 evenly time spaced starts per hour for manually controlled motors.
6. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors.
7. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque.
8. Frames: NEMA Standard No. 48 or 54; use driven equipment manufacturer's standards to suit specific application.
9. Bearings:
   a. Ball or roller bearings with inner and outer shaft seals.
   b. Re-greasable, except permanently sealed where motor is normally inaccessible for regular maintenance.
   c. Designed to resist thrust loading where belt drivers or other drives produce lateral or axial thrust in motor.
   d. For fractional horsepower, light duty motors, sleeve type bearings are permitted.
10. Enclosure Type:
    a. Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
    b. Guarded drip-proof motors where exposed to contact by employees or building occupants.
    c. Weather protected Type I for outdoor use, Type II where not housed.
11. Overload Protection: Built-in thermal overload protection and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.
12. Noise Rating: "Quiet".
13. Efficiency: "Premium Efficient" motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112, test method B. If efficiency not specified, motors shall have a higher efficiency than "average standard industry motors", in accordance with IEEE Standard 112, Test Method B.
14. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
15. Provide magnetic bearing protection rings for all inverter rated motors that are controlled by variable speed drives. The bearing protection ring shall channel harmful shaft voltages to ground and protect bearing races from pitting.

C. Starters, Electrical Devices, And Wiring: (Provided By The HVAC Subcontractor For Each Packaged Piece Of HVAC Equipment Requiring Such):
1. Motor Starter Characteristics:
   a. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have NEC proper class and division.
   b. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
2. Manual Switches shall have:
   a. Pilot lights and extra position for multi-speed motors.
   b. Overload Protection: Melting alloy type thermal overload relays.
3. Magnetic Starters:

a. Maintained contact push buttons and pilot lights, properly arranged for single speed or multi-speed operation.
b. Trip-free thermal overload relays, each phase.
c. Interlocks, switches and similar devices for co-ordination with control requirements of Division 23 Controls Sections.
d. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
e. Externally operated manual reset.
f. Under-voltage release or protection.

4. Capacitors:
   a. Individual unit cells.
   b. All welded steel housing.
   c. Each capacitor internally fused.
   d. Non-flammable synthetic liquid impregnant.
   e. Craft tissue insulation.
   f. Aluminum foil electrodes.
   g. KVAR size shall be to correct motor power factor to 90 percent or better and shall be installed on all motors one horsepower and larger, that have an uncorrected power factor of less than 85 percent at rated load.
5. Disconnect Switches:
   a. Fusible Switches: Fused, each phase; general duty; horsepower rated; non-teasible quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the "OPEN" position; arc quenchers; capacity and characteristics.
   b. Non-fusible Switches: For equipment two horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating. For equipment larger than 2 horsepower, switches shall be the same as fusible type.

2.02 VALVES

A. General:
1. Comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.
2. Valves shall have rising stem, or rising outside screw and yoke stems; except, non-rising stem valves may be used where headroom prevents full extension of rising stems.
3. Pressure and temperature ratings shall suit system pressures and temperatures.
4. Unless otherwise indicated, provide valves of same size as upstream pipe size. Automatic control valves shall be sized by the ATC Contractor and shall not exceed a 3 POUNDS PER SQUARE INCH drop.
5. Provide the following special operator features:
   a. Handwheels fastened to valve stem, for valves other than quarter turn, by brass nut on a square-topped stem.
   b. Lever handle on quarter-turn valves six inch and smaller, except for plug valves. Provide one wrench for every ten plug valves, and one years supply of recommended lubricant and sealant.
   c. Chain-wheel operators for valves 2-1/2 inch and larger installed 7two inch or higher above finished floor elevation. Extend chains to an elevation of five feet-0 inch above finished floor elevation.
   d. Gear drive operators on quarter-turn valves eight inch and larger.
6. Where insulation is indicated or specified, provide extended stems arranged to receive insulation.
7. Bypass and drain connections shall comply with MSS SP-45.
8. End connections shall be as specified in the individual valves specifications.
   a. Threads: Comply with ANSI B2.1.
   b. Flanges: Comply with ANSI B16.1 for cast iron ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.
   c. Grooved: Comply with (or similar to) AWWA C606 for ductile iron valves and to copper-tubing sizes for valves used with copper tubing systems
9. Solder-Joint: Comply with ANSI B16.18.

10. Caution: Where soldered end connection are used, use solder having a melting point below 840 degrees Fahrenheit . for gate, globe, and check valves; below 421 degrees Fahrenheit . for ball valves.
11. Any manually operated valve used to control flow rate will be equipped with a memory stop and valve tag showing flow rate setting and valve position.
12. All valves and piping connections which are joined by dissimilar materials must be separated with a dielectric connection.
13. All balancing valves, double duty and triple duty valves shall have a isolation valve installed upstream so that the balancing valve, double or triple duty valve can be serviced without draining down the entire system.

B. Gate Valves:
1. Gate Valves - two inch and smaller: MSS SP-80; Class 150, body and union bonnet of ASTM B 62 cast bronze, threaded ends, solid disc, bronze alloy stem with less than 6 percent zinc content, brass packing gland, in. Teflon" impregnated packing, and malleable iron handwheel.

	THREADED	
MANUFACTURER	NRS	RS
Crane:	x	431UB
Jenkins:	x	47CU
Lunkenheimer:	x	3151
Nibco:	T-136	T-134
Stockham:	B-130	B-120
Milwaukee:	41M	1151M

Or equal

2. Gate Valves (Hot) 2-1/2 inch and larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

MANUFACTURER	OS&Y RS	NRS
Crane:	465-1/2	461
Jenkins:	651C	326C
Lunkenheimer:	1430	1428
Nibco:	F-617-0	F-619
Stockham:	G-623	G-612
Milwaukee:	F-2885-M	F-2882-M

Or equal

C. Ball Valves:
1. Ball Valves one inch and smaller: Rated for 150 pounds per square inch saturated steam pressure, 600 pounds per square inch WOG pressure, 2-piece construction, bronze body conforming to ASTM B 62, standard (or regular) port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for service, threaded ends for heating hot water.

	THREADED	SOLDER
MANUFACTURER	ENDS	ENDS
Milwaukee:	BA-ten0	BA-150
Conbraco (Apollo)	70-ten0	70-200
Crane:	9302	9322
Jamesbury:	21-ten00TT	x
Jenkins:	900A	902A
Lukenheimer:	AQ311	x
Nibco:	T-585	S-585
Watts:	B-6000	B-6001
Stockham:	S-216 BR-R-T	S-216 BR-R-S

Or equal

For Vic-Press connections Victaulic Series P569, and for plain end QuickVic SD connections, Series P89.

2. Ball Valves 1-1/4 inch to two inch: Rated for 150 pounds per square inch saturated steam pressure, 600 pounds per square inch WOG pressure; three-piece construction, bronze body conforming to ASTM B 62, conventional port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for services, threaded ends for heating hot water.

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Milwaukee:	BA-300	BA-350
Conbraco (Apollo):	82-ten0	82-200
Nibco:	T-595-Y	S-595-Y
Watts:	B-6800	B-6801
Stockham:	S-216 BR-R-T	S-216 BR-R-T

Or equal

For grooved end connections use Victaulic Style 721 or equal. Vic-Press connections Series P569; and for plain end QuickVic SD connections, Series P89.

D. Plug Valves
1. Plug Valves - two inch and smaller: 150 pounds per square inch WOG, bronze body, straightaway pattern, square head, threaded ends.

MANUFACTURER
Rockwell: 214.
Lunkenheimer: 454.
Crane: 250.
Or equal

2. Plug Valves - 2-1/2 inch and larger: MSS SP-78; 175 pounds per square inch, lubricated plug type, semi-steel body, single gland, wrench operated, flanged ends.

MANUFACTURER
Rockwell: 305.
Nordstrom: 143.
Serck-Audco: LSW-133-GG.
Homestead: 612.
Victaulic Series 377 (eccentric type)
Or equal

E. Globe Valves:
1. Globe Valves - two inch and smaller: MSS Sp-80; Class 150, body and union bonnet of ASTM B 62 cast bronze, threaded ends, brass or replaceable composition disc, bronze alloy stem with less than 6 percent zinc content, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel.

MANUFACTURER
Jenkins: 106-B.
Lunkenheimer: 407.
Nibco: T-235-Y.
Stockham: B-22.
Or equal

2. Globe Valves - 2-1/2 inch and larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; outside screw and yoke, bronze mounted, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

MANUFACTURER	STRAIGHT BODY	ANGLE BODY
Milwaukee:	F-2981-M	x
Crane:	351	353
Jenkins:	613C	x
Lunkenheimer:	1123	x
Nibco:	F-718-B	x
Stockham:	G-512	G-515

Or equal

F. Butterfly Valves:
1. Butterfly Valves (Hot Water) - 2-1/2 inch and larger: MSS SP-67; 300 pounds per square inch, ductile iron body conforming to ASTM A536, Grade 65-45-12 or cast iron body conforming to

ASTM A 126, Class B. Valves shall have field replaceable EPDM sleeve, with aluminum bronze disc, stainless steel, and EPDM 0-ring stem seals, offset from the disc centerline to provide complete 360-degree circumferential seating. Seat shall be pressure responsive in sizes through 12 inch. Sizes two through six inch shall have lever operators with locks, and sizes eight through 24 inch shall have gear operators with position indicator. Valves on dead end service or requiring additional body strength shall be lug-wafer type, drilled and tapped.

MANUFACTURER	WAFER	
	LEVER	GEAR
Milwaukee:	x	MW-123-E
Center Line:	x	Series A
Crane:	42	x
Keystone:	ten0	x
Nibco:	WD-20003	WD-20003
Stockham:	LG-512-BS3E	LG-522-BS3E
Or equal		

	LUG	
	LEVER	GEAR
Milwaukee:	x	ML-123-E
Center Line:	x	Series LT
Crane:	44	x
Keystone:	129	x
Nibco:	LD-20003	LD-20005
Stockham:	LG-712-BS3E	LG-722-BS3E
Or equal		

Grooved Ends: Victaulic Series Vic 300 Masterseal 2-12 inch Victaulic AGS-Vic 300 14-24 inch, or equal.

G. Check Valves:

1. Swing Check Valves - two inch and smaller: MSS SP-80; Class 150, cast bronze body and cap, conforming to ASTM B 62, horizontal swing, with a Teflon disc, and having threaded ends. Valve shall be capable of being repaired while the valve remains in the line.

MANUFACTURER	
Milwaukee:	5tenT
Crane:	x
Jenkins:	352C
Lunkenheimer:	230-70
Nibco:	T-433-Y
Stockham:	B-321
Or equal	

For grooved connections use Victaulic Series 716, 779, or equal.

2. Swing Check Valves - 2-1/2 inch and larger: MSS SP-71; Class 125 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.

MANUFACTURER	CLASS 125	CLASS 175
Milwaukee:	F-2974-M	x
Crane:	373	375
Jenkins:	624C	477
Lunkenheimer:	1790	x
Nibco:	F-918B	x
Stockham:	G-931	G-940
Or equal		

3. Wafer Check Valves - (Non-Slam): Class 250, cast iron body, replaceable lapped bronze seat, lapped and balanced twin bronze flappers and stainless steel trim. Valve shall be designed to open and close at approximately one foot differential pressure. Twin flappers shall be loaded with a stainless steel torsion spring to minimize flapper drag and assure even non-slam checking action.

MANUFACTURER
Milwaukee: 1400-2C
Center Line: CLC
Metraflex: Chexx
Mission: 12HMP
Stockham: WATER GUAGE970
Or equal

For grooved connection use Victaulic Series 716 and 779, and for 14-24 in use Victaulic AGS W715.

4. Lift Check Valves - two inch and smaller: Class 125, cast bronze body and cap conforming to ASTM B 62, horizontal, lift type valve, bronze disc and threaded ends. Valve shall be capable of being refitted and ground while the valve remains in the line.

MANUFACTURER HORIZONTAL
Milwaukee: 544
Hammond: 901
Jenkins: 117C
Lunkenheimer: 2142
Or equal

H. Flow Control Manual Balancing Valves
1. Balancing valves shall be installed, as shown on the drawings and as required, to ensure the accurate balancing of all flows in the hydronic heating and cooling systems. The balancing shall meet the specified water flows with a maximum tolerance of ±5 percent.
2. Valves shall be of the "Y" pattern globe style design and must offer a minimum of four full rotations of the handwheel for accurate adjustment and for precise flow control.
3. Valves shall exhibit an accuracy of ±5 percent within the normal operating range.
4. Valves shall have integral self-sealing metering ports for measuring differential pressure, flow rates and temperature. Ports shall be protected with individual threaded caps.
5. Valves must offer ten0 percent positive, leakproof shutoff against the same fluid pressure as the valve body rating to a nominal value of 300 degrees Fahrenheit at 250 pounds per square inch.
6. Valves sizes 1/2 inch to two inch similar to TA (STAD/S) shall have a digital handwheel for positioning accuracy. Provide a transparent dust/paint cover to prevent destruction of the digits during construction. Sizes 2 1/2 inch to 12 inch similar to TA (STAF/G) shall have a numerical vernier sleeve for position readout.
7. All balancing valves must offer a hidden memory feature to prevent unauthorized adjustment and to ensure a return to the original setting after shutoff.
8. All balancing valves shall comply with international quality standard ISO 9001.
9. Valves larger than 12 inch: use lubricated plug valve.
10. All balancing valves size 1/2 inch to two inch shall be manufactured from pressure diecast dezincification resistant AMETAL copper alloy which does not require dielectric fittings. Valve bodies size 2 1/2 inch to 12 inch shall be manufactured from a cast iron equivalent to ASTM 35B with all wetted, moving parts of dezincification resistant AMETAL copper alloy.
11. Acceptable Manufactures: Manufacturers subject to specification requirements above include: Tour and Anderson, Crane, Griswold or Equal.

I. Coil Pak – Manual Flow Control: Contractor shall provide and install manual flow control coil piping packages at all locations as detailed in the construction documents that meet specification requirements.
1. Coil Paks shall be designed for a minimum 600 POUNDS PER SQUARE INCH WOG working pressure for sizes ½ inch through 2½ inch and up to 325 degrees Fahrenheit.
2. Each Coil Pak is to include a minimum of UltraMB™ or equal combination manual flow control valve, dual isolation valve, and integral union with two pressure & temperature test plugs; UltraY™ combination y-strainer, isolation valve, blow down / drain valve, and union with one pressure and temperature test plug; UltraU™ accessory port union with one manual air vent and one pressure and temperature test plug. Provide isolation valve for each air vent to allow for future replacement.
3. Each Coil Pak shall be “Bagged & Tagged” for easy identification and storage.

4. Extended pressure and temperature test plugs, manual air vents and handles shall be available. Extended handles shall not break the vapor barrier when operated.
5. Balancing Valves, double duty and triple duty valves shall have downstream Isolation valve to allow for future change out of valve without the need to drain the entire system.
6. Control valves shall have downstream and upstream isolation valves to allow for change out of control valve without the need to drain system and terminal unit or coil piping.
7. Valve Body:
   a. Valves two inch and smaller shall be a forged DZR brass, two pressure/temperature test ports for flow measuring, EPDM o-ring seals, permanent flow direction indication arrow, and rated at 360 POUNDS PER SQUARE INCH WOG, 250 degrees F. Valves shall be available in NPT connections; like the Nexus Dynamic™ (Model ND.)
   b. Extended temperature test plugs shall be provide in locations above ceiling tiles.
   c. The valve shall carry a minimum five year product warranty.
8. Y Strainers:
   a. Y type strainers ½ inch through 2½ inch shall be a combination Y Strainer and Ball Valve with integrated Union. Valves shall be a forged brass construction for sizes ½ inch through 1½ inch and cast brass for sizes two inch – 2½ inch with the following features; like Nexus UltraY™ (Model UY).
   b. A minimum of 600 POUNDS PER SQUARE INCH WOG, 325 degrees Fahrenheit.
   c. Interchangeable union end with FKM o-ring seal.
   d. Multiple ¼ inch tapped ports for test plugs, vents or other accessories.
   e. Blowout proof stem with dual FKM o-rings.
   f. Hard chrome plated ball with Teflon™ seats.
   g. A 304 stainless steel filter screen accessible without affecting the valve piping.
   h. A port in the filter cap for a blow down/drain valve.
   i. Valves shall be available with NPT, SWT, PRESS or PUSH connections.
   j. Solid stainless steel ball and stainless steel valve stem shall be provided
   k. Valve shall carry a minimum five year product warranty.
9. Unions:
   a. Unions ½ inch through two inch shall be a combination ported type. Unions shall be a forged brass construction with the following features; like Nexus UltraU™ (Model UU).
   b. A minimum of 600 POUNDS PER SQUARE INCH WOG, 325 degrees F.
   c. Interchangable union end with Viton o-ring seal.
   d. Multiple ¼ inch tapped ports for test plugs, vents or other accessories.
   e. Union shall carry a minimum five year product warranty.
10. Stainless Steel Braided Hoses:
    a. Contactor at his option may use stainless steel flexible hose assemblies. Hose materials shall be stainless steel braiding over a Kevlar reinforced EPDM rubber tube with the following features; like Nexus UltraFlex™ (Model UFHF, UFHM, UFH).
    b. Ferrules shall be stainless steel for sizes ½ inch – two inch.
    c. Hoses ¾ inch– one inch shall be double swivel design.
    d. End fittings for sizes ¾ inch – 2 shall be brass NPSM swivel with seal or MNPT.
    e. Temperature rating for ¾ inch – two inch hoses shall be 5 – 248 degrees F.
    f. Working pressure shall be 400 POUNDS PER SQUARE INCH for ½ inch – one inch and 300 POUNDS PER SQUARE INCH for 1¼ inch – two inch.
    g. Hoses shall meet or exceed ASTM E 84-00 fire rating. (NFPA 255, ANSI/UL 723 & UBC 8-1)
    h. Size 2½ inch stainless steel braiding over stainless fire rated tube shall be available.
    i. Hoses shall carry a minimum five year product warranty.
11. Approved Manufacturers:
    a. Nexus Valve, Inc.
    b. Tour Anderson
    c. Hayes
    d. Or Equal

2.03 METERS AND GAGES

A. Glass Thermometers
   1. General: Provide glass thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

2. Case: Die cast aluminum finished in baked epoxy enamel, glass front, spring secured, nine inch long.
3. Adjustable Joint: Die cast aluminum, finished to match case, 180 degrees adjustment in vertical plane, 360 degrees adjustment in horizontal plane, with locking device.
4. Tube and Capillary: magnifying red liquid, 1 percent scale range accuracy, shock mounted.
5. Scale: Satin faced, non-reflective aluminum, permanently etched markings.
6. Stem: Copper-plated steel, or brass, for separable socket, length to suit installation.
7. Range: Conform to the following:
   a. Hot Water: 30 degrees - 240 degrees Fahrenheit . with five degrees Fahrenheit . scale.
   b. Chilled Water and Condenser Water: -30 degrees - 1ten degrees Fahrenheit . with five degrees Fahrenheit . scale
8. Manufacturer: Subject to compliance with requirements, provide glass thermometers of one of the following:
   a. Ernst Gage Co.
   b. Marshalltown Instruments, Inc.
   c. Trerice (H.O.) Co.
   d. Weis Instruments, Inc.
   e. Or Equal.

B. Thermometer Wells
1. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide two inch extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.
2. Manufacturer: Subject to compliance with requirements, provide glass thermometers of one of the following:
   a. Ernst Gage Co.
   b. Marshalltown Instruments, Inc.
   c. Trerice (H.O.) Co.
   d. Weis Instruments, Inc.
   e. Or Equal.

C. Pressure Gages
1. General: Provide pressure gages of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
2. Type: General use, one percent accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection.
3. Case: Drawn steel or brass, glass lens, 4-1/2 inch diameter.
4. Connector: Brass with 1/4 inch male NPT. Provide protective siphon when used for steam service.
5. Scale: White coated aluminum, with permanently etched markings.
6. Range: Conform to the following:
   a. Water: 0 - ten0 pounds per square inch.
      50 - 300 pounds per square inch.
7. Manufacturer: Subject to compliance with requirements, provide pressure gages of one of the following:
   a. Ametek/U.S. Gauge.
   b. Marsh Instrument Co., Unit of General Signal.
   c. Marshalltown Instruments, Inc.
   d. Trerice (H.O.) Co.
   e. Weiss Instruments, Inc.
   f. Or Equal.

D. Pressure Gage Cocks
1. General: Provide pressure gage cocks between pressure gages and gage tees on piping systems. Construct gage cock of brass with 1/4 inch female NPT on each end, and "T" handle brass plug.
2. Siphon: 1/4 inch straight coil constructed of brass tubing with 1/4 inch male NPT on each end.
3. Manufacturer: Same as for pressure gages.

E. Annular Element Flow Meters And Fittings
   1. General: Provide flow metering elements constructed of brass and stainless steel, equipped with readout valves to facilitate connecting of differential pressure meter to flow meter. Equip each readout valve with integral shut-off valve designed to minimize system fluid loss during monitoring process. Provide ball type brass isolation valve. Provide calibrated nameplate with flow meter detailing its flow range through range of differential head pressures. Each element shall be of the bi-directional type having four diametrically opposed sensing ports on both upstream and downstream sides in order to ensure average velocity and static pressure. Elements shall be capable of operating at a maximum temperature of 300 degrees Fahrenheit. and maximum pressure of 250 pounds per square inch.
   2. Manufacturer: Subject to compliance with requirements, provide flow meters of one of the following:
      a. Preso Industries Corp.
      b. Meriam Instrument.
      c. Dieterich Standard Corp.
      d. Or Equal.

F. Calibrated Balance Valves
   1. General: Provide calibrated balance valves equipped with readout valves to facilitate connecting of differential pressure meter to balance valves. Equip each readout valve with integral EPT check valve designed to minimize system fluid loss during monitoring process. Provide calibrated nameplate to indicated degree of closure of precision machined orifice. Construct balancing valve with internal EPT 0-ring seals to prevent leakage around rotating element. Provide balance valves with preformed polyurethane insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment.
   2. Manufacturer: Subject to compliance with requirements, provide calibrated balance valves of one of the following:
      a. Bell & Gossett ITT; Fluid Handling Div.
      b. Taco, Inc.
      c. Armstrong Pumps Inc.
      d. Tour and Andersson
      e. Or Equal.

2.04 HANGERS AND ATTACHMENTS (Refer to section 230548 for coordination)

A. Horizontal-Piping Hangers and Supports:
   1. General: Except as otherwise indicated, provide factory-fabricated horizontal piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-58 and manufacturer's published product information. Use only one type by one manufacture for each piping service. Select size of hangers and supports to exactly fit pip size for bare piping, and to insulated piping. Provide copper-plated hangers and supports for copper-piping systems.
      a. Adjustable Steel Clevises Hangers: MSS Type 1.
      b. Steel Pipe Clamps: MSS Type 4.
      c. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
         1) Plate: Unguided type.
         2) Plate: Guided type.
         3) Plate: Hold-down clamp type.
      d. Pipe Saddle Supports: MSS Type 36, including steel pipe base-support and cast-iron floor flange.
      e. Pipe Stanchion Saddles: MSS Tube 37, including steel pip base support and cast-iron floor flange.
      f. Adjustable Pipe Saddle Supports: MSS Type 38, including steelpipe base support and cast-iron floor flange.
      g. Single Pipe Rolls: MSS Type 41.
      h. Adjustable Roller Hangers: MSS Type 43.
      i. Pipe Roll Stands: MSS Type 44.
      j. Pipe Rolls and Plates: MSS Type 45.
      k. Adjustable Pipe Roll Stands: MSS Type 46.
   2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:

a. Carpenter and Patterson, Inc.
b. Corner & Lada Co., Inc.
c. Elcen Metal Products Co.
d. Fee & Mason Mfg. Co.; Div. Figgie International
e. ITT Grinnel Corp.
f. Or Equal.

B. Wire (Air Craft Cable) Hangers
1. Wire hangers shall be used to suspend all mechanical, ductwork and HVAC services that are located above metal perforated ceilings or in exposed areas. Coordinate with Construction Manager for all locations. Coordinate with electrical contractor for installation of cable tray under ring (flat oval) ductwork.
2. Wire hangers consist of a pre-formed wire rope sling with either a ferruled loop, permanently fixed threaded ¼ inch (or 3/8 inch) stud, or permanently fixed nipple end with toggle, at one end or hook or eyelet. The end fixings and the wire must be of the same manufacturer. The system is secured and tensioned with a self-locking grip at the other end.
3. Only wire and or supports supplied and or approved, shall be used with the system
4. Standards
   a. Wire hangers must be independently tested APAVE, TUV, UL, CSA and SMACNA, approved by ULC and CSA and comply with the requirements of DW/144 and BSRIA - Wire Rope Suspension Systems.
   b. Wire rope used must be manufactured to BS EN 12385: 2002.
5. Product Selection
   a. The HVAC Sub-contractor shall select the correct specification of wire hanger to use for supporting each particular service from table 1 below.
   b. Each size is designated with a maximum Safe Working Load limit (which incorporates a 5:1 safety factor).
   c. The correct specification of Wire hanger required is determined using the following formula:
   d. Weight per meter of object suspended (kg) x Distance between suspension points (m) equal Weight loading per hanger suspension point (kg).
   e. Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations given in the manufacturer's handbook.
   f. The HVAC Sub-contractor shall select the correct length of wire rope required to support the service. Lengths from 5, 10, 15, 20 and 30 ft lengths. Specials can be made, check with manufacturer.
   g. No in-line joins should be made in the rope.
   h. Table 1
   i. Wire Hanger Safe Working Loads

Size	**Working Load limit (lbs)**
No.1	0-22 lbs
No.2	23-ten0 lbs
No.3	101-200 lbs
No.4	2ten -495 lbs
No.5	496 – 715 lbs

6. Installation
   a. The wire hangers can be fixed to any building structure.
   b. Hanger Loop end can be wrapped around purlins, beams, roof trusses and other accessible building features.
   c. Hanger Stud end can be fixed with suitable anchors into concrete ceilings and structures, metal decking and pressed metal brackets (using nuts).
   d. Hanger Toggle end can be fixed into profile roof cladding, light fittings and luminaries.
   e. Other wire rope systems can be fixed to an approved structure, as determined by the Engineer
   f. The Wire hangers should not be fixed to any other services, without the approval of the Engineer.
   g. When using wire hangers with other manufacturer's fixings these must be installed in accordance with the manufacturer's loading and installation instructions. The free end of

the wire rope should be threaded through one channel of the self-locking grip before being either passed around the object being suspended or connected to it, using a suitable fixing. The wire rope is then threaded back through the second channel in the grip until the required level is achieved.

h. It is recommended that objects be installed low and adjusted upwards to the required level.
i. Should the object require lowering, the grip can be unlocked using a setting key allowing the suspension to be lowered or lengthened. When unlocking the grip, the weight of the suspended object must be independently supported.
j. The wire rope must not be damaged, twisted or deformed in any way prior to, or during, installation. Any such ropes must be discarded and replaced.
k. When installing wire hangers the angle between the ropes when exiting the self locking grip must never exceed 60°.
l. Lubricants, paint or any other coating should not be applied to the wire hanger as it may impair its performance.
m. Wire hangers must always be installed in accordance with all the manufacturer's recommendations.

C. Vertical-Piping Clamps:
1. General: Except as otherwise indicated, provide factory-fabricated vertical-piping clamps, complying with MSS SP-58, of one of the following types listed, selected by Installer to suit vertical piping systems, in accordance with MSS SP-58 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper-piping systems.
a. Two-Bolt Riser Clamps: MSS Type 8.
b. Four-Bolt Riser Clamps: MSS Type 42.
2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
a. Carpenter and Patterson, Inc.
b. Corner & Lada Co., Inc.
c. Elcen Metal Products Co.
d. Fee & Mason Mfg. Co.; Div. Figgie International
e. ITT Grinnel Corp.
f. Or Equal.

D. Hanger-Rod Attachments:
1. General: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-pipe hangers and building attachments, in accordance with MSS SP-58 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems.
a. Steel Turnbuckles: MSS Type 13.
b. Swivel Turnbuckles: MSS Type 15.
c. Malleable Iron Sockets: MSS Type 16.
2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
a. Carpenter and Patterson, Inc.
b. Corner & Lada Co., Inc.
c. Elcen Metal Products Co.
d. Fee & Mason Mfg. Co.; Div. Figgie International
e. ITT Grinnel Corp.
f. Or Equal.

E. Building Attachments:
1. General: Except as otherwise indicate, provide factory-fabricated building attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit building substrate conditions, in accordance with MSS SP-58 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper-piping systems.
a. Concrete Inserts: MSS Type 18.
b. Top Beam C-Clamp: MSS Type 19.

c. Side Beam or Channel Clamps: MSS Type 20.
d. Center Beam Clamps: MSS Type 21.
e. Welded Beam Attachments: MSS Type 22.
f. C-Clamps: MSS Type 23.
g. Top Beam Clamps: MSS Type 25.
h. Side Beam Clamps: MSS Type 27.
i. Steel Beam Clamps W/Eye Nut: MSS Type 28.
j. Linked Steel Clamps W/Eye Nut: MSS Type 29.
k. Malleable Beam Clamps: MSS Type 30.
l. Steel Brackets: One of the following for indicated loading:
1) Light Duty: MSS Type 31.
2) Medium Duty: MSS Type 32.
3) Heavy Duty: MSS Type 33.
m. Side Beam Brackets: MSS Type 34.
n. Plate Lugs: MSS Type 57.
o. Horizontal Travelers: MSS Type 58.

2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
a. Carpenter and Patterson, Inc.
b. Corner & Lada Co., Inc.
c. Elcen Metal Products Co.
d. Fee & Mason Mfg. Co.; Div. Figgie International
e. ITT Grinnel Corp.
f. Or Equal.

F. Saddles and Shields:
1. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
2. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
3. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.
4. Manufacturer: Subject to compliance with requirements, provide thermal hanger shields of one of the following:
a. Elcen Metal Products Co.
b. Pipe Shields, Inc.
c. Carpenter Patterson, Inc.
d. ITT Grinnel Corp.
e. Or Equal.

G. Miscellaneous Materials:
1. Metal Framing: Provide products complying with NEMA STD ML 1.
2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A 36.
3. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of one part cement to three parts sand, by volume, with minimum amount of water required for placement and hydration.
4. Heavy Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.
5. Pipe Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

2.05 MECHANICAL IDENTIFICATION (Refer to section 01 91 13 - for additional contract requirements)

A. Plastic Pipe Markers:
1. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1
2. All exposed piping that is visible shall be provided with color coordinated PVC jacketing by pipe type and system PVC

3. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1
4. Insulation: Furnish one inch thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees Fahrenheit or greater. Cut length to extend two inch beyond each end of plastic pipe marker.
5. Small Pipes: For external diameters less than sox inch (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:
    a. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
    b. Adhesive lap joint in pipe marker overlap.
    c. Laminated or bonded application of pipe marker to pipe (or insulation).
    d. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4 inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2 inch

B. Application: Provide pipe labels for the following piping system:
1. Heating hot supply and return.
2. Refrigerant liquid and suction.
3. Condensate drain.
4. Chilled water supply and return
5. Compensated Chilled water Supply & Return
6. Condenser water (ground source) supply and return
7. Make-up water

C. Valve Tags:
1. Brass Valve Tags: Provide 19-gage polished brass valve tags with stamp-engraved piping system abbreviation in 1/4 inch high letters and sequenced valve numbers 1/2 inch high, and with 5/32 inch hole for fastener.
    a. Provide 1-1/2 inch diameter tags, except as otherwise indicated.
    b. Provide size and shape as specified or scheduled for each piping system.
    c. Fill tag engraving with black enamel.
2. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

D. Valve Schedule Frames:
1. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.

E. Plastic Equipment Markers:
1. General: Provide manufacturer's standard laminated plastic, color-coded equipment markers. Conform to the following color code:
    a. Green: Cooling equipment and components.
    b. Yellow: Heating equipment and components.
    c. Yellow/Green: Combination cooling and heating equipment and components.
    d. Blue: Equipment and components that do not meet any of the above criteria.
2. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
    a. Equipment label “ID” from schedules.
    b. Design capacity from schedules.
3. Size: Provide approximate 2-1/2 inch by six inch markers for each piece of equipment.
4. Application: Provide equipment labels for the following equipment:
    a. Water source Heat Pump Chillers
    b. Boilers
    c. Pumps
    d. Expansion Tanks
    e. Rooftop Air Handling Units (RTU) and Air Handling Units (AHU)
    f. Kitchen Make-Up Air Units (MAU)
    g. Exhaust Fans
    h. Air Cooled Condensing Units
    i. VAV Boxes
    j. Terminal Heating Units equipped with fans

k. Ductless Cooling Unit Systems
l. Buffer Tanks
m. Glycol Feeder Units
n. Expansion Tanks
o. Air Separators

F. Ductwork Labels:
1. Provide painted stencils or standard laminated plastic, color coded labels for the following systems:
a. Supply Ductwork
b. Return Ductwork
c. Exhaust Ductwork
d. Hazardous / Fume Hood Exhaust
e. Outside Air Ductwork
f. Grease Ductwork

2.06 MECHANICAL INSULATION (Note: Insulation for pipe and equipment within water source heat pump chiller room shall be field installed and provided by HVAC insulation contractor).

A. Piping Insulation Materials:
1. Fiberglass Piping Insulation: ASTM C 547, Class 45 required.
a. Class 1 for use to 450 degrees Fahrenheit; Class 2 for use to 650 degrees Fahrenheit; Class 3 for use to 1200 degrees Fahrenheit.
2. Flexible Unicellular Piping Insulation: ASTM C 534, Type as required.
a. Type I - tubular; Type II - sheet. For use between -40 degrees F and 200 degrees F.
3. Jackets for piping Insulation: ASTM C 921, with vapor barrier for piping with temperatures below ambient.
4. Encase pipe fittings insulation with one-piece pre-molded PVC fitting covers, fastened as per manufacturer's recommendations.
5. Encase straight pipe insulation, where exposed in visible areas, including piping located in mechanical room with one piece 20mil thick PVC Jacketing. PVC covering color shall be per ANSI/ASME 13.1 Standard. Submit color chart for Architect/Engineer review and approval. Fasten and seal as per manufacturer's recommendations.
6. Encase all exterior piping insulation with embossed aluminum jacket with weather-proof construction.
7. Staples, Bands, Wires and Cement: As recommended by insulation manufacturer for applications indicated.
8. Adhesives, Sealants and Protective Finishes: As recommended by insulation manufacturer for applications indicated.
a. Refer to section 230001, 2.05 for insulated pipe jacketing requirements.

B. Piping Insulation Application and Thickness:
1. Application: Cold Piping (40 Degrees Fahrenheit to Ambient):
a. Insulate the following cold HVAC piping systems:
1) HVAC make-up water piping.
2) Air conditioner condensate drain piping.
3) Refrigerant liquid and suction piping.
4) Chilled water supply and return piping.
5) Condenser (ground source) water supply and return piping.
6) **Flexible Unicellular insulation may be used for suction and liquid refrigerant pipes provided it meets the specified thickness listed in in section 2.06 paragraph B.1 and is IMC code compliant.**
b. Insulate piping system specified above with the following type and thickness of insulation:
1) Fiberglass: 1-1/2 inch thick for all pipe sizes.
2) **Flexible Unicellular insulation may be used for suction and liquid refrigerant pipes provided it meets the specified thickness listed in in section 2.06 paragraph B.1 and is IMC code compliant.**
2. Application: Hot HVAC Piping (to 200 Degrees Fahrenheit)
a. Insulate the following hot HVAC piping systems
1) HVAC hot water supply and return piping.
2) Hot gas refrigerant piping.

b. Insulate each piping system specified above with the following type and thickness of insulation:
   1) Fiberglass: 1-1/2 inch thick for pipe sizes up to and including 1 1/4 in, two inch thick for all 1-1/2 inch pipe and larger.
   2) Flexible Unicellular: (Refrigerant piping only) one inch thick.

3. Insulation on Piping Exposed to Weather: Protect outdoor insulation from weather by installing outdoor protective finish embossed aluminum jacketing installed as recommended by the manufacturer. Insulation thickness shall be increased by one size versus specified pipe insulation thickness.
4. Refrigerant liquid and suction piping exposed indoors shall have armaflex insulation and be protected with weatherproof/UV resistant PVC jacketing. Exterior refrigerant piping insulation shall be double the specified thickness and have an embossed aluminum jacket.
5. Provide PVC colored pipe jacket for all exposed HVAC piping in mechanical room. PVC jacketing shall be based on pipe type colors in accordance with ANSI/ASME B.1 Standard for the identification of pipes. A full color chart of recommended PVC jacket colors shall be submitted to the architect and engineer for final selections and approval.
   a. Recommended PVC color jacket color chart should be as follows:
      1) Chilled water shall be light blue
      2) Condenser water shall be light green
      3) Heating hot water shall be orange
      4) Make Up Water shall be Dark Blue
      5) Drain lines shall be Dark Gray
   b. All colors shall be confirmed in ANSI/ASME 13.1 standard for identification of pipes and submitted to the architect and engineer for final review and approval.

C. Ductwork Insulation Materials:
1. Rigid Fiberglass Ductwork Insulation (R-8): ASTM C 612, Class as required.
   CLASS 2 - 400 DEGREES FAHRENHEIT; 4 Pounds per Cubic Foot.
   CLASS 3 - 850 DEGREES FAHRENHEIT; 12 Pounds per Cubic Foot.
   CLASS 4 - ten00 DEGREES FAHRENHEIT; 12 Pounds per Cubic Foot.
   CLASS 5 - 1800 DEGREES FAHRENHEIT; 20 Pounds per Cubic Foot.
2. Flexible Fiberglass Ductwork Insulation (R-6): ASTM C 512, Class as required.
   CLASS 2 - 400 DEGREES FAHRENHEIT; .75 Pounds per Cubic Foot.
   CLASS 3 - 850 DEGREES FAHRENHEIT; 1.5 Pounds per Cubic Foot.
3. Jackets for Ductwork Insulation: ASTM C 921, with vapor barrier.
4. Ductwork Insulation Accessories: Provide staples, bands, wire, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.
5. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.

D. Ductwork Insulation Application and Thickness:
1. Application: Ventilation and AC System Ductwork:
   a. Insulate the following ductwork:
      1) Outdoor air intake ductwork between air entrance and air handling unit inlet.
      2) HVAC supply ductwork between HVAC unit discharge and room terminal outlet.
      3) Insulate neck and bells of supply diffusers.
      4) HVAC return ductwork 20 feet downstream of HVAC unit inlet;.
      5) HVAC plenums and unit housing not pre-insulated at factory or lined.
      6) Exhaust ductwork between in-line exhaust fan and point of exit in building, or 20 feet of exit of building.
      7) Omit exterior insulation for double walled internally lined/insulated ductwork exposed within occupied areas of the building.
      8) Omit exterior insulation on exposed ductwork within occupied areas of the building where specifically noted on the plans. If ductwork is not noted specifically noted on plans to have exterior insulation omitted, exterior insulation must be provided.
   b. Insulate each ductwork system specified above with the following type and thickness of insulation:

1) Rigid Fiberglass: In machine rooms, fan rooms, and mechanical spaces insulate all supply air, return air and outside air ductwork with two inch thick rigid (minimum R-8).
2) Flexible Fiberglass: 1-1/2 inch thick (minimum R-6), application limited to concealed locations which shall include above ceilings, in chases, and shafts.
3) All outside air ductwork within conditioned areas of the building shall be two inch rigid (minimum R-8). All outside air ductwork within un-conditioned areas of the building shall be three inch rigid (minimum R-12).
4) Refer to Exterior Ductwork systems specification for exterior ductwork.

2. Equipment Insulation Materials:
3. Rigid Fiberglass Equipment Insulation (R-8): ASTM C 612, Class as required.
   CLASS 2 - 400 DEGREES FAHRENHEIT; Pounds per Cubic Foot.
   CLASS 3 - 850 DEGREES FAHRENHEIT; Pounds per Cubic Foot.
   CLASS 4 - ten00 DEGREES FAHRENHEIT 12 Pounds per Cubic Foot.
   CLASS 5 - 1800 DEGREES FAHRENHEIT; 20 Pounds per Cubic Foot.
4. Flexible fiberglass Equipment Insulation (R-6): ASTM C 553, Type and Class.
   TYPE I - RESILIENT, FLEXIBLE;
   CLASS B-1 - 0.65 Pounds per Cubic Foot
   CLASS B-2 - 0.75 Pounds per Cubic Foot
   CLASS B-3 - 1.00 Pounds per Cubic Foot
   CLASS B-4 - 1.50 Pounds per Cubic Foot
   CLASS B-5 - 2.00 Pounds per Cubic Foot
   CLASS B-6 - 3.00 Pounds per Cubic Foot
   TYPE II - FLEXIBLE; CLASS F-1 - 4.50 Pounds per Cubic Foot
   TYPE III - SEMIRIGID; CLASS F-2 - 4.50 Pounds per Cubic Foot
5. Flexible Unicellular Equipment Insulation: ASTM C 534, Type as required.
   TYPE I - TUBULAR.
   TYPE II - SHEET.
6. Jacketing material for Equipment Insulation: Provide pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.
7. Equipment Insulation Compounds; Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.
8. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

E. Equipment Insulation Application and Thickness:
1. Application: Cold Equipment (Below Space Temperature):
   a. Insulate the following cold equipment:
      1) Drip pan under chilled equipment.
      2) Expansion and Buffer Tanks
      3) Chilled Water pumps
      4) Condenser Water Pumps
      5) Air Separator
   b. Insulate each item of equipment specified above with the following type and thickness of insulation:
      1) Fiberglass: two inch thick for cold surfaces above 35 degrees Fahrenheit and three inch thick for surfaces 35 degrees Fahrenheit and lower.
      2) Flexible Unicellular: one inch thick.
2. Application: Hot Equipment
   a. Insulate the following:
      1) Expansion Tank
      2) Air Separator
      3) All Radiant Panels (laid on top of the panel/Coord with manufacturer)
   b. Insulate each item of equipment specified above with the following type and thickness of insulation:
      1) Fiberglass two inch thick.
      2) Faced Fiberglass one inch thick for radiant panels.

2.07 KITCHEN GREASE DUCT INSULATION

A. MATERIAL
   1. Thermal Material: 2192 degrees Fahrenheit rated core blanket, manufactured from patented bio-soluble Superwool chemistry (Calcium Magnesium Silicate).
      a. Product: FireMaster FastWrap XL or Pyroscat Duct Wrap XL as manufactured by Thermal Ceramics.
      b. Fully encapsulated thermal material in fiberglass reinforced aluminum/polypropylene scrim (FSP).
         1) Encapsulation FSP marked with UL Classification Mark.
         2) Encapsulation FSP marked with ICC-ES report number ESR 2213 or ESR 2832.
         3) Collars supplied in six inch (150 mm) wide by 25 feet (7620 mm) long rolls.
   2. Product Characteristics:
      a. Thickness: 1-1/2 inch (38 mm).
      b. Nominal Density: six pounds per cubic foot.
      c. R-Value: 7.35 per layer of FireMaster FastWrap XL or Pyroscat Duct Wrap XL when tested in accordance with ÅSTM C 518 at 75 Fahrenheit.
      d. Flame Spread: <25 when tested in accordance with ASTM E 84.
      e. Smoke Development: <50 when tested in accordance with ASTM E 84.

B. ACCESSORY MATERIALS:
   1. Glass Filament Tape: Minimum 3/4 inch (19 mm) wide - used to temporarily secure blanket until permanent attachment using steel banding and/or steel insulation pins.
   2. Aluminum Foil Tape: Minimum three inch (76 mm) used to seal cut edges.
   3. Carbon Steel or Stainless Strapping Material Minimum: 1/2 inch (13 mm) wide and 0.015 inch (.38 mm) thick
   4. Steel Insulation Pins: Minimum 12-gauge, length sufficient to penetrate through duct wrap insulation.
   5. Insulation Clips: Galvanized steel, minimum 1-1/2 inch (38 mm) round or square.
   6. Through Penetration Firestop Sealants:
      a. Packing Material: Remove encapsulation material from FireMaster FastWrap XL or Pyroscat Duct Wrap XL, use core blanket (white) as penetration packing material.
      b. Firestop sealants per applicable building code report and/or laboratory design listings.
   7. Grease and HVAC Duct Access Doors:
      a. Thermal Ceramics FastDoor XL Access doors; Supplied in standard door sizes of six by ten inch (152 mm by 254 mm), 8 by 12 inch (203 mm by 305 mm), 12 by 12 inch (305 mm by 305 mm) 12 by16 inch (305 mm by 406 mm), and 20 by20 inch (508 mm by 508 mm).

2.08 HYDRONIC PIPING AND ACCESSORIES

A. HVAC Hydronic Piping shall be Schedule 40 Steel or Type L Copper for piping ½ inch thru two inch size and Schedule 40 Steel Piping. Schedule 40 Steel Piping over two inch size shall be welded.

B. Manufacturer: Subject to compliance with requirements, provide piping system products from one of the following:
   1. Grooved Mechanical Joint Pipe, Fittings and Couplings:
      a. Victaulic Company of America.
      b. Anvil Gruvlok
      c. Grinnell
      d. Or equal
   2. Pump Discharge Valves (Triple-Duty Valve):
      a. Bell & Gossett ITT; Fluid Handling Div.
      b. Amtrol, Inc.
      c. Armstrong Pumps, Inc.
      d. Taco, Inc.
      e. Or equal
   3. Safety Relief Valves:
      a. Bell & Gossett ITT; Fluid Handling Div.
      b. Amtrol, Inc.
      c. Spirax Sarco.
      d. Watts Regulator Co.
      e. Or equal

4. Pressure Reducing Valves:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Amtrol, Inc.
   c. Armstrong Pumps, Inc.
   d. Taco, Inc.
   e. Victaulic/Bermad
   f. Or equal
5. Air Vents (Automatic):
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Armstrong Machine Works.
   c. Hoffman Specialty ITT; Fludi Handling Div.
   d. Spirax Sarco.
   e. Or equal
6. Air Separators:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Amtrol, Inc.
   c. Armstrong Pumps, Inc.
   d. Taco, Inc.
   e. Or equal
7. Diaphragm-Type Compression Tanks:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Amtrol, Inc.
   c. Armstrong Pumps, Inc.
   d. Or equal
8. Pump Suction Diffusers:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Amtrol, Inc.
   c. Armstrong Pumps, Inc.
   d. Taco, Inc.
   e. Or equal
9. Chemical Feeder:
   a. Dearborn USA.
   b. Vulcan Laboratories, Subsidiary of Clow Corp.
   c. York-Shipley, Inc.
   d. Or equal
10. Basket Strainers:
   a. Crane Co.
   b. Metraflex Co.
   c. Spirax Sarco.
   d. Or equal

C. PIPE AND TUBING MATERIALS
1. Copper Tubing: ASTM grade B 88, Type L hard drawn temper copper tubing.
2. Copper Tubing: ASMT grade B 88, Type K, annealed copper tubing.
3. Steel Pipe: ASTM A-53 grade B, Schedule 40, seamless, black steel pipe, beveled ends.
4. CPVC Plastic Pipe: ASTM D 2846, Chlorinated Poly (Vinyl Chloride) (CPVC) pipe.
5. UNDERGROUND PIPE AND TUBING MATERIALS
   a. Supply and return piping shall be a factory fabricated HDPE-Jacketed underground piping as manufactured by Perma-Pipe, Insul-tek, Ameron, Rovanco or equal.
   b. The underground piping shall be fiberglass jacketed; spray applied polyurethane foam insulated piping system suitable for underground installation.
   c. Contractor shall show pipe sizes, locations and elevations on submittals and coordination drawings. Show piping in trench, cased pipe with details showing clearances between piping and show insulation thickness.
   d. Carrier Pipe: Schedule-40 ASTM A53, Grade B, ERW, black steel in single or double-random lengths, with ends factory-beveled for field-welding of joints.
   e. Carrier Pipe Insulation: Polyisocyanurate Foam Pipe Insulation capable of operating at continuous service temperatures of 300O F: Rigid, closed-cell, high-pressure injected between carrier pipe and jacket, 1-1/2 inch minimum thickness, all around. Comply with

ASTM C591, Grade 2, Type IV; thermal conductivity (k-value) shall not exceed 0.165 BTU-in/hr-ft2-OF aged 180-days at 75OF. Pre-insulated pipe manufacturer shall furnish independent test reports and data supplied by the manufacturer of the foam insulation that the insulation meets or exceeds the requirements specified herein

f. Casing: Seamless extruded black High-Density Polyethylene (HDPE) manufactured from polyethylene resin compound qualified as Type III, Category 5, Class C, Grade P23 or P34 in accordance with ASTM D1248 and D3350, having a casing wall thickness of not less than 175 mils.
g. Provide pipe ends, STEEL to HDPE transition fittings and connections to ground source well piping that are compatible with the ground source well piping manufacturer's piping material and going requirements.
h. Install underground piping in accordance with manufacturers requirements.

6. Propress or equal piping and fittings shall be allowable at contractor option for copper piping sized two inch and under.
7. Victaulic or equal grooved piping and fittings shall be allowable at the contractor option for Schedule 40 steel piping 2 ½ inch or larger. HVAC Contractor shall obtain the services of a grooved coupling manufacturer's factory trained representative to provide the following:
    1) Prior to grooving, on-site inspection of the proposed grooving tools and written acceptance of same.
    2) Prior to grooving, on-site training of Contractor's field personnel in the use of grooving tools. application of groove and installation of grooved joint products. Contractor to provide written proof of training.
    3) During construction, the grooved fitting/coupling manufacturer shall provide on-site inspection of ten0percent of the grooved joint installations. Joint installations that do not pass inspection criteria shall be corrected and re-inspected. Any installation that has not been corrected, or has not been inspected, will not be considered as part of the successful completion. Installations shall not be insulated until deemed successfully completed. All inspections shall be witnessed by the Commissioning Agent, and a written report of the inspections shall be provided by the manufacturer's representative for inclusion in IOM manuals.

D. FITTINGS
1. Cast-Iron Threaded Fittings: ANSI B16.4, Class 125, standard pattern, for threaded joints. Threads shall conform to ANSI B2.1.
2. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ANSI B2.1.
3. Steel Fittings: ASTM A 234, seamless or welded, for welded joints.
4. Grooved Mechanical Fittings: ASTM A 106, or ASTM A 53/A53M, Type F, E or S, Grade B fabricated steel, or ASTM A 234, Grade WPB forged steel fittings with grooves or shoulders designed to accept grooved end couplings.
5. Grooved Rigid Mechanical Couplings: Consist of a two- piece ductile iron housing per ASTM A536, a synthetic rubber gasket of a central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
    a. Rigid Couplings:
        1) Housings 12 inch and smaller cast with offsetting angled-pattern bolt pads to provide visual confirmation upon metal-to-metal pad contact with no torque requirement. Victaulic Style 107V or equal. Designs that permit spaces at bolt pads or require a torque per manufacturer’s written installation instructions not permitted. Installation-ready for direct stab installation without field disassembly.
        2) Housings 14 inch and larger cast with wedge-shaped groove profile, lead-in chamfer and flat pad design for metal-to-metal pad contact. Victaulic Style W07 or equal.
    b. Flexible Couplings:
        1) Use in locations where vibration attenuation and stress relief are required. Victaulic Style 177N, 77 or W77 or equal. Three flexible couplings may be used in lieu of each flexible connector for vibration attenuation. Couplings shall be placed in close proximity to the vibrating source in accordance with published guidelines.
    c. Flange Adapters: Ductile iron housing, flat face, for use with grooved end pipe and fittings, for mating directly with ANSI Class 125, 150, and 300 flanges. Victaulic Style 741, 743 or W741 or equal.

6. Installation-Ready™ fittings for Schedule 40 plain end carbon steel piping in HVAC and mechanical applications sizes ½ thru two inch System rated for a working pressure of 300 pounds per square inch. Fittings consist of a ductile iron housing conforming to ASTM A536, Grade 65-45-12, with Installation-Ready™ ends, complete with gasket liner, zinc-electroplated steel bolts and nuts as per the mechanical properties of ASTM A449, and 300 series stainless steel retainer. Basis of Design: Victaulic QuickVic™ SD
   a. Victaulic Style 904 flange adapter for HDPE to flanged pipe.
   b. Victaulic Style 905 coupling for HDPE pipe.
   c. Victaulic Style 907/W907 HDPE to steel transition coupling.
7. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.
8. CPVC Plastic Fittings: ASTM D 2846, Chlorinated Poly Vinyl Chloride (CPVC) socket-type fittings and solvent for solvent cemented joints.
9. Cast-Iron Threaded Flanges: ANSI B16.1, Class 125; raised ground face, bolt holes spot faced.
10. Cast Bronze Flanges: ANSI B16.24, Class 150; raised ground face, bolt holes spot faced.
11. Steel Flanges and Flanged Fittings: ANSI B16.5, including bolts, nuts, and gaskets of the following material group, end connection and facing:
    a. Material Group: 1.1.
    b. End Connections: Butt Welding.
    c. Facings: Raised face.
12. Solder Filler Metals: ASTM B 32, 50-50, Tin-Lead, for condenser water, chilled water, and make-up water and drain piping.
13. Solder Filler Metals: ASTM B 32, 95-5 Tin-Antimony, for heating hot water and low pressure steam piping.
14. Brazing Filler Metals: AWS A5.8.
15. Gasket Material: EPDM Thickness, material, and type suitable for fluid to be handled, and design temperatures and pressures.
16. Flexible Connectors: Stainless steel bellows with woven flexible bronze wire reinforcing protective jacket; minimum 150 pounds per square inch working pressure, maximum 250° Fahrenheit. operating temperature. Connectors shall have flanged, grooved, or threaded end connections to match equipment connected; and shall be capable of 3/4 inch misalignment.
    a. Three three flexible couplings may be used in lieu of each flexible connector for vibration attenuation. Couplings shall be placed in close proximity to the vibrating source in accordance with published guidelines.
17. Condenser Water Filter
    a. Condenser Water Filter shall be Side-stream arrangement provided with manual isolation valves.
    b. Filter shall be similar to Shelco Model BFS Size 2 Housing or equal, and rated for minimum 150 gallons per minute
    c. 304L Stainless steel construction with swing bolt closure,
    d. Flanged inlet & outlets – three inch size. Provide gaskets.
    e. Provide ½ inch drain, and ¼ inch gauge and vent ports. HVAC contractor shall provide all manual pressure gauges, air vents and drain down valving.
    f. Provide with quantity of four 60 mesh strainers and quantity of four 75 mesh strainers.
    g. Provide with integral support stand. Bolt stand to concrete housekeeping pad support.
    h. ATC contractor shall provide DDC DP sensor and associated control wiring to ATC/BS system for monitoring.
    i. Install in accordance with manufacturer's requirements. Contractor to coordinate all connection locations.

E. PIPE SLEEVES AND ESCUTCHEONS
1. General: Provide schedule 40 black steel or 18 gage galvanized pipe sleeve large enough to accept pipe along with specified pipe insulation at each point where pipe penetrates a wall or floor. Sleeve shall be large enough to allow for free movement of pipe however minimized to prevent leakage of smoke and fire during a fire emergency. For all piping exposed to view provide a chrome plated escutcheon that will surround insulation where applicable on pipe for

a neat finished appearance. Where piping is concealed above ceilings no escutcheons are required.

F. SPECIAL DUTY VALVES
   1. General: General duty valves (i.e., gate, check, ball, and butterfly valves) are specified in Division 23 Section "Valves" Special duty valves are specified in this Article by their generic name; refer to the drawings for specific applications of these valves.
   2. Pump Discharge Valves (Triple-Duty Valve): 175 POUNDS PER SQUARE INCH working pressure, 300 degrees Fahrenheit. maximum operating temperature, cast-iron body, bronze disc and seat, stainless steel stem and spring, and "Teflon" packing. Valves shall have flanged connections and straight or angle pattern as indicated. Features shall include non-slam check valve with spring-loaded weighted disc, and calibrated adjustment feature to permit regulation of pump discharge flow and shutoff.
      a. In grooved installations, Tri-Service Assemblies may be used in lieu of Triple-Duty Valves. Straight pattern, (300-pounds per square inch) pressure rating, combination shut-off, throttling, and non-slam check service in one unit. Victaulic Vic®-300 MasterSeal™ or equal, butterfly valve assembled with Series 779 Venturi Check valve or equal, with flow measurement capabilities and Victaulic or equal couplings (style to be determined by system requirements) for two inch through 12 inch. Straight pattern, 230-pounds per square inch pressure rating combination shut-off, throttling, and non-slam check service in one unit. Victaulic AGS-300 or equal butterfly valve assembled with Series W715 or equal check valve and Victaulic or equal couplings for 14 inch and larger.
      b. Provide isolation valve to allow for future change out of triple duty valve without the need to drain the entire system.
      c. Provide valve tag and note final setting
   3. Pressure Reducing Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment.
   4. Safety Relief Valves: 125 pounds per square inch working pressure and 250° F. maximum operating temperature: designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber. Select valve to suit actual system pressure and BTU capacity.
   5. Combined Pressure/Temperature Relief Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment. Safety relief valve designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber; 125 pounds per square inch working pressure and 250 degrees Fahrenheit. maximum operating temperature. Select valve to suit actual system pressure and BTU capacity. Provide with fast fill feature for filling hydronic system.

G. HYDRONIC SPECIALTIES:
   1. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150 pounds per square inch working pressure, 240 degrees Fahrenheit. operating temperature; and having 1/4 inch discharge connection and 1/2 inch inlet connection.
   2. Diaphragm-Type Compression Tanks: Size and number as indicated; construct of welded carbon steel for 125 pounds per square inch working pressure, 375 degrees Fahrenheit. maximum operating temperature. Separate air charge from flexible diaphragm securely sealed into tank. Provide taps for pressure gage and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 01.
   3. Pump Suction Diffusers: Cast-iron or ductile iron body, with threaded connections for two inch and smaller, flanged or grooved connections for 2-1/2 inch and larger; 175 pounds per square inch working pressure, 300 degrees Fahrenheit. maximum operating temperature for flanged

and 300 pounds per square inch working pressure, 230 degrees Fahrenheit for grooved; and complete with the following features:

a. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
b. Cylinder strainer with 3/16 inch diameter openings with total free area equal to or greater than five times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
c. Disposable fine mesh strainer to fit over cylinder strainer.
d. Permanent magnet, located in flow stream, removable for cleaning.
e. Adjustable foot support, designed to carry weight of suction piping.
f. Blowdown tapping in bottom; gage tapping in side.

4. Chemical Feeder: (Provide one for each piping system). Bypass type chemical feeders of five gallon capacity, welded steel construction; 125 pounds per square inch working pressure; complete with fill funnel and inlet, outlet, and drain valves.
5. WATERTIGHT FOUNDATION LINK SEAL
   a. Use a mechanical seal, consisting of rubber links shaped to continuously fill the annular space between the pipe and the wall opening.
   b. Link-Seal pressure plates shall be molded of glass reinforced nylon. Hardware shall be 316 Stainless Steel, Per ASTM F593-95 Tensile Strength equal 85,000 pounds per square inch, average. Coloration shall be throughout elastomer for positive field inspection.
   c. Each link shall have permanent identification of the size and manufacturer's name molded into the pressure plate and sealing element.
   d. The HVAC Sub-contractor will submit to verify the modular seals are domestically manufactured at a plant with a current ISO-9001:2000 registration.
   e. Modular mechanical seals shall be manufactured by EnPro Industries, Trumbull, Eaton, Pipeline Seal & Insulator, or approved equal.

H. Chemical Treatment
1. A contract agreement satisfactory in form and substance shall be executed between the HVAC Trade Contractor and water treatment company to furnish water chemical treatment service to assure the use of the proper chemical treatment thereof. The water treatment company shall perform the following specified services through its agent for two years of initial service, including quarterly site visits to provide testing, reports, and chemical treatment. The water treatment company shall provide an option for Owner to renew service contract at the completion of the two year service contract period.
   a. Supervise the cleaning and flushing of all systems and the initial introduction of water treatment chemicals.
   b. Furnish all required chemicals for the cleaning and proper initial and quarterly treatment of all systems hereinafter described, together with all necessary testing equipment and reagents for field analysis of the water.
   c. Submit a written report of test results of the field analyses to the Owner and Engineer when the systems are cleaned and treated with corrosion inhibitors. Submit certificate of completion for all systems indicating that all treatment systems are properly functioning and that the associated systems are properly treated, and provide report for all subsequent quarterly visits.
2. The hot, chilled and condenser water piping systems shall be cleaned with sufficient chemicals to ensure the removal of all cutting oil, compound, slag, soiling and/or debris. These chemicals shall not be harmful to the various materials of the systems. The treatment company representative shall supervise this operation including the flushing of the system and shall test the final rinsed system to ensure that the remnants of the cleaning solution do not impart alkalinity to the water in excess of 300 PARTS PER MINUTE.
3. Hot, chilled and condenser water systems shall be treated with sufficient amounts of the proper chemicals to conform to the Dianodic method for corrosion protection. Take various samples of water to assure proper level of chemical treatment
4. Initial Fill: De-ionized water supplied by the HVAC contractor by either using city water and HVAC contractor provided water de-ionizer, filter and water softener equipment, or pretreated de-ionized water with a pH between seven 1/2 to nine shall be used to fill and mix with propylene glycol to charge the system to 20percent by volume propylene glycol solution that shall meet the water quality criteria listed below:

5. Prior to HVAC systems and equipment being operated, and having the building HVAC hot, chilled and ground water source condenser piping systems opened to the ground source wellfield loop, the water quality for all piping hot, chilled and condenser loops quality shall be tested and determined to be within the following guidelines as minimum. If manufacturer's guidelines are stricter, than those shall be followed.
6. Water Quality Guidelines:

TEST	CONDENSER WATER	HOT & CHILLED WATER
pH (initial fill) Limits	7.5-8.5	7.5-8.5
pH (operating) Limits	7.5-9	7.5-9
Total Dissolved Solids (TDS) Limits	< 900 Parts per Minute	< 900 Parts per Minute
Total dissolved solids (TDS) (initial deionized fill) Limits	10-30 Parts per Minute	10-30 Parts per Minute
Alkalinity, (as CaCO3) Limits	30-300 Parts per Minute	30-300 Parts per Minute
Hardness, (as $CaCO_3$) Limits	30 – 150 Parts per Minute	30 – 150 Parts per Minute
Chlorides(cupronickel or 316 S/S heat exchangers) Limits	< 125 Parts per Minute	< 125 Parts per Minute
Chlorides (copper heat exchangers) Limits	<20 Parts per Minute	<20 Parts per Minute
Free Chlorine Limits	<0.5 Parts per Minute	<0.5 Parts per Minute
Sulfates Limits	< 125 Parts per Minute	< 125 Parts per Minute
Ammonia Limits	< 2 Parts per Minute	< 2 Parts per Minute
Nitrates Limits	< 0.5 Parts per Minute	< 0.5 Parts per Minute
Manganese (initial fill) Limits	< 0.5 Parts per Minute	< 0.5 Parts per Minute
Manganese (operating) Limits	< 2.5 Parts per Minute	< 2.5 Parts per Minute
Iron (dissolved initial fill) Limits	<0.5 Parts per Minute	<0.5 Parts per Minute
Iron (total) Limits	< 2.5 Parts per Minute	< 2.5 Parts per Minute
Copper Limits	< 1 Parts per Minute	< 1 Parts per Minute
Free Carbon Dioxide Limits	<50 Parts per Minute	< 50 Parts per Minute
Hydrogen Sulfide Limits	<0.5 Parts per Minute	<0.5 Parts per Minute

Notes: The following guidelines are minimum requirements. Water chemical treatment shall contractor shall also include any recommended water treatment industry standard testing for additional chemicals/substances, and include those test results along with recommended

ranges in water quality test reports. Water chemical treatment service contractor shall also include treatment of these additional chemical solutions in their treatment program.

7. Each water source heat pump chiller and electric boiler system shall be treated with sufficient amounts of the proper chemicals to provide positive protection against corrosion, scale formation and carry over.
8. At the end of the two year contract agreement, the chemical water treatment company shall provide to the owner and copy to Architect, a log of type, quantity and dosage of treatment and test results of treatment performed through the two years of service.
9. Following the second year of service, chemical treatment company shall provide recommended maintenance and treatment schedule to owner and a copy to architect for testing and treating the water. This schedule shall be posted in the mechanical room along with the testing and treatment log.
10. Upon completion of first year of service, the chemical treatment company shall instruct the owner to the owner's responsibility to test and treat water or to contract with chemical treatment company to perform testing and treatment services.
11. All hydronic systems that are indicated in the project schedules (hot, chilled, compensated chilled, and condenser water) to have propylene glycol solution shall be provided to 20 percent solution by volume upon the completion of the installation work.
12. Propylene Glycol
    a. The Air Source Heat Pump system, hot water and chilled water, and compensated chilled water systems shall be charged with a 20 percent by volume solution of propylene glycol antifreeze with corrosion inhibitor to demonstrate adequate corrosion protection for all materials commonly found in the proposed air source heat pump systems.
    b. Propylene Glycol with approved corrosion inhibitors and environmental stabilizer additives to be mixed with water to protect piping circuit and connected equipment from physical damage caused by freezing or corrosion
    c. The heat transfer fluid shall not be less than 90percent biodegradable. Five days Biological Oxygen Demand at 20 degrees Celsius (68 degrees Fahrenheit) shall not exceed 0.25 gram oxygen per gram in accordance with Standard Method 52tenB produced by the American Public Health Association, the American Water Works Association, and the Water Environment Federation
    d. The antifreeze must be safe, environmentally friendly, and nontoxic and have excellent heat transfer properties and must be approved by the Environmental Protection Agency, the State and all local authorities having jurisdiction at this facility.
    e. The HVAC Contractor shall coordinate to ensure that identical manufacturers and formulations of inhibited propylene glycol are provided. Submittal of differing manufacturers and formulations shall not be acceptable.
    f. All air source heat pump systems shall be labeled and identified at the loop charging valves. The labels shall be of a permanent type with the following information:
        1) Antifreeze type and concentration
        2) Service date
        3) Company name
        4) Company phone number and responsible party or person.
13. Provide a coupon rack for each piping system to allow for water testing and chemical treatment system.
    a. Provide a four station corrosion coupon test rack and assembly: Constructed of corrosion resistant material, complete with piping, valves, strainer, flow monitoring device, quick disconnect O-ring sealed coupon holders, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test coupon assembly. One corrosion coupon rack is necessary for each system in this specification.
14. The HVAC Sub Contractor shall be responsible for filling and providing glycol for the entire building interior and exterior HVAC equipment and ASHP piping systems including the Heat recovery chiller and interior water piping between the heat recovery chiller plant and the mechanical room. Furnish all glycol required for the entire HW, CHW & CCHW system loops.

I. Y-Pattern Strainers: Cast-iron body (ASTM A 126, Class B), flanged ends for 2-1 two inch and larger, threaded connections for two inch and smaller, bolted cover, perforated Type 304 stainless steel basket, bottom drain connections; 125 pounds per square inch working pressure.

J. Basket Strainers: High tensile cast-iron body (ASTM A 126, Class B), flanged end connections, bolted cover, perforated Type 304 stainless steel basket, bottom drain connections; 125 pounds per square inch working pressure.
K. Grooved-End Strainers:
   1. Y-Pattern: Ductile iron body ASTM A536, grooved ends for two inch and larger, coupled cover, perforated Type 304 stainless steel basket, bottom drain, 300 pounds per square inch working pressure.
   2. T-Pattern: Ductile iron body ASTM A536, grooved ends for two inch and larger, coupled or T-bolt hinged cover, perforated 304 stainless steel basket, bottom drain, up to 750 pounds per square inch working pressure.
L. Grooved-End Expansion for Steel Piping two inch and larger (Water Service):
   1. two inch Through six inch: Packless, gasketed, slip-type expansion joint with grooved end telescoping body for installation with Victaulic Style 107 or 07 rigid couplings. Provides axial end movement to three inch, designed for water services up to 230 degrees Fahrenheit and working pressure to 350 pounds per square inch. Victaulic Style 150 Mover®.
   2. Two inch Through 24 inch: Combination of short nipples and Victaulic Style 177 or 77 flexible couplings joined in tandem for increased expansion. Joint movement and expansion capabilities dependent on number of couplings/nipples used in the joint. Pressure rating dependent on size and style of flexible couplings used. Victaulic Style 155.
   3. Expansion Loops: Pipe bends and loops in grooved piping systems shall consist of eight Victaulic Style 177, 77 or W77 flexible couplings, four Victaulic 90 degrees. elbows, and three grooved end pipe spools provided in water systems to +250 degrees Fahrenheit in accordance with the latest Victaulic recommendations for expansion compensation. Rigid couplings shall not be used on loop corners.
   4. Expansion Joints: Provide pipe expansion joints at all building expansion joints. Utilize a seismic expansion fitting similar to Metra-Flex, Metra Loop Grooved ends or equal. The expansion fitting shall provide absorption in the lateral offset and angular movement.
   5. Expansion Joints: Provide pipe expansion joints at all building expansion joints. Utilize a seismic expansion fitting similar to Metra-Flex, Metra Loop Flanged ends or equal. The expansion fitting shall provide absorption in the lateral offset and angular movement.
M. Glycol/Make-up Tank and Pump - Provide a packaged automatic glycol solution make up unit for each hydronic system (chilled, hot, and condenser water) consisting of a base, polyethylene reservoir with removable lid and visible solution level scale in gallons, y-strainers, isolation valves, fill pump with a minimum capacity of five gallons per minute at ten0 pounds per square inch discharge, open drip proof motor, pump isolation, check and balancing valves, discharge pressure gauge, motor contactor, pressure control and necessary interconnecting piping. Pump shall be a bronze gear driven design and shall have a standard 120 volt power electrical cord and all necessary controllers and safeties. The unit shall provide alarm outputs (high, low, general alarms) for BMS connection.
N. Factory Assembled Grooved End Vibration Pump Drops: three inch through 12 inch (DN80 though DN300). Orange enamel coated installation-ready assembly with flexible couplings to accommodate vibration attenuation and stress relief. Rated for working pressure to 300-pounds per square inch (2068-kPa).
   1. Discharge Drop: Class 150 flange for pump connection, [base elbow for horizontal pump connection] [straight line with concentric reducer for vertical pump connections], tri-service valve assembly consisting of a spring-actuated check [Venturi-Check] valve and butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool with thermometer and pressure ports. Basis of Design: Victaulic Series 380.
   2. Suction Drop: Suction diffuser with stainless steel basket and diffuser and Class 150 flange for pump connection, butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool with thermometer and/or pressure ports. Basis of Design: Victaulic Series 381.
   3. Suction Drop: 90-degree base elbow with Class 150 flange for pump connection, Wye pattern strainer with stainless steel perforated metal basket, butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool(s) with thermometer and/or pressure ports. Basis of Design: Victaulic Series 382.
O. Air and Dirt Separators - Air and dirt removal device shall be constructed of steel. It shall be designed, fabricated and stamped per ASME Section VIII Division 1 with a maximum working pressure of 125 pounds per square inch at 270 degrees Fahrenheit . Manufacturer shall be holder

of ASME U stamp. Manufacturer to have optional 250 pounds per square inch and 150 pounds per square inch ASME units available. Units up to three inch in size shall be provided with threaded connections as standard. Units four inch and larger shall be provided with flanged system connections as standard. Inlet and outlet connections to be inline with piping system. Both inlet and outlet to be in the same horizontal and vertical planes. Each air and dirt removal device shall be equipped with a brass conical shaped air venting chamber designed to minimize system fluid from fouling the venting assembly. The air vent shall be able to be closed to allow flushing and purging of dirt via side port without dirt passing through vent on initial system fill. A brass flushing cock shall be located on the side of each separator to facilitate system fast-fill and removal of the floating impurities from the air system interface within the separator. A blow down valve shall be provided by the unit manufacturer on the bottom of each unit to allow blow down and cleaning. On units 2 ½ inch and smaller the valve and all of its fittings shall be one inch. On units three inch and larger the valve and all openings shall be two inch.

P. Flexible Expansion Loop (seismic and thermal expansion applications):
   1. All equipment, either rigidly mounted or mounted on vibration isolators, shall be attached to the piping system using flexible loops designed for seismic movement. Flexible loops shall be capable of movement in the X, Y, and Z planes and must completely isolate the equipment from the piping.
   2. All piping passing through building seismic joints shall contain a flexible expansion loop designed for seismic movement. Flexible loops shall be located at, or near the building seismic joint. A vertical support hanger, located within four pipe diameters, shall be installed on each side of the flexible loop. Each hanger to be transversely and longitudinally braced per local codes. Seismic bracing shall not pass through building seismic joint and shall not connect or tie together different sides or parts of building structure. Flexible loops shall be capable of move in the X, Y, and Z planes.
   3. Flexible expansion/seismic loops shall consist of two flexible sections of hose and braid, two 90 elbows, and a 180 return assembled in such a way that the piping does not change direction, but maintains its course along a single axis. Flexible loops shall have a factory supplied, center support nut located at the bottom of the 180 return, and a drain/air release plug. Flexible loops shall impart no thrust loads to system support anchors or building structure. Flexible loops may be installed to accommodate both thermal and seismic motion. For steam service, loops must be installed with flexible legs horizontal to prevent condensate buildup. Materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings. Movement capabilities and location, relative to seismic separation, shall be determined manufacturers recommendations.
   4. Flexible expansion/seismic loops to be Metraloop(r) or approved equal

Q. Expansion Tank:
   1. Expansion tanks shall be manufactured in an ISO recognized facility. Each unit shall be factory tested per Hydraulic Institute standards at the factory of origin For systems using air management systems, the expansion tank shall be a horizontal. The tank shall be designed, constructed, and stamped for 150 POUNDS PER SQUARE INCH at 650 degrees Fahrenheit in accordance with ASME Boiler and Pressure Vessel Code. The tank must be supplied with an airtrol fitting to be installed in bottom of the tank, and piped to the vent connect on the air separator.
   2. For air elimination systems, the expansion tank shall be a pressurized horizontal or vertical tank. The tank shall utilize either a bladder, or diaphragm to separate the air from the system water. Diaphragm and bladder tanks shall be factory charged with a .302-32 charging valve connection. The tank shall be designed, constructed, and stamped for 150POUNDS PER SQUARE INCH at 650 degrees Fahrenheit in accordance with ASME Boiler and Pressure Vessel Code

R. Buffer Tank
   1. Designed and constructed per ASME Code Section VIII, Division 1.
   2. Construction: Carbon Steel with exterior red oxide primer finish.
   3. Maximum Design Pressure and Temperature: 125 pounds per square inch at 375 degrees Fahrenheit .
   4. Flanged inlet and outlet System Connections (Refer to Plans for Sizes).
   5. Registered with the National Board of Pressure Vessel Manufacturers.

6. Buffer tanks shall be factory insulated with 1 in cellular foam with vapor barrier insulation rated in accordance with NFPA 90a Fire/smoke ratings.
7. Refer to drawings for capacity
8. Acceptable Manufacturers
    a. Cemline,
    b. Amtrak
    c. Wessels
    d. Or equal

S. Manufacturer: Subject to compliance with requirements, provide piping system products from one of the following:
1. Grooved Mechanical Joint Pipe, Fittings and Couplings:
    a. Victaulic Company of America.
    b. Anvil Gruvlok
    c. Grinnell
    d. Or Equal
2. Pump Discharge Valves (Triple-Duty Valve):
    a. Bell & Gossett ITT; Fluid Handling Div.
    b. Amtrol, Inc.
    a. Armstrong Pumps, Inc.
    b. Taco, Inc.
    c. Victaulic (Tri-Service Assembly)
    d. Or equal
3. Safety Relief Valves:
    a. Bell & Gossett ITT; Fluid Handling Div.
    b. Amtrol, Inc.
    c. Spirax Sarco.
    d. Watts Regulator Co.
    e. Or equal
4. Pressure Reducing Valves:
    a. Bell & Gossett ITT; Fluid Handling Div.
    b. Amtrol, Inc.
    c. Armstrong Pumps, Inc.
    d. Taco, Inc.
    e. Or equal
5. Air Vents (Automatic):
    a. Bell & Gossett ITT; Fluid Handling Div.
    b. Armstrong Machine Works.
    c. Hoffman Specialty ITT; Fludi Handling Div.
    d. Spirax Sarco.
    e. Or equal
6. Air Separators:
    a. Bell & Gossett ITT; Fluid Handling Div.
    b. Amtrol, Inc.
    c. Armstrong Pumps, Inc.
    d. Taco, Inc.
    e. Or equal
7. Diaphragm-Type Compression Tanks:
    a. Bell & Gossett ITT; Fluid Handling Div.
    b. Amtrol, Inc.
    c. Armstrong Pumps, Inc.
    d. Or equal
8. Pump Suction Diffusers:
    a. Bell & Gossett ITT; Fluid Handling Div.
    b. Amtrol, Inc.
    c. Armstrong Pumps, Inc.
    d. Taco, Inc.
    e. Victaulic (style 731-D / W731-D)
    f. Or equal

9. Chemical Feeder:
    a. Dearborn USA.
    b. Vulcan Laboratories, Subsidiary of Clow Corp.
    c. York-Shipley, Inc.
    d. Or equal
10. Basket Strainers:
    a. Crane Co.
    b. Metraflex Co.
    c. Spirax Sarco.
    d. Victaulic Company of America. (732/W732/730/W730)
    e. Or equal

2.09 REFRIGERANT PIPING

A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as shown on drawings. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide materials and products complying with ANSI B31.5 Code for refrigeration piping where applicable, base pressure rating on refrigerant piping system maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in refrigerant piping systems. Where more than one type of materials and products are indicated, selection is Installer's option.

B. Material: Provide pipes and pipe fittings in accordance with the following listing:
    1. Tube Size 4-1/8 inch and Smaller: Copper tube; Type ACR, hard-drawn temper; wrought-copper, solder-joint fittings; brazed joints.

C. Soldered Joints: Solder joints using silver-lead solder, ASTM B32, Grade 96 TS.

D. Brazed Joints: Braze joints using American Welding Society (AWS) classification BCUO-4 for brazing filler metal.

E. Piping Specialties: Provide piping specialties complying with Division 23 "Hydronic Piping" in accordance with the following listing:
    1. Pipe escutcheons.
    2. Drip pans.
    3. Sleeves.
    4. Sleeve seals.

F. Refrigerant Valves: Special valves required for refrigerant piping include the following types.
    1. Globe Shutoff Valves: Forged brass, packed, back seating, winged seal cap, 300 degrees Fahrenheit temperature rating, 700 POUNDS PER SQUARE INCH working pressure.
    2. Check Valves: Forged brass, accessible internal parts, soft synthetic seat, fully guided piston and stainless steel spring, 250 degrees Fahrenheit temperature rating, 700 POUNDS PER SQUARE INCH working pressure.
    3. Manufacturer: Subject to compliance with requirements, provide globe and check valves of one of the following:
        a. Henry Valve CO.
        b. Parker Hannifin Corp.; Refrigeration & Air Cond. Div.
        c. Sporlan Valve Co.
        d. Or Equal
    4. 2-Way Solenoid Valves: Forged brass, designed to conform to ARI 760, normally closed, teflon valve seat, NEMA 1 solenoid enclosure, 24 volt, 60 Hz., UL-listed, ½ inch conduit adapter, 250 degrees Fahrenheit temperature rating, 400 POUNDS PER SQUARE INCH working pressure.
    5. Manufacturer: Subject to compliance with requirements, provide solenoid valves of one of the following:
        a. Alco Controls Div.; Emerson Electric Co.
        b. Automatic Switch Co.
        c. Sporland Valve CO.
        d. Or Equal
    6. Refrigerant Strainers: Brass shell and end connections, brazed joints, monel screen, ten0 mesh, UL-listed, 350 POUNDS PER SQUARE INCH working pressure.

7. Moisture-Liquid Indicators: Forged brass, single port, removable cap, polished optical glass, solder connections, UL-listed, 200 degrees Fahrenheit temperature rating, 700 POUNDS PER SQUARE INCH working pressure.
8. Refrigerant Filter-Driers: Steel shell, ceramic fired desiccant core, solder connections, UL-listed, 700 POUNDS PER SQUARE INCH working pressure.
9. Refrigerant Filter-Driers: Corrosion-resistant steel shell, steel flange ring and spring, wrought copper fittings, ductile iron coverplate with steel cap screws, replaceable filter-drier core, 700 POUNDS PER SQUARE INCH working pressure.
10. Evaporator Pressure Regulators: Provide corrosion-resistant, spring loaded, stainless steel springs, pressure operated, evaporator pressure regulator, in size and working pressure indicated, with copper connections.
11. Refrigerant Discharge Line Mufflers: Provide discharge line mufflers as recommended by equipment manufacturer for use in service indicated, UL-listed.
12. Manufacturer: Subject to compliance with requirements, provide refrigeration accessories of one of the following:
    a. Alco Controls Div.; Emerson Electric CO.
    b. Henry Valve CO.
    c. Parker-Hannifin Corp.; Refrigeration & Air Conditioning Div.
    d. Sporlan Valve Co.
    e. Or Equal.

G. Pipe Roof Penetration Housing & curb
1. Product: The Vault by Roof Penetration Housings.
2. Construction:
    a. 0.080 inch thick aluminum housing and curb.
    b. UV protected powder coated finish (2 mil thick).
    c. Stainless steel vandal proof fasteners.
    d. Gasketed lid to housing and housing to curb connection joints to ensure compliance to ICC 2015/2018 Air Permeance Levels.
    e. Standard Color: White – To meet an initial SRI of 88.
    f. Seismic available upon request. Seismic calculations, conditions to be furnished to RPH by engineer.
    g. Constructed to withstand wind to 225 MPH, third party tested.
3. Style & Sizes:
    a. Series AW Vault: All aluminum construction, (zero plastic), wind rated to 225 mph and pre-insulated (R-2 for Condensate), vandal proof stainless steel fasteners. AW Vault meets ICC 2021 Energy Code for Air Permeance Levels.
        1) Small Vault Model: AW-16tenten: L- 16 ½” W- 9 ¾” H- 10”; Designed for small A/C condensing units up to 7 ½ tons. Accommodates up to 1.9” O.D. pipe, conduit or telecommunication cable. Designed for power or control conduits and liquid or suction lines.
        2) Medium Vault Model: AW-201412: L- 20 ½” W- 14 ½” H – 12”; Accommodates multiple pipes, conduit or telecommunication cables to the roof. Designed for four condensing units (two on each side) up to (16) Series 5000 Exit Seals.
        3) Mega Vault Model: AW-343424:L – 34” W – 34” H – 24”; Allows for a wide variety of installation choices, including multiple A/C units, larger pipe diameters, large electrical disconnects and ducts up to 30”, Series 5000 Exit Seals.
        4) Custom – Consult Factory – 1-800-994-0945
    b. Series AWI Vault (Required for Project): Same as AW Series w/Pre-Insulated curb 6” thick R-40 Factor to meet ICC–2015/2018 Energy Code.
        1) Small Vault Model: AWI-16tenten: L – 16 ½” W – 9 ¾” H – 10”
        2) Medium Vault Model: AWI-201412: L – 20 ½” W – 14 ½” H – 12”
        3) Mega Vault Model: AWI-343424: L – 34” W – 34” H – 24”
        4) **AWI SERIES AVAILABLE ONLY IN 18” CURB**
        5) Exit Seal capacities are dependent on size of seals required based on Series 5000 Exit Seals.
        6) AWI includes all AW components plus the ICE pre-insulated curb extension. Aluminum extension between housing and curb is 7” wide on each side of Vault® to

accommodate 6” insulation (R-40 Rating) supplied by RPH on the outside of the curb, +1” to accommodate roofing material.

4. Exit Seals
   a. Design: Weather tight seal for vertical surface/plane penetrations. Exit Seal construction to be manufactured in all aluminum construction and ten0percent Sil-X-14 silicone gaskets.
   b. Series 5000 - .25” to 1.90”
   c. Series 6000 – 2” to 3.125”
   d. Series 7000 – 3.5” large diameter double gasketed inside and out.
   e. Penetration pipe type as applicable: copper K and L, copper ACR, steel Schedule 40, PVC Schedule 40 and 80, electrical EMT, electrical rigid, aluminum, liquid light, and A/C or plumbing ducts.
5. Manufacturer: Subject to compliance with requirements, provide roof penetration housing of one of the following:
   a. RPH Advanced Building solutions – Model AWI
   b. Pate
   c. Thybar
   d. Or equal

H. Basic Vibration Control: Provide vibration control products in accordance with the following listing:
   1. Isolation hangers.
   2. Riser isolators.
   3. Riser support isolators.
   4. Flexible pipe connectors.

2.10 AIR SOURCE-TO-WATER SIMULTANEOUS HEATING AND COOLING MODULAR CHILLERS WITH HEAT RECOVERY (Refer to section 01 91 13 - and Section 23 08 00 HVAC Commissioning for additional contract requirements)

A. GENERAL
   1. Provide outdoor packaged air-cooled liquid heat pump heat recovery chiller with the Hot water and Chilled Water capacities as scheduled on drawings at job site elevation listed. Non modular chiller designs shall not be acceptable. Providing less modules than what is specified at higher tonnage per module is not acceptable. The specified module quantity must be provided.
   2. The units shall be complete with compressors, chilled water heat exchanger, hot water heat exchanger and refrigerant to air heat exchanger.
   3. The units shall be installed in accordance with all local and State codes.
   4. The assembled chiller shall be completely capable of being serviced and repaired in place without the need for removal of a module. If modules need to be removed for servicing, then chiller manufacturer shall provide an extended ten year labor warranty with chiller.
   5. Chiller/Heater shall be designed to operate using R-454B Refrigerant.
   6. The liquid to be heated and cooled will be water containing corrosion inhibitors and 20 percent propylene glycol by volume that is compliant with manufacturers requirements.
   7. Each Chiller shall have:
      a. Dual point power per bank of modules.
      b. Carbon steel lifting frame.
      c. A single hot water supply connection.
      d. A single hot water return connection.
      e. A single chilled water supply connection.
      f. A single chilled water return connection.
      g. A single point for all BAS control connections.
      h. Evaporator insulation.
   8. Unit shall be shipped pre-charged with refrigerant and oil as specified on the equipment schedule.
   9. Chiller shall be designed for variable water flow through both the chilled water and hot water piping supplies to each module. The liquid to be chilled/heated will be water containing corrosion inhibitors and antifreeze solution as required.
   10. Unit shall be shipped with firmly attached metal plates that indicate name of manufacturer, chiller model number, chiller serial number, and refrigerant used.

11. Compressors, heat exchangers, condenser fans, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module. Module shall be provided within a steel enclosure suitable for outdoor use. Exposed steel surfaces shall be provided with a powder coat paint finish.

B. CODES AND STANDARDS: Comply with the latest edition of the following codes and standards
   1. IMC (latest adopted edition)
   2. IECC 2021 with MA Amendments and ASHRAE 90.1– Energy Efficiency compliance
   3. ARI 550/590
   4. ANSI/ASHRAE 15 ANSI/ASHRAE Standard 15 – Safety Code for Mechanical Refrigeration
   5. ASHRAE 34 – Number Designation and Safety Classification of Refrigerants
   6. ARI Standard 550/590 – Positive Displacement Compressors and Water Cooled Rotary Screw Water-Chilling Packages
   7. Conform to UL code for construction of chillers and provide UL/cUL listing label for electrical panel construction. All modules' electrical panels shall be constructed in accordance with UL and bear the UL Listing mark. Additionally, the heat exchangers shall bear the UL Stamp.
   8. OSHA - Occupational Safety and Health Act
   9. ANSI/NFPA Standard 70 – National Electrical Code (N.E.C.)
   10. ASME Boiler & Pressure Vessel Code, Section VIII, Division 1
   11. ETL
   12. CE
   13. CSA

C. SUBMITTALS: Submittals shall include the following:
   1. Chiller dimensional drawings with elevation overview. Drawings to include shipping and assembled dimensions, required service clearances, location of all field installed piping and electrical connections.
   2. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories. Specifically, include:
   3. Cooling and Heating Capacities with specified fluid at specified operating conditions
   4. Heating capacity across a range of ambient temperatures. Temperature range shall be 0 to 65 deg F ambient.
   5. Product construction data, including heat exchanger materials, compressors details and data, evaporator and condensing coils construction.
   6. A summary of all auxiliary utility requirements for normal system operation required. Auxiliary utility requirements include: electrical, water, and air. Summary of auxiliary equipment shall include quantity and quality of each specific auxiliary utility required.
   7. Chiller Control documentation to include: Chiller control hardware layout, wiring diagrams depicting factory installed wiring, field installed wiring diagrams with points of connection for power, signal and control wiring, control panel product data, and points of connection for BAS control/interface points (BACNet IP).
   8. Sequence of operation depicting overview of control logic used.
   9. Installation and Operating Manuals.
   10. Manufacturer certified performance data at full load EER in addition to either IPLV or NPLV efficiency ratings. This efficiency data shall be provided at both AHRI and specified operating conditions for Heating, Cooling and Heat Recovery Modes of Operation.
   11. Manufacturer's warranty details specified within these specifications.

D. QUALITY ASSURANCE
   1. Manufacturer Qualifications: Chiller manufacturer must have ten years of experience (at minimum) producing Air Cooled Heat Recovery chillers that are capable of having different modules operate simultaneously in cooling, water-to-water heating and heating. Producing air cooled chillers with de-superheaters does not qualify as time towards this experience requirement. If the manufacturer has not been manufacturing these types of equipment for at least ten years, that manufacturer must provide an additional three year full parts and labor warranty beyond what is specified/required by the substantial completion dates.
   2. Regulatory Requirements: Products shall be Designed, Tested, Rated and Certified in accordance with, and installed in compliance with Standards and Codes indicated in Codes and Standards section of this specification.
   3. Factory Test: Chiller shall be pressure-tested, evacuated and fully charged.

4. Chiller is required to be run tested at manufacturer's facility prior to shipment on an AHRI certified test stand. Provide run test report to Architect/Engineer

E. DELIVERY and HANDLING
1. Chiller modules shall be delivered to the job site completely assembled and charged with complete refrigerant charge.
2. Installing contractor to comply with the manufacturer's instructions for transporting, rigging, and assembly of chiller.

F. WARRANTY AND START-UP
1. Manufacturer shall provide full parts and labor warranty coverage for entire chiller for a period of one year after date of substantial completion. All parts shall be warranted against defects in material and workmanship. Similar parts-only coverage shall be provided for the chillers compressors for a period of ten years. The warranty period shall commence either on the project substantial completion date.
2. Manufacturer shall provide the services of a Factory Authorized Service Engineer to provide complete start-up supervision. After start-up a Manufacturer's Representative shall provide a minimum of eight hours of operator training to the owner's designated representative(s) for the complete heat pump chiller assembly.
3. Manufacturer shall provide the services of a factory authorized service engineer to help commission the heat pump chiller/heater for a minimum of 40 hours. The controls contractor must make themselves available to work with the chiller manufacturer for 16 of those hours at a minimum.
4. Warranty Certificate: Submit the following after award of contract:
   a. Certificates: For certification required in "Quality Assurance" Article
   b. Startup service reports.
   c. Operation and Maintenance Data: For each equipment item to include in emergency, operation, and maintenance manuals.
   d. Manufacturer shall provide a two year service contract to provide all manufacturer recommended and required preventative maintenance service. This will be two years from the date of startup. If additional service is required to meet the one year from date of substantial completion requirement, the contractor is to provide that service.

G. REFRIGERANT
1. Material: R-454B – provide full operating charge of refrigerant and oil for all modules. No other refrigerants are acceptable.
2. Provide refrigerant charging port.
3. Comply with ASHRAE standard 15-2022 & 34-2022, IMC 2021 requirements.

H. WATER-COOLED MODULAR HEAT RECOVER HEAT PUMP (HRHP) CHILLER / HEATER
1. Water to water low ambient heat pump chiller with auxiliary air cooled condenser shall incorporate scroll type compressors and can consist of multiple30-ton modules. Each refrigerant circuit shall consist of a tandem compressor, evaporator, refrigerant to hot water heat exchanger, air to refrigerant heat exchanger, electronic expansion valves, liquid line solenoid valves, filter driers, four 2-way motorized refrigerant valves, and control system. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical stand-point. The multi-module chiller must be able to produce chilled water and hot water even in the event of a failure of one or more refrigerant circuits.
2. Basis of Design Multi-Stack Unit incorporates Virtual Moveable Endcap Technology: The Chiller/Heater shall be designed for simultaneous variable heating and cooling capacity. VME II valve module shall contain fast-acting motorized butterfly valves that open/close on a command from the central control system. The motorized actuators shall be modulating NEMA 2 rated. Valves shall be fast acting type with a maximum stroke time (full closed to full open) of 35 seconds. Valves with a longer stroke time of 35 seconds will not be accepted. Valve modules shall be built into pre-engineered headers. VME II valves shall be grooved connection type. Alternate HRHP Chiller/Heater manufacturers must provide equivalent construction materials, components, performance, capacity control, unit module configuration and operating controls.
3. Heat Exchanger Variable Flow Valves: Condenser and Evaporator heat exchangers shall be equipped with motorized modulating butterfly type valves driven independently by signals from the module controller and powered from the main power feed. The motorized actuators shall

be modulating NEMA 2, IP-54 with a stroke time of no more than 35 seconds and easily visible position indicators and internal thermal motor overload protection.

4. Load side valves shall modulate to maintain modular leaving load temperatures. When heat exchangers are using sink/source due to unequal heating/cooling duty, master controller shall modulate valve to provide minimum required head pressure control in order to maximize efficiency of those Chiller/Heater modules and to provide equipment protection. All valves must be installed such that proper piping practices are observed, including proper distances before and after elbows.
5. Modules shall ship wired and charged with refrigerant. All modules shall be factory run tested prior to shipment on an AHRI certified test stand.
6. Compressors, heat exchangers, piping and controls shall be mounted on a heavy gauge steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module.Basis of design is Multistack. Approved equals by Waterfurnace and Aermec.
7. Chiller/Heater Modules shall be ETL listed in accordance with UL Standard 60335, CSA certified per Standard C22.2#60335-2-40. Prior to shipment the chiller controls shall be tested under power to verify proper controls operation.
8. Chilled Water Mains: Each module shall include supply and return mains for chilled water. Cut grooved end connections are provided for interconnection to four, six, eight-inch standard piping with grooved type couplings unless otherwise specified on the schedule. Rolled grooved shall be unacceptable
9. Evaporators and condensers: Each evaporator and condenser shall be dual circuited, brazed plate heat exchangers constructed of 316 stainless steel; designed, tested, and UL stamped in accordance with ASME Section VIII pressure vessel code for 650 pounds per square inch working refrigerant pressure on the evaporator and 650 pounds per square inch working pressure on the condenser. Both the condenser and evaporator heat exchanger shall have a working pressure for the water circuits at least 285 pounds per square inch.

    Both evaporator and condenser brazed plate heat exchangers shall have a waterside flush connection with ball valve on each module to permit backflushing or cleaning of individual heat exchangers without removing chiller headers or other in place components. Single flush ports for entire bank are not acceptable due to having to shut down entire bank of modules for heat exchanger cleaning. Manufactures providing a chiller where components need to be removed in order to backflush or clean the brazed plate heat exchanger shall provide a ten year labor warranty to remove necessary components to clean the heat exchangers in the event that they get clogged or reduced flow.
10. Hot Water Mains: Each module shall include supply and return mains for hot water. Cut grooved end connections are provided for interconnection to four, six, eight-inch standard piping with grooved type couplings – unless otherwise specified on the schedule. Rolled grooved shall be unacceptable.
11. Source/Sink Fans: Each module shall contain two fans. Module shall utilize ECM Fans. Blades are aluminum construction owlet design seven blade axial fan with integral EC motor (direct drives with external VFD driven motors are not acceptable). Efficiency exceeds criteria set out in the ErP 2015 directive. Individual fans are factory tested. Encapsulation required. Encapsulation is a process of filling a complete electronic assembly with a solid compound for resistance to shock and vibration, and for exclusion of moisture and corrosive agents. Sound pressure reductions at 30 feet, as compared to standard fan option, ranges from 3-6 dBA.
12. Compressor: Each module shall contain two scroll compressors with refrigerant injection technology. The compressors have active map management to monitor discharge temperature, resulting in safe compressor operation and maximizing lift capabilities. Compressors are in a tandem piping arrangement mounted to the module with rubber-in-shear isolators. Each system also includes high discharge pressure and low suction pressure safety cut-outs.
13. Compressors must be designed specifically to produce 130 degrees Fahrenheit hot water at 0 deg F ambient in air source heat pump/heat recovery chiller/heater.
14. Refrigerant to Water Heat Exchangers
15. Evaporator: Each evaporator shall be a brazed plate heat exchanger constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 pounds per square inch working pressure. The evaporator heat exchanger shall not be

mounted above the compressor, to eliminate the effect of migration of refrigerant to the cold evaporator with consequent liquid slugging on start-up.

16. Condenser: Each condenser shall be a brazed plate heat exchanger constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 pounds per square inch working pressure.
17. Chiller/heater shall have external inputs and outputs to be compatible with the building management system to include Remote Start/Stop capability and Cooling Alarm output.
18. Each refrigerant circuit shall include all refrigerant specialties including a properly sized refrigerant receiver to provide reliable operation down to 0□F Ambient. Chiller must be able to reliably produce 130 degrees Fahrenheit hot water at 0 degrees Fahrenheit Ambient.
19. Heat Pump shall be provided with a single point power connection at a 65,000 amp SCCR. This will include pre-engineered wiring for field installation and connection to a factory mounted Heat Pump junction box. Junction box shall include individual fusing for each Module Set and provide a single point of connection to building power. Chillers to be provided with dual point power if specified.
20. Heat Pump Chiller shall ship from the factory on a six (W6X15) inch I-beam painted steel frame will be provided with all modules mounted upon it. Typically, all water and wiring connections will be made between the modules at the factory. Depending on chiller length or customer requests, larger I-beams can be furnished.
21. IFM flow switch per module. Integral to each module and powered by the module for individual module proof of flow and flow safety. Modules without independent IFM switches per module are not acceptable alternates.
22. All wiring, including communication wiring from the master controller must be factory installed. Each heat pump chiller skid must be controlled by a single master controller able to oversee the operation of the chiller skid. If the chiller does not have a modular design with a master controller able to be factory wired, the manufacturer must provide a full plant controller system separate from the BMS capable of controlling all heating and cooling operation. If the manufacturer does not provide a plant controller to control flow and chiller mode operation of a non-modular design, the ATC/contractor is responsible for providing the chiller/heater plant controller in addition to their base scope.
23. Variable Flow Operation: Chilled Water and Condenser Water Butterfly type isolation valves shall incorporate appropriate accessories and controls to allow the chiller to operate efficiently in a variable primary flow system. Motorized valve per module shall operate for variable flow. Chiller system must be able to turn down to a single modules flow. Chiller must be capable of variable flow via factory controls and a single set up pumps. If the chiller is not capable, the manufacturer or installing contractor must provide a hot water and chilled water plant controller system and all associated valves, pumps and piping accessories needed to accomplish variable flow. Controlling to a chiller pressure drop less than 5.5 feet H20 for variable flow is not acceptable.
24. Sound Attenuation Package: Chiller must meet the sound levels shown on the schedule. The chiller manufacturer must provide an enhanced sound attenuation package to meet the scheduled values. Sound package shall include factory installed compressor wraps and discharge silencers. Discharge silencers shall ship loose for field installation by mechanical contractor.

I. CONTROLS, SAFETIES AND DIAGNOSTICS

1. Scheduling of the various compressors shall be performed by a microprocessor based control system (Master Controller). A new lead compressor is selected every 24 hours to assure even distribution of compressor run time.
2. Remote Monitoring capability: Chiller controller shall be able to be remotely monitored via an external device. The local factory service must be able to connect this device to the chiller for the factory to view programming, operation and make remote changes to the programming.
3. The Master Controller shall monitor and report the following on each refrigeration system:
   a. Discharge Pressure Fault
   b. Suction Pressure Fault
   c. Compressor Winding Temperature
   d. Suction Temperature
   e. Evaporator Leaving chilled water Temp
   f. Condenser leaving hot water temp.

4. The Master Controller shall monitor and report the following system parameters:
   a. Chilled Water Entering and Leaving Temperature
   b. Discharge/Suction Refrigerant Temperature
   c. Proof of Chilled Water Flow
   d. Hot Water Entering and Leaving Temperature
   e. Discharge Refrigerant Temperature
   f. Proof of Hot Water Flow
5. An out of tolerance indication from these controls or sensors shall cause a “fault” indication at the Master Controller and shutdown of that compressor with the transfer of load requirements to the next available compressor. In the case of a System Fault the entire Heat Pump will be shut down. When a fault occurs, the Master Controller shall record conditions at the time of the fault and store the data for recall. This information shall be capable of being recalled through the keypad of the Master Controller and displayed on the Master Controller’s LCD. A history of faults shall be maintained including date and time of day of each fault (up to the last 20 occurrences).
6. Individual monitoring of leaving Load water temperatures from each refrigeration system shall be programmed to protect against freeze-up. Individual monitoring of leaving hot water temperatures from each refrigeration system shall be programmed to protect against hi head pressure conditions.
7. The Chiller shall be capable of interfacing to a building automation system. Interface shall be accomplished using an Interoperability Web Portal and shall be capable of communication over BACNet IP or MSTP, Modbus or LON.
8. Operation
   a. The control system shall monitor entering and leaving chilled water and hot water temperatures to determine both the chilled water and hot water system demand. The control system will use the demand to make staging mode (cooling, heating, or simultaneous heat recovery) decisions and select the number of compressor circuits required to operate. Mode decisions shall be available from the controller as well as via remote input. Response times and set points shall be adjustable. The system shall provide for variable time between compressor sequencing and temperature sensing, so as to optimize the chiller performance to different existing building loads.
   b. Modules shall be able to provide the following capabilities:
      1) Full cooling capacity with zero need for hot water
      2) Full simultaneous heat recovery, providing full heating and cooling capacities.
      3) Full heating capacity with zero need for chilled water.
9. The chiller safety controls shall be provided (minimum) as follows:
   a. Low evaporator refrigerant pressure
   b. Loss of water flow through the evaporator
   c. High condenser refrigerant pressure
   d. High compressor motor temperature
   e. Low suction gas temperature
   f. Low leaving evaporator water temperature
10. Failure of chiller to start or chiller shutdown due to any of the above safety cutouts shall be annunciated by display of the appropriate diagnostic description at the unit control panel. This annunciation will be in plain English. Alphanumeric codes shall be unacceptable.
11. The chiller shall be furnished with a Master Controller as an integral portion of the chiller control circuitry to provide the following functions:
    a. Provide automatic chiller shutdown during periods when the load level decreases below the normal operating requirements of the chiller. Upon an increase in load, the chiller shall automatically restart.
    b. Provisions for connection to automatically enable the chiller from a remote energy management system.
    c. The control panel shall provide alphanumeric display showing all system parameters in the English language with numeric data in English units.
12. Normal Chiller Operation
    a. When chiller is enabled, the factory supplied Master Controller modulates the chiller capacity from minimum to maximum as required by building load.

b. The Chiller control system shall respond to Entering Water Temperature and will have an integral reset based on entering water temperature to provide for efficient operation at part-load conditions.

J. Heat Pump Chiller Master Controller Bacnet Point List:

1. The following BACnet points must be available from the air to water heat pump and must be mapped by the ATC Contractor. Individual modules shall display specific status so the BMS will know the specific mode of operation and active alarms/status for each module. BACnet points list must be provided in submittal with specific names and instances for all alarms/modes.

Object Name	Description	Notes/Units
Analog Read Points		
COOL_CAPACITY	Total Cooling Capacity	percent
HEAT_CAPACITY	Total Heating Capacity	percent
COOL_DEMAND	Cooling Demand	percent
HEAT_DEMAND	Heating Demand	percent
ECHW_TEMP	System Entering Chilled Water Temp	°F or °C
LCHW_TEMP	System Leaving Chilled Water Temp	°F or °C
ECW_TEMP	System Entering Condenser Water Temp	°F or °C
LCW_TEMP	System Leaving Condenser Water Temp	°F or °C
COOL_UPPER_SETPT	Cooling Upper Setpoint	°F or °C
COOL_LOWER_SETPT	Cooling Lower Setpoint	°F or °C
COOL_ON_OFFSET	Cooling On Offset	# of degrees
COOL_OFF_OFFSET	Cooling Off Offset	# of degrees
COOLING_VSP	Cooling Variable Setpoint	percent
HEAT_UPPER_SETPT	Heating Upper Setpoint	°F or °C
HEAT_LOWER_SETPT	Heating Lower Setpoint	°F or °C
HEAT_ON_OFFSET	Heating On Offset	# of degrees
HEAT_OFF_OFFSET	Heating Off Offset	# of degrees
HEATING_VSP	Heating Variable Setpoint	percent
CHW_FLOW_BYPASS	Chilled Water Flow Bypass UI,BAS	percent
CW_FLOW_BYPASS	Condenser Water Flow Bypass UI,BAS	percent
COOL_CW_MIN_VLV	Cooling Cond Water Min Valve Position	percent
HEAT_CW_MIN_VLV	Heating Cond Water Min Valve Position	percent
CHW_MIN_VLV_POS	Chilled Water Min Valve Position	percent
LAC_SETPT	Low Ambient Control Setpoint	°F or °C
CHIL_CHW_LOWDP_SET	Chiller CHW Low DP Setpoint	Bar or POUNDS PER SQUARE INCH
CHIL_CW_LOWDP_SET	Chiller CW Low DP Setpoint	Bar or POUNDS PER SQUARE INCH
ACTUAL_CHW_BYPASS	CHW Bypass value used from UI,BAS,Custom IO	percent
ACTUAL_CW_BYPASS	CW Bypass value used from UI,BAS,Custom IO	percent
M1_LCHW	Module 1 (include for each module) Leaving Chilled Water Temp	°F or °C
M1_LCW	Module 1 (include for each module) Leaving Condenser Water Temp	°F or °C

M1_EVAP_VLV_REQ	Module 1 (include for each module) Evap Valve Requested	percent
M1_EVAP_VLV_FDBK	Module 1 (include for each module) Evap Valve Actual	percent
M1_COND_VLV_REQ	Module 1 (include for each module) Cond Valve Requested	percent
M1_COND_VLV_FDBK	Module 1 (include for each module) Cond Valve Actual	percent
Integer Read Points		
COMPS_ONLINE	Number of Compressors Online	#
COMPS_ERROR	Number of Compressors in Error	#
COMPS_AVAILABLE	Number of Compressors Available	#
FAULTS	Number of Faults	#
SYSTEM_STATUS	System Status	Table A
SYSTEM_WARNING	System Warning	Table B
SYSTEM_FAULT	System Highest Priority Fault	Table C
PRIORITY_MODE	Priority Control	Table P
FAIL_INDICATOR	Allowed Percent of Comp Failure	percent
CONTROL_MODE	Operation Mode	Table D
SEQUENCING	Compressor Sequencing	Table E
BAS_UNIT_MEASURE	BAS Unit of Measurement	Table F
LOADLIMIT_COOL_CTRL	Cooling Load Limit via UI or BAS	percent
LOADLIMIT_HEAT_CTRL	Heating Load Limit via UI or BAS	percent
LOAD_LIMIT_COOL_DISP	Cooling Load Limit Value used	percent
LOAD_LIMTI_HEAT_DISP	Heating Load Limit Value used	percent
HOUR	System Internal Date & Time (Hour)	
MINUTE	System Internal Date & Time (Minute)	
MONTH	System Internal Date & Time (Month)	
DAY	System Internal Date & Time (Day)	
YEAR	System Internal Date & Time (Year)	
M1_MODE	Module 1 Mode	Table - H
M1_COMP_A_STAT	Module 1 Compressor A Status	Table - I
M1_ZONE	Module 1 Compressor Zone	Table - J
M1_COMP_B_STAT	Module 1 Compressor B Status	Table - I
M1_WARN	Module 1 Warnings	Table - L
M1_FAULT	Module 1 Faults	Table - M
M1_COMP_A_FAULTS	Module 1 Compressor A Faults	Table - N
M1_COMP_B_FAULTS	Module 1 Compressor B Faults	Table - N
M1_DEFROST_STAT	Module 1 Defrost Status	Table - O
Digital Read Points		
ON_OFF_STATUS	System On Off Status	0 equal Disabled, 1 equal Enabled
ON_OFF_CTRL	System On Off Control	0 equal Disabled, 1 equal Enabled
BMS_COOL_REMOTE_SS	BMS Remote Start/Stop for Cooling	0 equal Disabled, 1 equal Enabled
BMS_HEAT_REMOTE_SS	BMS Remote Start/Stop for Heating	0 equal Disabled, 1 equal Enabled
SYSTEM_MODE	System Mode of Operation	0 equal Cool, 1 equal Heat

EX1_INPUT	System EX1 Input	0 equal No Fault, 1 equal Fault
REMOTE_START_COOL	System Cooling Remote Start/Stop	0 equal Disabled, 1 equal Enabled
REMOTE_START_HEAT	System Heating Remote Start/Stop	0 equal Disabled, 1 equal Enabled
ALARM	System Alarm	0 - No Alarm, 1 equal Alarm
CHW_RESET_EN	Chilled Water Reset	0 equal Inactive, 1 equal Active
CW_RESET_EN	Condenser Water Reset	0 equal Inactive, 1 equal Active
M1_COMP_A_ON_OFF	Module 1 Compressor A Run Status	0 equal Comp OFF, 1 equal Comp On
M1_COMP_B_ON_OFF	Module 1 Compressor B Run Status	0 equal Comp OFF, 1 equal Comp On
M1_CHW_FLOW	Module 1 Chilled Water Flow Status	0 equal Flow, 1 equal No Flow
M1_CW_FLOW	Module 1 Condenser Water Flow Status	0 equal Flow, 1 equal No Flow
M1_PARTS PER MINUTE_STATUS	Module 1 Power Phase Monitor Status	0 equal No Fault, 1 equal Fault
M1_COMM_ERROR	Module 1 Communication Error	0 equal Comms, 1 equal No Comms
M1_DEROST_REQ	Module 1 Defrost Requested	0 equal Inactive, 1 equal Active
M1_DEFROST_STATE	Module 1 Defrost State	0 equal Inactive, 1 equal Active
Analog Write Points		
COOL_LOWER_SETPT	Cooling Lower Setpoint	°F or °C
HEAT_UPPER_SETPT	Heating Upper Setpoint	°F or °C
CHW_FLOW_BYPASS	Chilled Water Flow Bypass UI,BAS	percent
CW_FLOW_BYPASS	Condenser Water Flow Bypass UI,BAS	percent
Integer Write Points		
PRIORITY_MODE	Priority Control	Table P
CAPACITY_LIMIT	Capacity Limit	percent
CONTROL_MODE	Operation Mode	Table D
LOADLIMIT_COOL_CTRL	Cooling Load Limit via UI or BAS	percent
Digital Write Points		
ON_OFF_CTRL	System On Off Control	0 equal Disabled, 1 equal Enabled
BMS_COOL_REMOTE_SS	BMS Remote Start/Stop for Cooling	0 equal Disabled, 1 equal Enabled
BMS_HEAT_REMOTE_SS	BMS Remote Start/Stop for Heating	0 equal Disabled, 1 equal Enabled

K. Central Heat Pump Heat Recovery (HPHR) Chiller Plant Control System
   1. A central chiller plant control system shall be provided by the Heat Pump Chiller / Heater manufacturer and shall be field installed by the ATC Contractor. The central plant control system shall control all heat pump chiller equipment, associated chilled water and hot water heating pumps, and supplemental boiler operation along with all associated valves. The project ATC Contractor shall integrate the heat pump heat recovery plant controls into the building energy management system.

   2. The Heat Pump Heat Recovery (HPHR) Chiller Plant control shall include Master-Slave functionality as an integral portion of the chiller control circuitry to provide the following functions:
      a. Provide automatic chiller shutdown during periods when the load level decreases below the normal operating requirements of the chiller. Upon an increase in load, the chiller shall automatically restart.
      b. The control panel shall provide Touch Screen and alphanumeric display showing all system parameters in the English language with numeric data in English units.
      c. Provide kWh consumption and kW demand per each bank of units energy readings. KW metering is by electrical contractor.

d. Provide all Sequences of Operations and Control Points listed on the Control Drawings.

3. Provide connection and integration to the Building Management System via BACNet IP or MSTP, to allow automatic enable control and monitoring of the heat recovery chiller plant system from the building energy management system.

L. The following document provides exacting specifications required for the implementation of a chiller plant control and optimization system.

M. The chiller plant control and optimization system will provide an integrated chiller plant control and optimization solution designed to minimize consumption of electrical power and reduce CO2-e emissions.

N. The system will be furnished in factory wired metal panels consisting of a master panel incorporating a touch screen interface and slave panels for chillers, cooling towers, boilers and other ancillary plant to suit the chiller installation.

O. The system hardware shall contain factory-programmed software configured by a series of input screens and wizards.

P. CHILLER PLANT OPTIMIZATION SYSTEM CONTROLLER HARDWARE COMPONENTS

Q. The central plant optimization system hardware shall consist of the following parts:

a. CPU

R. Intel® Atom™ E3815 (1.46 GHz / 512 KB cache) + 400 MHz GPU

a. RAM

S. 2GB DDR3L 800MHz

a. Memory

T. 32Gb Embedded MMC on-board Flash

a. USB

U. 1 x USB 3.0
1 x USB 2.0

a. Ethernet

V. 1 x 10/100 Fast Ethernet (RJ-45)

W. 1 x 10/100 Fast Ethernet (RJ-45) with PoE

a. Serial Communication

X. No RS-485 on board serial communication but expandable using IP to RS-485 gateways

a. Integrated IO

Y. No onboard integrated IO

a. Operating Platform

Z. Niagara Framework embedded on base OS

a. Communication protocols

AA. BACnet IP

BB. Expandable as required

a. Expansion IO

CC. using IP to RS-485 gateways

a. Chiller plant optimization system controller hardware power requirement

DD. 24V AC or 24V DC

EE. Heat Pump Heat Recovery (HPHR) Chiller/Heater plant optimization system controller hardware power requirement

FF. Power Input

a. 24V AC or 24V DC
b. POE or 12-57V DC

GG. HPHR Chiller plant optimization system controller hardware environmental rating.

a. Operating Temp - 0 deg. C to 60 deg. C
b. Storage Temp - 0 to 70 deg. C
c. Operating Humidity - 5 to 95 percent (Non-condensing)
d. Controller must continue operation even during loss of network connection

HH. HPHR Chiller plant optimization system controller hardware certifications

a. FCC Part 15 Subpart B
b. Class B RoHs
c. CE EN 61326-1
d. UL Certified
e. Canadian ICES-3

II. HPHR Chiller plant optimization system will be delivered in a single package that includes the following components:
    a. FCC, CE, UL & IP rated industrial electrical cabinet
    b. All required input/output devices
    c. Power supply, including required circuit breakers
    d. Communication protocol converters as required
    e. 2 x GPO power outlets
    f. Pre-wired electrical jumpers for simple installation

JJ. Heat Pump Heat Recovery (HPHR) Chiller plant system controls and optimization

KK. The heat recovery heat pump chiller plant optimization system is to provide controls for the following plant equipment:
    a. Heat Recovery Heat Pump Chillers
        1) Minimum support up to 10 HPHR Chiller/Heaters
        2) Brand, Compressor & refrigerant type agnostic
    b. Primary Hot/Chilled Water pumps (Pump Arrays)
        1) Constant speed & variable speed
        2) Dedicated and headered Pump Array configurations
        3) Lead/lag configuration
    c. Secondary pumps
        1) Constant speed & variable speed
        2) Single or Multiple Secondary Circuits
    d. Chilled and Hot water bypass valve for pump turndown on secondary.
    e. Air source heat pump bypass valves if required by the heat pump manufacturer.
    f. Chiller/Heater (HRHP) isolation valves
        1) Analogue
        2) Digital single input
        3) Digital dual input
    g. Boilers
        1) Boiler pumps, EC Motor Control
        2) Dedicated and headered configuration
        3) Valve control
    h. Other ancillary equipment as required

2. Plant equipment control detail
    a. From system idle state, plant control system shall sense start up conditions based on:
        1) External system cooling call
        2) External system heating call
        3) Internal system schedule
        4) Water temperature feedback
        5) Ambient temperature feedback
    b. When Cooling or Heating Call, Internal Schedule and Ambient Temperature conditions are met, plant control system shall activate stage zero to start the chilled or Hot water pump array for the lead HPHR chiller module to allow for water circulation.
    c. When the return chilled water temperature setpoint for plant start is met, plant control system shall enable the HPHR chiller cooling sequence. When the hot water temperature setpoint for plant start is met, plant control system shall enable the HPHR chiller heating or heat recovery heating sequence.
    d. When starting HPHR chillers, plant control system shall first start appropriate chilled and/or hot water and condenser water pumps and ensure that water flow on both vessels is within a safe level. Only after confirmation of safe water flow level shall the plant control system send the HPHR chiller start enable command.
    e. When stopping HPHR chillers, plant control system shall await a configurable condenser water pump run on time and configurable evaporator water pump run on time before disabling condenser water and evaporator water pumps respectively
    f. HPHR Chiller/Heater Plant control system shall begin process of adding capacity when the following conditions become valid:
        1) HPHR Chiller load (kW-r) exceeds configurable safe/acceptable limits
        2) Chilled water temperature exceeds chilled water set point by a configurable amount

3) Hot water temperature is lower than hot water set point by a configurable amount, for Heating and Heat Recovery Heating Modes.

g. Plant control system shall begin process of removing capacity when the following conditions become valid:
   1) HPHR Chiller load (kW-r) is sufficiently low such that current load can be easily maintained by lower stage chiller sequence without requirement for subsequent stage up. System shall ensure that after stage down, subsequent load on remaining chillers shall be no greater than a configurable limit.
   2) Chilled water temperature is sufficiently close to chilled water set point
   3) Hot water temperature is sufficiently close to hot water set point for Heating and Heat Recovery Heating Modes.
h. HPHR Chiller plant control system shall select chiller sequences based on one of the following strategies.
   1) Configurable fixed sequence
   2) HPHR Chiller run time balance sequence to equalize HPHR chiller module runtime
   3) Dynamic Smart chiller sequence which selects the most efficient combination of chillers to start to provide maximum efficiency and simultaneously meet building cooling load requirement.
i. HPHR Chiller plant control system sequencing shall be configurable to suit site requirements.
j. HPHR Chilled water temperature set point shall be modulated to reduce total electrical consumption based on feedback from chilled water return sensor.
   1) Chilled water set point shall not modulate outside of configured limits
   2) Chilled water set point shall not modulate faster than a configured step time
   3) Chilled water set point shall be returned to an acceptable level upon sensing conditions are being lost
k. Condenser water temperature set point shall be modulated to reduce total electrical consumption based on feedback from ambient temperature and humidity sensor
l. Chiller plant control system shall modulate system chilled water, hot water and condenser water bypass valve to maintain the following parameters:
   1) Safe chiller flow through all active HPHR chiller modules.
   2) Field differential pressure
m. Chiller plant control system shall modulate chilled water pump speed to maintain one of the following two parameters selectable via dedicated circuit configuration page;
   1) Primary - Chiller evaporator vessel flow rate
   2) Secondary - Field differential pressure
n. HPHR Chiller plant control system shall modulate condenser water pump speed to maintain the chiller condenser vessel flow rate for the primary.
o. HPHR Chiller plant control system shall stage and modulate secondary pumps on one or more secondary water loops based on feedback from field differential pressure
p. The chiller plant optimization system shall not interfere with any HPHR chillers stand-alone operating or safety algorithms but shall enhance the operation by adjusting control variables to optimize the efficiency of each chiller

3. Plant equipment optimization
   a. The HPHR chiller plant optimization system is to provide the following optimization strategies in order to reduce total electrical consumption and CO2-e emissions.
   b. Dynamic Smart Machine Learning Chiller Sequencing Algorithm
      1) Dynamic Smart Machine Learning Chiller sequencing should allow the chiller plant to run the most efficient combination of chillers for the given conditions even when some machines may be out of service. Dynamic intelligent chiller sequencing should select the most efficient load point for each chiller running. If a chiller goes below the nominal efficiency of that chiller, the chiller can be proactively checked by service personnel minimizing electrical energy waste and avoiding compounding service issues that can be costly. Dynamic intelligent chiller sequencing algorithm should be able to learn the chiller performance then use the learnt information to predict the chiller performance at any condition.

Dynamic Smart Machine Learning Chiller sequencing should be conducted using peer reviewed ASHRAE* chiller model as its basis.

2) Dynamic Smart Machine Learning chiller sequencing should predict the future cooling load of the chiller plant so the chiller staging can accommodate and adapt to the future chiller plant needs smoothly.

c. Heat Recovery Heat Pump Chiller/Heater Lift Optimization
   1) Plant optimization system should be able to control chilled water set points and entering condenser water temperatures to reduce total load on chillers.

4. Manual Intervention
   a. Plant control system must allow for manual intervention
   b. Plant control system shall allow for temporary and permanent manual override of the following set points:
      1) Chilled and Hot Water / Heat Recovery water set point
      2) Field DP set point
      3) Chiller demand limit set point
   c. Operator must be able to perform the following tasks manually from within the program:
      1) Heat Recovery Heat Pump Chiller start/stop (per module)
      2) Pumps start/stop
      3) Pumps frequency change
      4) Open or Close Chiller Isolation Valves
      5) Change the Service State of any unit (Chillers, Pumps,) from Available to Offline or vice-versa for a user-defined period.
      6) Perform a stage up or stage down event action under Automatic Control

LL. HPHR Chiller plant monitoring, verification, reporting and alarming
1. The system will incorporate a real time verification and measurement system by calculating HPHR Chiller efficiency real time based on Chiller performance based on design information from HPHR Chiller Manufacturer or by learning the performance over time and will analyze the operation of individual chillers and the whole plant as a single system.
2. The system will measure the real time performance of each individual chiller in COP terms and compare against the manufacturers ARI 550/590 IPLV/NPLV rated performance data and against an extended performance algorithm that calculates performance data at any condition.
3. The instantaneous cost of chilled, hot / heat recovery water production in cents/kWr will be calculated and displayed for each chiller and the whole plant
4. Predictive Maintenance - Chiller Analytics and Diagnostics
   a. A diagnostics engine will carry out analysis on the heat exchange efficiency
   b. A diagnostics engine will carry out analysis on as well as the vapor compression gas cycle of each individual chiller.
   c. Where the real time performance of any chiller falls below the rated performance data the diagnostic engine will determine operational issues affecting performance.
   d. Diagnostics will be captured and stored within the system and will be displayed in order of priority as a percentage of run time of each HPHR chiller module.
   e. Diagnostics will be able to initiate email alerts to user defined recipients.
5. The following chiller diagnostics will be provided at minimum;
   a. Low Load for Extended Periods
   b. Stacking
   c. Fouled Scaled Evaporator
   d. Fouled Scaled Condenser
   e. Non Condensable
   f. Sensor Imbalance Evaporator
   g. Sensor Imbalance Condenser
   h. Low Refrigerant Level
   i. High Refrigerant Level
   j. High Suction Superheat
   k. Low Suction Superheat
   l. Surging
   m. Hunting CHW, HW Temps
   n. Chiller Short Cycling
   o. Chiller Alarm

6. Other plant diagnostics / alarms to be provided at a minimum are as follows;
   a. Continuous HW & CHW Pump Running
7. Plant and Chiller alarming
   a. Chiller plant optimization system should deliver alarms to users via email.
   b. Limit alarms will be configurable within system.
   c. At minimum the following limit alarms with adjustable tolerances will be provided as standard;

Point Name	Default High Limit	Default Low Limit	Notes
Volts	+10 percent	-10 percent	User Configurable
Amps	+10 percent	0	User Configurable
pf	1	0.8	User Configurable
CHW & HW Temp In	+5	-5	User Configurable
CHW & HW Temp Out	+5	-5	User Configurable
CHW & HW Flow	+20 percent	-20 percent	User Configurable
CHW & HW Approach Temp	+20 percent	-20 percent	User Configurable
CW Temp In	+5	-5	User Configurable
CW Temp Out	+5	-5	User Configurable
CW Flow	+20 percent	-20 percent	User Configurable
CW Approach Temp	+20 percent	-20 percent	User Configurable
Power Absorbed	+10 percent	0	User Configurable
Heat Balance	+20 percent	-20 percent	User Configurable
Superheat Temp	+10	-10	User Configurable
COP	1	30	User Configurable
kW/Ton (per bank & Total)	1.5	0.20	User Configurable

8. Plant and Chiller history logging
   a. The system as standard will log data at a minimum of five minute intervals.
   b. The system must be capable of one minute interval data capture for critical plant functions.
   c. The system will store data for a minimum period of one year on board the local controller with ability to push data to a supervisor or cloud for long term storage.
   d. A graph engine should be provided from within the system to allow a user to create custom graphics to aid in understanding of plant operating conditions
9. Plant and HPHR Chiller reporting
   a. A daily log must be provided showing a status of each chiller for the day.
   b. Daily logs must be provided to required users via email in both SI and US format depending on preference.
   c. A monthly energy report must be provided displaying month-to-date, year-to date and year-on-year energy consumption information.
   d. Monthly energy report must be delivered to users via email in both SI and US formats depending on preference

MM. HPHR Chiller plant optimization system commissioning and use
1. Software Supply
   a. All application software performing the required measurement, verification and control functions shall be factory-supplied
2. Software Configuration
   a. Full configuration of plant equipment must be possible using a Web browser
   b. Configuration of networks and network linking must be possible from within the program using a Web Browser
   c. Configuration must be possible non-specialized programs such as a web browser
   d. Configuration must be a step-by-step process using a wizard style interface
3. Software Commissioning
   a. An easy to use commissioning portal must be available to aid point-to-point commissioning
   b. Controller shall interface at high level with the chiller system manager using an inbuilt network manager which will allow multiple open protocol selection

c. It must be possible to run multiple open protocols simultaneously and to translate information between protocols.
d. Provide BACnet IP Protocol.
e. high level communication is not possible via high level, an add on chiller interface module, pump interface module, cooling tower interface module, flow interface module or utility module must be supplied. The Interface modules will be hard wired with the System Manager panel and will also include a number of mandatory sensors that will need to be installed so as to provide the necessary information and control.

4. Access to program
   a. Program must be accessible via non-specialized program such as web browser
   b. Program must be accessible via a minimum 19 inch touch screen monitor mounted in plant room
   c. Three levels of user accessibility are required to ensure the appropriate information/configuration is shown to the correct personnel. These user levels are as follows:
      1) Admin: Access to full configuration suite, manual intervention and monitoring portal
      2) Building Manager/Technician: Access to manual intervention suite.
      3) Building User: Access to monitoring portal
   d. Program must be easily assessable anywhere in the world via the internet
   e. Secure passwords must be used to protect data within program
5. Data Visualization Graphical User interface
   a. Graphical user interface must be in HTML5 using responsive layout that auto configures layouts based on the device and can be accessed by a standard web browser from any standard operating system like Windows 10/11, MAC OS, Linux, Android 5.0+, iOS 9.0+.
   b. Graphical user interface must be laid out in a logical, easy to use format.
   c. Graphical user interface must be automatically generated upon configuration of chiller plant during commissioning phase.
   d. Graphical user interface must provide possibility on manual addition of custom graphics to suit plant layout as required.
   e. Graphical user interface must be informative and provide appropriate information to the user regarding operational status, efficiency and performance of plant and chillers.
   f. Graphic representation of HRHP chillers must be representative of actual chiller and compressor type.
   g. Graphic representation of HRHP plant equipment including all pumps, tanks, valves, etc. should be realistic and show animation of moving parts when active.

NN. MANUFACTURERS
1. Manufacturers: Subject to compliance with requirements, provide chillers by one of the following:
   a. MultiStack
   b. Clima Cool Corp.
   c. Aermec
   d. Water Furnace
   e. Or Equal

2.11 PUMPS (P) (Refer to section 01 91 13 for additional contract requirements)

A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer.
B. Inline Circulator Pumps:
   1. General: Provide in-line circulator pumps where indicated, and of capacities as scheduled.
   2. Type: Horizontal mount, vertical split case, oil-lubricated, designed for 125 pounds per square inch working pressure, and 225 degrees Fahrenheit continuous water temperature.
   3. Body: Cast-iron, with suction and discharge gage tappings.
   4. Shaft: Hardened alloy steel.
   5. Bearings: Oil-lubricated bronze journal bearings.
   6. Seal: Mechanical, with carbon seal ring and ceramic seat.

7. Motor: Non-overloading at any point on pump curve, open, drip-proof, oil-lubricated journal bearings, resilient mounted construction, built-in thermal overload protection on single phase motors.
   a. Provide shaft grounding ring similar to AEGIS.
8. Couplings: Self-aligning, flexible coupling.
9. Impeller: Enclosed type hydraulically and dynamically balanced, and keyed to shaft
10. Provide Vertical In-Line (VIL) pumps, single stage, single or double suction type, with pump characteristics which provide rising heads to shut off. Refer to pump schedule for pump flows and heads and motor speed, enclosure, efficiency and power requirements and other system conditions. Provide Armstrong Series 4300 split-coupled type VIL units, with rigid spacer type coupling.
11. Pump Construction: Pump Casing - Cast Iron with 125 pounds per square inch ANSI/PN16 flanges for working pressure below 175 pounds per square inch (12 bar) at 150 degrees Fahrenheit (65 degrees. Celsius) and Ductile Iron with 250 pounds per square inch ANSI/PN25 flanges for working pressures to 375 pounds per square inch (25 bar) at 150 degrees Fahrenheit (65 deg. C). Suction and discharge connections shall be flanged and the same size and shall be drilled and tapped for seal flush and gauge connections.
12. Impeller - Bronze, fully enclosed type. Dynamically balanced. Two-plane balancing is required where installed impeller diameter is less than 6 times the impeller width.
13. Shaft - Provide Stainless Steel pump shaft
14. Coupling - Rigid spacer type of high tensile aluminum alloy. Coupling to be designed to be easily removed on site to reveal a space between the pump and motor shafts sufficient to remove all mechanical seal components for servicing and to be replaced without disturbing the pump or motor.
15. Mechanical Seals - Shall be Stainless Steel multi-spring outside balanced type with Viton secondary seal, carbon rotating face and silicon carbide stationary seat. Provide 316 stainless steel gland plate. Provide factory installed flush line with manual vent.
16. All split coupled pumps shall be provided with a lower seal chamber throttle bushing to ensure seals maintain positively cooling and lubrication.
17. Seal flush line accessories, if required to improve seal chamber cleanliness: Supply in the flush line to the mechanical seal a 50 micron cartridge filter and sight flow indicator, to suit the working pressure encountered.
18. Filters shall be changed, by the installing contractor, after system is flushed and on a regular basis until turned over to the owner.
19. Alternately, a maintenance-free accessory needing pump differential pressures exceeding 70 feet/30 pounds per square inch/200 kPa for effective operation: Supply in the flush line to the mechanical seal a maintenance-free sediment separator, with sight flow indicator.
20. Manufacturer: Subject to compliance with requirements, provide in-line circulator pumps of one of the following:
    a. Bell & Gosset ITT; Fluid Handling Div.
    b. Armstrong Pumps, Inc.
    c. Taco, Inc.
    d. Or Equal

C. End Suction Pumps:
1. General: Provide end suction pumps where indicated, and of capacities and having characteristics as scheduled.
2. Type: Horizontal mount, single stage, vertical split case, flexible coupling, base mounted, designed for 175 pounds per square inch working pressure.
3. Casing: Cast iron, 125 pounds per square inch ANSI flanges, tappings for gage and drain connections.
4. Shaft: Stainless Steel with replaceable shaft sleeve.
5. Bearing: Regreasable ball bearings.
6. Seal: Mechanical, with carbon seal ring and ceramic seat.
7. Motor: Open, dripproof, regreasable ball bearings.
   a. Provide shaft grounding ring similar to AEGIS.
8. Impeller: Bronze Construction, Enclosed type, hydraulically and dynamically balanced keyed to shaft and secured with locking screw.
9. Baseplate: Structural steel with welded cross members, and open grouting area.

10. Coupling: Flexible, capable of absorbing torsional vibration, equipped with coupling guard.
11. Manufacturer: Subject to compliance with requirements, provide frame-mounted end suction pumps of one of the following:
    a. Bell & Gosset ITT; Fluid Handling Div.
    b. Armstrong Pumps, Inc.
    c. TACO
    d. Or Equal.

D. PUMP ARRAY
1. VARIABLE SPEED PACKAGED PUMPING SYSTEM
    a. Furnish and install a pre-fabricated and tested variable speed packaged pumping system to maintain a constant or variable differential pressure.
    b. The packaged pump system shall be a standard product of a single pump manufacturer. The entire pump system including pumps and pump logic controller, shall be designed, built, and tested by the same manufacturer.
    c. The complete packaged water booster pump system shall be certified and listed by UL (Category QCZJ – Packaged Pumping Systems) for conformance to U.S. and Canadian Standards.
2. PUMPS
    a. The pumps shall be of the in-line vertical multi-stage design.
    b. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20 percent higher than the head at the best efficiency point.
    c. Small (CR3 to CR20) Vertical In-Line Multi-Stage Pumps (Nominal flow from three to 12 five gallons per minute) shall have the following features:
        1) The pump impellers shall be secured directly to the pump shaft by means of a splined shaft arrangement.
        2) The suction/discharge base shall have ANSI Class 250 flange or internal pipe thread (NPT) connections as determined by the pump station manufacturer.
        3) Pump Construction.
            a) Suction/discharge base, pump head, motor stool: Cast iron (Class 30)
            b) Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
            c) Shaft: 316 or 431 Stainless Steel
            d) Impeller wear rings: 304 Stainless Steel
            e) Shaft journals and chamber bearings:Silicon Carbide
            f) O-rings: EPDM

            Shaft couplings for motor flange sizes 184TC and smaller shall be made of cast iron or sintered steel. Shaft couplings for motor flange sizes larger than 184TC shall be made of ductile iron (ASTM 60-40-18).

            Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel.
        4) The shaft seal shall be a balanced o-ring cartridge type with the following features:
            a) Collar, Drivers, Spring: 316 Stainless Steel
            b) Shaft Sleeve, Gland Plate: 316 Stainless Steel
            c) Stationary Ring: Graphite embedded Silicon Carbide
            d) Rotating Ring: Graphite embedded Silicon Carbide
            e) O-rings: EPDM
        5) Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, shaft coupling and motor. The entire cartridge shaft seal shall be removable as a one-piece component.
        6) Pumps with motors equal to or larger than 15 horsepower shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.
    d. Large (CR32 to CR155) In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 1070 gallons per minute) shall have the following features:
        1) The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.

2) The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.
3) Pump Construction.
   a) Suction/discharge base, pump head — Ductile Iron (ASTM 70-50-05)
   b) Shaft couplings, flange rings: — Ductile Iron (ASTM 70-50-05)
   c) Shaft — 431 Stainless Steel
   d) Motor Stool — Cast Iron (ASTM Class 30)
   e) Impellers, diffuser chambers, outer sleeve: — 304 Stainless Steel
   f) Impeller wear rings: — 304 Stainless Steel
   g) Intermediate Bearing Journals: — Silicon Carbide
   h) Intermediate Chamber Bearings: — Leadless Tin Bronze
   i) Chamber Bushings: — Graphite Filled PTFE
   j) O-rings: — EPDM

   Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel.
4) The shaft seal shall be a balanced O-ring cartridge type with the following features:
   a) Collar, Drivers, Spring: — 316 Stainless Steel
   b) Shaft Sleeve, Gland Plate: — 316 Stainless Steel
   c) Stationary Ring: — Graphite embedded Silicon Carbide
   d) Rotating Ring: — Graphite embedded Silicon Carbide
   e) O-rings: — EPDM
5) Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. The entire cartridge shaft seal shall be removable as a one-piece component.
6) Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

3. INTEGRATED VARIABLE FREQUENCY DRIVE MOTORS
   a. Efficiency: The motors shall be of permanent magnet design meeting IE5 efficiency levels where the combined motor and VFD efficiency exceed NEMA Premium Efficiency standards.
   b. Bearing Current Mitigation: Motors shall use WSB (Winding Set Back) and/or CHS (Coil Head Shield) designs that reduce the Bearing Voltage Ratio (BVR) far enough to eliminate damaging bearing currents. Shaft grounding rings/brushes or common mode filters shall not be required.
   c. Motor Enclosure/Cooling: The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face with Class F insulation and a temperature rise class no higher than Class B. The cooling design of the motor and VFD shall be such that a Class B motor temperature rise is not exceeded at full rated load and speed at a minimum switching frequency of 9.0 kHz.
   d. The power and control electronics shall be housed in a UL Type 3 enclosure and the combined motor/VFD rating shall be IP55 (protection against dust and nozzle directed water from any direction).
   e. The VFD shall be of the PWM (Pulse Width Modulation) design using IGBT (Insulated Gate Bipolar Transistor) technology.
   f. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor current suitable for centrifugal pump control and to eliminate the need for motor de-rating.
   g. The VFD shall automatically reduce the switching frequency and/or the output voltage and frequency to the motor during periods of sustained ambient temperatures that are higher than the normal operating range. The switching frequency shall be reduced before motor speed is reduced.
   h. An integral RFI filter shall be standard in the VFD.
   i. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.

j. The VFD shall have internal solid-state overload protection designed to trip within the range of 105-1ten percent of rated current.
k. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature. Three-phase integrated VFD motors shall be capable of providing full output voltage and frequency with a voltage imbalance of up to ten percent.
l. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:
   1) Speed Reference Signal: 0-10 VDC, 4-20mA
   2) Digital remote on/off
   3) Fault Signal Relay (NC or NO)
   4) Fieldbus communication port (RS485)
m. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 20,000 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

4. PUMP SYSTEM CONTROLLER
   a. The pump system controller shall be a standard product developed and supported by the pump manufacturer.
   b. The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller user interface shall have a color display with a minimum screen size of 3-1/2 inch x 4-5/8 inch for easy viewing of system status parameters and for field programming. The display shall have a back light with contrast adjustment. Password protection of system settings shall be standard.
   c. Galvanic Isolation: The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.
   d. Backup Battery: The controller shall have the ability to be connected to a backup battery to supply power to the controller during periods of loss of supply power.
   e. Home Status Screen: The controller shall display the following as status readings from a single display on the controller (this display shall be the default):
      1) Current value of the control parameter, (typically differential pressure)
      2) Most recent existing alarm (if any)
      3) System status with current operating mode
      4) Status of each pump with current operating mode and rotational speed as a percentage (percent)
      5) Estimated flow-rate, (or actual flow if flow sensor is used)
      6) One user defined measured parameter (i.e. power consumption)
   f. Inputs/Outputs: The controller shall have as a minimum the following hardware inputs and outputs:
      1) Three analog inputs (4-20mA or 0-tenVDC)
      2) Three digital inputs
      3) Two digital outputs
      4) Ethernet connection (built-in web server)
      5) Field Service connection to PC for advanced programming, software and/or firmware upgrades and data logging
   g. Pump system programming: As a minimum, the following parameters shall be available and/or field adjustable:
      1) Sensor Settings: Suction, Discharge, Differential Pressure [analog supply/range]
      2) PI Controller: Proportional gain (Kp) and Integral time (Ti)
      3) Low suction: Pressure/level shutdown via digital contact
      4) Limit Exceeding function: For low system, low suction warnings and shut down [via analog input]
      5) Flow meter settings (if used, analog signal)
   h. Pump Curve Data: The actual pump performance curves (5^{th} order polynomial) shall be loaded (software) into the pump system controller. Pump curve data shall be used for the following:
      1) Display and data logging of calculated flow rate
      2) Variable pressure control (quadratic or proportional)
      3) Pump outside of duty range protection

4) Sequence pumps based on efficiency

i. Variable Pressure Control: The controller shall have variable pressure control to compensate for pipe friction loss by decreasing the pressure set-point at lower flow-rates and increasing the pressure set-point at higher flow-rates by using the actual flow rate or calculated flow rate. Variable pressure control that uses power consumption and speed only shall not be considered equal to variable pressure control that uses actual differential pressure measurement along with pump power and speed.

j. Multi-Sensor: The controller shall be able to control using up to six differential pressure (DP) sensors (zones). Each zone shall have a programmable maximum and minimum DP range. The controller shall be capable of an energy optimal mode where pump speed/energy shall be reduced until any of the zones reach the minimum DP setting.

k. Check Valve Failure Detection (Systems with integrated VFD motors): The system controller shall be able to detect motors turning in the opposite direction and give check valve failure notification.
   1) For minor leaks the pump shall start with a warning indicated
   2) For major leaks the pump shall remain off to prevent damage with an alarm indication

l. Pulse flow meter: The system controller shall be able to receive pulse readings from a digital pulse meter and log/display accumulated flow.

m. DP Subtraction: The system controller shall be able to control off subtraction of two pressure or temperature sensors for differential pressure or differential temperature control.

n. Programmable Setpoints: The system controller shall be able to accept up to seven programmable set-points via a digital input, (additional input/output module may be required).

o. Setpoint Influence: The system pressure set-point shall be capable of being automatically adjusted by using an external set-point influence. The set-point influence function enables the user to adjust the control parameter (typically differential pressure) by measuring an additional parameter. (Example: Lower the system differential pressure set-point based on a flow or outdoor temperature measurement).

p. Remote Control: The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote system on/off (digital) signal.

q. Setpoint Ramp: The controller shall be able to adjust the ramp time of a change in set point (increase and decrease).

r. Warnings and Alarms: The pump system controller shall store up to 24 warnings and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:
   1) Individual pump failure — Check valve failure
   2) VFD trip/failure — Loss of sensor signal (4-20 mA)
   3) Loss of remote set-point signal (4-20mA) — External Fault
   4) Pump outside of duty range — Limit 1 and 2 exceeded*

   *The controller shall be capable of monitoring two analog signals (i.e. suction pressure and discharge pressure) for additional pump or system protection.

s. Built-in data log: The controller shall have built-in data logging capability. Logged values shall be graphically displayed on the controller and shall be downloadable to a notebook/pc as a delimited text file. A minimum of 7200 samples per logged value shall be available for the following parameters:
   1) Estimated flow-rate (or actual flow if flow sensor is connected)
   2) Speed of pumps
   3) Process Value/sensor feedback (usually differential pressure)
   4) Power consumption
   5) Controlling parameter (setpoint)
   6) Inlet pressure (when remote differential pressure is the primary sensor)

t. Redundant Primary Sensor: The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor.

u. Secondary Sensor: Upon loss of signal from the remote sensor, the controller shall be capable of reverting control to the pump system mounted sensors with a programmable

setpoint. The pumps shall maintain a constant, proportional or quadratic pressure across the system until the remote setpoint signal is restored.

v. Pump Test: The controller shall have a pump "Test Run" feature such that pumps are switched on during periods of inactivity (system is switched to the "off" position but with electricity supply still connected). The inoperative pumps shall be switched on for a period of three to four seconds every 24 hours, 48 hours or once per week and at a programmable time of day.

w. Reduced Operation: During backup generator operation, the controller shall be capable of reducing the power consumed by the pump system by either limiting the number of pumps in operation or by limiting the amount of power consumption (kW). The controller shall receive a digital input indicating backup generator operation.

x. Power and Energy Consumption: The controller shall be capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).

y. Specific Energy: When a flow sensor is connected, the controller shall be capable of displaying instantaneous specific energy in Watt-hours per gallon (Wh/gal) or Watt-hours per 1,000 gallons (Wh/kgal).

z. Built-in Ethernet: The controller shall have an Ethernet connection with a built-in web server allowing for connection to a building computer network with read/write access to the controller via a web browser.

aa. Service Contact Information: The controller shall have a programmable Service Contact Field that can be populated with service contact information including: contact name, address, phone number(s) and website.

5. CONTROL PANEL
   a. SCCR: The complete control panel assembly shall have a Short Circuit Current Rating of ten0 kA
   b. BMS Integration: Standard shall be BACnet IP
      The pump system controller shall be mounted in a UL Type 3R rated enclosure. A self-certified NEMA enclosure rating shall not be considered equal. The entire UL Type 3R control panel shall be UL 508 listed as an assembly. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions. The control panel shall include the following:
      1) 80 dB System Fault Audible Alarm with push button to silence
      2) Emergency/Normal Operation Switches (Control bypass)
      3) Individual Service Disconnect Switches (accessible outside of panel)
      4) Pump Run Lights
      5) System Fault Light
      6) Surge Arrestor
6. SEQUENCE OF OPERATION
   a. The system controller shall operate equal capacity variable speed pumps to maintain a constant differential pressure (sensor feedback from remote DP sensor) or variable differential pressure setpoint. The system controller shall receive an analog signal [4-20mA] from the factory installed pressure transducers on the discharge and suction manifolds, indicating the actual system pressure and inlet pressure. The controller shall be capable of controlling off the subtraction of discharge minus suction pressure for differential pressure across the manifolds.
   b. Standard Cascade Control (Pumping Efficiency Based): The pump system controller shall adjust pump speed as necessary to maintain system set-point pressure as flow demand changes. Utilizing the pump curve information (5^{th} order polynomial) combined with suction and discharge pressure measurements, the pump system controller shall stage on additional pumps when pump hydraulic efficiency is determined to be higher with additional pumps in operation. Exception: When the flow and head are outside the operating pumps allowable operating range, the controller shall switch on an additional pump, distributing flow and allowing all pumps to operate within their allowable operating range. When the system pressure is equal to the system set-point, all pumps in operation shall reach equal operating speeds.
   c. Optional Cascade Control (Pump Start Speed Based):As flow demand increases the pump speed shall be increased to maintain the system set-point pressure. When the

operating pump(s) reach 96 percent of full speed (adjustable), an additional pump will be started and will increase speed until the system set-point is achieved. When the system pressure is equal to the system set-point all pumps in operation shall reach equal operating speeds. The pump system controller shall have field adjustable Proportional Gain and Integral time (PI) settings for system optimization.

d. The system controller shall be capable of switching pumps on and off to satisfy system demand without the use of flow sensors, flow switches, motor current monitors or temperature measuring devices.
e. All pumps in the system shall alternate automatically based on demand, time and fault. If flow demand is continuous (no flow shut-down does not occur), the system controller shall have the capability to alternate the pumps every 24 hours, every 48 hours or once per week. The interval and actual time of the pump change-over shall be field adjustable.

7. SYSTEM CONSTRUCTION
   a. Suction and discharge manifold construction shall be in way that ensures minimal pressure drops, and minimizes potential for corrosion. Manifold construction that includes sharp edge transitions or interconnecting piping protruding into the manifold is not acceptable.
   b. The suction and discharge manifolds material shall be 316 stainless steel. Manifold connection sizes shall be as follows:
      1) three inch and smaller: Male NPT threaded
      2) four inch through eight inch: ANSI Class 150 rotating flanges
      3) 10 inch and larger: ANSI Class 150 flanges
   c. Isolation Valves: Pump Isolation valves shall be provided on the suction and discharge of each pump. Isolation valve sizes two inch and smaller shall be nickel plated brass full port ball valves. Isolation valve sizes three inch and larger shall be a full lug style butterfly valve. The valve disk shall be of stainless steel. The valve seat material shall be EPDM and the body shall be cast iron, coated internally and externally with fusion-bonded epoxy.
   d. Check Valves: A spring-loaded non-slam type check valve shall be installed on the discharge of each pump. The valve shall be a wafer style type fitted between two flanges. The head loss through the check valve shall not exceed 5 pounds per square inch at the pump design capacity. Check valves 1-1/2 inch and smaller shall have a POM composite body and poppet, a stainless steel spring with EPDM or NBR seats. Check valves two inch and larger shall have a body material of stainless steel or epoxy coated iron (fusion bonded) with an EPDM or NBR resilient seat. Spring material shall be stainless steel. Disk shall be of stainless steel or leadless bronze.
   e. Pressure Transducers: Pressure transducers shall be factory installed on the suction and discharge manifolds. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be plus/minus 1.0 percent full scale with hysteresis and repeatability of no greater than 0.1 percent full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.
   f. Pressure Gauges: A bourdon tube pressure gauge, 2.five inch diameter, shall be placed on the suction and discharge manifolds. The gauge shall be liquid filled and have copper alloy internal parts in a stainless steel case. Gauge accuracy shall be 2/1/2 percent. The gauge shall be capable of a pressure of 30 percent above its maximum span without requiring recalibration.
   g. Base Frame: The base frame shall be constructed of corrosion resistant 304 stainless steel for systems with multistage pumps with four inch connections and smaller (CR3 to CR64). For multistage pumps with six inch or larger connections (CR95 to CR155), the base frame shall be constructed of ASTM A36 structural carbon steel, powder coated white aluminum RAL9006.
   h. Control Panel Mounting: Depending on the system size and configuration, the control panel shall be mounted in one of the following ways:
      1) On a 304 stainless steel fabricated control cabinet stand attached to the system skid.
      2) On a 304 stainless steel fabricated skid, separate from the main system skid
      3) On its own base (floor mounted with plinth)

8. TESTING
   a. The tester used for testing the pump system shall be constructed and calibrated according to the requirements of hydraulic test standard ISO 9906.

b. The entire pump station shall as a minimum be factory tested for functionality and documented results of functionality test supplied with pump station.
c. Functionality testing shall include the following parameters:
   1) Complete System Hydrostatic Test – 1.5 times the nameplate maximum pressure
   2) Water Shortage Test
   3) Two-Point Setpoint Performance Test.
d. Water used for testing shall be treated with three different filtration systems to ensure only clean water is used for testing pump station.
   1) 25 micron mechanical filter – removes solid parts from water
   2) Activated carbon filter – keeps water clear and eliminates odor
   3) Ultraviolet light system – kills all bacteria growth
e. Optional performance testing shall include:
   1) Witnessed Verified Performance Test

9. Acceptable Manufacturers: Grundfos, Wilo, Armstrong, B&G or equal.

2.12 ROOFTOP AIR HANDLING UNITS (RTU)

A. MANUFACTURERS
1. Subject to compliance with requirements specified here within provide rooftop units as manufactured by Custom Air Handling Solutions, Haakon Industries, Ventrol, Miller Picking, Semco, XNRGY, York Custom, Trane Custom, Air Flow Equipment, Cambridgeport, Temptrol or approved equal. (Rooftop and Indoor Air Handling Units must match the dimensional requirements and unit layouts shown on the drawings with manufacturer's recommended service clearances and code mandated airstream clearances being maintained)
2. Any substitution must fit within the equipment footprint and unit layouts shown on the Drawings and have similar weight to the specified units.

B. GENERAL:
1. Rooftop and indoor air handling units shall be capable of ten0 percent outside air design. Units shall be of the configuration, capacity, and style as indicated on the drawings and Equipment Schedule and as specified herein Through properly designed access; ease of maintenance, removability of components, and unit serviceability shall be assured.
2. The unit shall be constructed for outdoor installation. Outdoor unit to be provided with weatherproofing outside air intake hood and shutoff dampers for supply, return and exhaust.
3. The submitted units shall match the dimensions and layout of those shown on the unit details drawings on the plans as close as possible. Reduced dimensions at the cost of service access is not acceptable.

C. SUBMITTALS
1. Compliance:
   a. Specification Compliance: Include this specification along with the unit submittal. The specification shall be marked up detailing where the submitted equipment is both in, and not in compliance. If the final units are found to be out of compliance with the specifications and it is not dictated in the submitted Specification Compliance, the unit shall be brought back into compliance at the expense of the manufacturer or their local representative.
   b. Schedule Compliance: The submittals shall include a schedule that matches the format of those shown on the plans for this equipment, so that unit performance can easily be compared to the design.
2. Provide all technical information relevant to the product being provided, including but not limited to all the information shown in the schedules of this specification. It is the responsibility of the supplier to highlight any variances that his equipment has with the requirements of this specification whether or not pre-approval has been obtained. Provide the information in the same measurement units as indicated elsewhere in this specification.
3. Provide fan curves (not fan tables), with specified operating points clearly plotted.
4. Provide coil selection worksheets, clearly showing proper consideration for altitude, air density, and glycol corrections. Indicate coil tube fin and casing construction.
5. Provide filter information, including initial APD, final APD, dust spot efficiency, final dust holding capacity, filter media description, filter frame details, and filter removal details.
6. Submit sound power levels for both air handling unit inlet, outlet and radiated at rated capacity. If unit exceeds sound power levels at scheduled conditions, manufacturer must provide sound attenuators and meet specified BHP.

7. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
8. Submit manufacturer's recommended installation instructions.
9. Omission of any of the above information will cause shop drawings to be rejected.

D. GENERAL DESCRIPTION
1. Provide factory-fabricated and factory-tested rooftop and indoor air-handling units as indicated, of sizes and capacities as scheduled, and as specified herein Contractor shall coordinate with rooftop unit manufacture for ship-split requirement and shall be responsible for field installation of all connections per RTU manufacturers requirements. Provide the unit with the following sections as a minimum:
   a. Modulating exhaust fan/economizer section
   b. Filter sections
   c. Modulating supply fan section
   d. Modulating hot water coil heating section
   e. Access sections
   f. Modulating cooling coil section
   g. Diffuser (as required)
   h. Discharge/intake plenums
   i. Modulating energy recovery wheel
2. The complete unit shall be ETL listed.
3. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Units shall be of a modular design with factory installed access sections available to provide maximum design flexibility.
4. Unit is to be shipped factory assembled in one complete section, when possible. Each unit shall be either completely factory assembled and shipped in one piece or split between the fan and cooling sections. Unit manufacturer and HVAC Trade Contractor shall coordinate ship split and field installation, and all unit field inter-connection requirements.
5. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include final balancing of the supply and return fan assemblies and a final unit inspection.
6. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.
7. The Rooftop unit shall be designed, manufactured, and independently tested, rated, and certified to meet the seismic standards of the 2021 International Building Code and ASCE 7-06.
8. Certificates of Compliance shall be provided with the submittal and include the manufacturer's identification, designation of certified characteristics, and the Independent Certifying Agency's name and report identification.
9. Clear installation instructions shall be provided including all accessory components.
10. Performance: All scheduled capacities and face areas are minimum accepted values. All scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.

E. Cabinet, Casing and Frame
1. Provide double-wall construction for all side wall access doors and floor areas shall be provided with 16 gauge exterior and 20 gauge interior aluminum interior liner construction. Inner liners shall protect insulation during service and maintenance. Unit cabinet shall be designed to operate at total static pressures up to 6.5 inches of water gauge.
2. Insulation on ceiling and end panels shall be secured with adhesive and mechanical fasteners. Heavy gauge solid galvanized steel liners shall be provided throughout, allowing no exposed insulation within the air stream.
3. All cabinet insulation, except floor panels, shall be a nominal two inch thick, three pound. density, 4.2 per inch, glass fiber. A combination of solid and perforated galvanized steel liners shall be provided throughout. Perforated liners to be used in the supply and return air plenums to provide improved sound attenuation. Insulation under perforated liners shall be coated with hospital grade liner rated in accordance with standard ASTM C-1071.
4. All floor panels shall include double wall construction and include a nominal four inch thick, three pound. density, R4.2 per inch glass fiber insulation.

5. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin gloss topcoat of a color selected by Architect. Unit exterior casing color finish shall be selected and approved by Architect prior to units being released for production. Painted Finished surface shall withstand a minimum 5,000-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance. Service doors shall be provided on both sides of each section in order to provide user access to all unit components.
6. All sealers shall be LEED qualified.
7. Acoustical Performance:
   a. The housing shall have been tested for acoustical performance by an independent laboratory that is accredited.
   b. Test methods and facilities used to establish sound transmission loss values shall
   c. Sound Transmission Loss DB ASTM E-90 & E413-73

	1	2	3	4	5	6	7	8	
two inch Walls	18	19	27	33	43	52	52	52	STC=l37

   d. Test methods and facilities used to establish sound absorption values shall conform explicitly with the requirements of the ASTM Standard Test Method for Sound Absorption Coefficients by the Reverberation Method: ASTM C423-84A and E795-83. Sound Absorption ASTM C423-84A & E795-83

	1	2	3	4	5	6	7	8	
two inch Walls	.10	.23	.75	1.08	1.05	.99	.97	.95	STC=37

8. Submit lab report for approval.

F. STRUCTURAL BASE CONSTRUCTION
1. Structural steel base shall be constructed from a structurally cataloged perimeter “C” channel frame with intermediate channel and angle iron supports. Sufficient structural support shall be provided beneath all major components. Provide a minimum of four lifting lugs per unit section. Base shall be sufficiently rigid to prevent wall panel joints from separating during lifting and rigging. Units less than or equal to 20 feet long shall have a minimum four inch channel, and units greater than 20 feet shall have a minimum six inch channel.
2. A 3/16 inch checkerplate aluminum floor shall be installed on the base. Floor seams shall be continuously welded providing a completely flat unit floor. A 1-1/2 inch ‘Z’ shaped perimeter collar shall be provided to ensure the unit is internally watertight. The collar shall be fully welded to unit floor and extend up the outside of the inner wall of the wall panel by 1-1/2 inches. The 1-1/2 inch welded collar should be around any floor openings, including section splits. Provide auxiliary 1.25 inch drains in all sections besides the fan sections. Auxiliary drains shall be fully welded and terminate at the exterior base rail, and capped. The 1-1/2 inch collar, together with the fully welded floor, shall guarantee no water leakage. A full 1-1/2 inch flood test shall be conducted in the factory (as part of this contract) for a period of 24 hours and certified by a professional engineer. Results shall be forwarded to owner before payment is released for the equipment. The base shall be sheeted with a 22 gauge galvanized steel underliner. The base liner shall be broken, tack welded and sealed for rigidity and vapor barrier integrity.

G. ACCESS DOORS AND PANELS
1. Provide access doors of the same construction as the unit casing as shown on the drawings for all unit sections containing equipment requiring service, where dampers or damper operators are installed, or areas for cleaning of unit components such as coils or other components which require regular cleaning or service per manufacturer requirements, is required. Access doors shall be equipped with continuous gaskets and shall fit in the door frame in a manner to guarantee 0 percent leakage at design operating pressure. Access door materials shall match casing material.
2. Each access door shall have a built-in static pressure probe port for ease of pressure readings across various internal components and to limit unnecessary or unauthorized access inside the unit.

3. Each access door shall be mounted with stainless steel continuous piano hinges to prevent door racking and air leakage. (Non-continuous hinges are not acceptable). At least two cast aluminum Vent- Lock Model No. 3ten handles operable from either side shall be provided. Other door accessories shall include self-locking nuts for handles and stainless steel hardware to ensure long-term, proper door operation.
4. Each door shall contain a thermal window of double pane safety glass sized at a minimum of 12 inch by 12 inch or 12 inch round, properly sealed to operate safely against the suction or pressure.
5. Access doors shall open against pressure.

H. COILS
1. All cooling coils shall be provided with drain pans. All drain pans shall be insulated and of double wall continuously welded 304 stainless steel. Intermediate drain pans shall be interconnected with stainless steel one inch down pipes. The quantity of down-spouts from intermediate pans to lower pans shall be calculated as a function of condensate loading of coils so that a backup of condensate will not occur and so the condensate has more than one path to travel in the event of a drain plug. Condensate drain shall be a minimum 1-1/4 inch diameter stainless steel tube extending one inch out from unit for solder connection to trap. Drain pans shall be dual sloped within unit and fully drainable. Under no circumstances shall multiple coils be placed one on top of another. Intermediate drain pans shall always extend under the full depth and width of the coil. Coils shall be individually removable without disturbing other coils.
2. Coils shall be certified in accordance with ARI Standard 4ten for water.
3. Construction:
   a. Tubes Horizontal, copper 5/8 inch diameter unless otherwise scheduled), 0.025 inches thick.
   b. Fins Aluminum mechanically bonded to tubes, 0.0095 inches thick. Maximum fin height equal 33 inches; Maximum fins per inch equal 10.
   c. Headers Seamless copper with vent and drain connections.
   d. Casing 16 gauge, galvanized steel (Heating Coils); 16 gauge, stainless steel (cooling coils)
4. All Chilled Water Coil racks shall be 304ss and all Heating Coil racks shall be Galvanized Steel to match coil casing.
5. Match quantities of coils shown on the Air Handler Detail drawings.

I. PLENUM FANS – VFD Control
1. Fans shall be manufactured by Haakon, Twin City, Barry Blower, Greenheck, or equal. Fans shall be centrifugal plenum (plug) type, designed without a scroll type housing. Fans shall incorporate a wheel, heavy gauge reinforced steel inlet plate with removable spun inlet cone, structural steel frame, and shaft and bearings in AMCA Arrangement three or four direct drive configuration as an entire assembly.
2. All fan wheels shall have tapered spun wheel cones or shrouds providing stable flow and high rigidity. The wheels shall be non-overloading type.
3. The blades shall be continuously-welded, die-formed Airfoil type, designed for maximum efficiency and quiet operation. Partial welding will not be acceptable on airfoil blades.
4. Impellers shall be statically and dynamically balanced and complete fan assembly shall be test balanced at the operating speed prior to shipment.
5. Shafts to be sized for first critical speed of at least 1.43 times the maximum speed for the class. Bearings are to be heavy duty, grease lubricated, anti-friction ball or roller, self-aligning, pillow block type and selected for an L10 200,000 hour life at the maximum class RPM.
6. When specified, the fans shall be supplied with internal or nested type variable inlet vanes for wheel diameter 16 ½ inch and larger.
7. Cantilevered vane blades are to be used through Size 490 to minimum air performance insertion losses and noise. Operating mechanism shall be out of the inlet airstream.
8. Provide OSHA approved fully enclosed metal belt guard sides of galvanized steel and expanded metal face. Belt guard shall be sized to allow either sheave to be increased by two sizes.
9. Plenum fan assembly must have an enclosed safety screen as per OSHA Standards.
10. Fans shall have inlet OSHA approved inlet screens.

11. Fan air performance shall be AMCA certified per AMCA Standard 2ten. Fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise well beyond the efficiency peak to assure quiet and stable operation under all conditions. Horsepower characteristics to be non-overloading and reach a peak in the normal selection area. Fan manufacturer shall provide sound power ratings in the eight octave bands based upon AMCA Standard 301. Sound power ratings shall be in decibels referenced to 10 power -12 watts.
12. Factory dynamic balance all fans after their assembly. Use a vibration analyzer to measure velocity, and ensure the final reading does not exceed 0.1 inches per second. Record the exact level of vibration on the fan as proof of the final dynamic balance at the factory.
13. Provide shaft ground protection rings similar to Aegis or equal for all fans.
14. Fan motors shall be premium efficiency inverter duty rated type.
15. VFDs for outdoor AHU/RTUs shall be provided by the unit Manufacturer. VFDs for indoor AHU units shall be provided by the ATC Contractor. For indoor AHUS, the unit Manufacturer shall provide all internal electrical power wiring from Fans, ERW Wheel to disconnect termination point form connection by ATC Contractor. Electrical Contractor shall provide power wiring to VFD.
16. Manufacturers that utilize EC Motors in lieu of VFDs shall be considered acceptable provided that they comply with the following Specifications requirements.

J. Non-Scrolled Fans – Plenum Type:
    1. Fans shall be manufactured by Ziehl Abegg , EBM Pabst or Equal. Fans impeller shall be a single-sided intake, rear-curved motor plenum (plug) type impeller, designed without a scroll type housing. Fans shall incorporate a wheel, steel inlet plate with inlet cone, steel mounting frame, shaft and bearing in an arrangement four direct drive configuration. Fans shall be designed to operate whether mounted horizontally or vertically. Fan shall be hard wall mounted without isolation to ensure tight seal and preserve fans integral dynamic and static balance.
    2. Fan range size shall range in nine frame sizes with an impeller diameter of 10 to 25 inch.
    3. All fans shall have a galvanized inlet nozzle with volume flow rate measuring tap with associated K-factor to report cfm when combined with a pressure transducer airflow measurement device.
    4. Impeller shall have seven rear-curved, profiled blades formed from high-strength composite material suited for plenum rated application and specifically designed for high efficiency and favorable acoustic behavior.
    5. The impeller, mounted direct drive with the external rotor EC motor, shall be statically and dynamically balanced according to ISO 21940 Part 1. Fan characteristic curve measurements shall be based on an inlet-side chamber test rig according to DIN 24163 Part 2 or ISO 5801.
    6. EC motor shall come with integrated electronics including:
        a. Overtemperature protection through active temperature management
        b. 0-tenv DC speed signal input for speed control
        c. Motor alarm status
        d. BACnet IP protocol. If alternate BMS integration protocol is utilized, manufacturer shall provide gateway and associated control wiring. ATC Subcontractor shall provide related programming.
    7. Fan and motor shall meet protection class IP55 and thermal class 155. Performance shall comply with Precision Class 2 according to DIN 24166
    8. Motor shall have a reliable charge temperature range of -4 degrees Fahrenheit to 104 degrees Fahrenheit and comply with IE5
    9. The RTU/AHU air handler manufacturer shall include a motor control center that includes the following features to integrate with unit controls:
        a. Airflow measurement of all fans, Supply and Exhaust/Return
        b. CFM displayed as a totalization
        c. Safety relay for any external lockouts (damper limit switches, fire/smoke alarms, other safeties)
        d. Fan enable and speed control signal
        e. Motor fault status
        f. Touchscreen display for motor control system interface
        g. BACnet/IP interface communication protocol

h. Sufficient space to accommodate ATC Contractor controller and related components.

K. AUTOMATIC TEMPERATURE CONTROLS
1. All internal RTU/AHU Control instruments shall be provided by RTU/AHU manufacturer via Factory, Field or Combination Factory/Field Installation. Unit manufacturer shall provide internal wiring of these control instruments and terminate wiring into Control center panel and cabinet. The RTU manufacturer shall coordinate with the ATC Contractor to ensure sufficient space is provided within the cabinet to house all RTU/AHU and ATC Contractor provided controllers, sensors, wiring and related components.
2. All Controls located downstream of RTU/AHU (e.g. including but not limited to duct mounted static pressure sensors, duct mounted CO2 sensors, duct mounted humidity percent RH sensors, Space combination Temperature/Humidity/CO2 sensors are to be provided by ATC Contractor and wired back to the RTU/AHU controller by the ATC contractor.
3. ATC Contractor shall provide main RTU/AHU Unit DDC Controller and shall connect internal and external control instruments to the main DDC controller and BMS system. ATC contractor shall be responsible for programming AHU/RTU controls sequence of operations and alarms, providing all specified control points into BMS, and providing BMS system animated graphics that are representative of the HVAC Control Drawing Requirements.
4. RTU/AHU manufacturer control instruments, control points and sequence of operation shall be integrated into the BMS by the ATC contractor using BACNet IP protocol.
5. Refer to RTU/AHU specifications and Control drawings for additional information.
6. HVAC and ATC Contractors shall coordinate with unit manufacturer to ensure all sequence of operation and control points are integrated with the BMS to complete the specified sequence of operation and points lists.
7. Rooftop and indoor air handling unit manufacturer shall provide the necessary time and documentation to the ATC sub-subcontractor to provide seamless communication and points to achieve the desired sequence and BMS interface.
8. HVAC and ATC Contractor and RTU/AHU manufacturer shall be responsible for coordinating with each other and confirming all point AO/AI/DO/DI/BACNEt IP Mapable types to ensure the provide point type meets requirements of the design sequence of operation.
9. RTU/AHU manufacturers shall refer to HVAC Control Diagram Drawings and Div 23 00 01 (ATC) Specifications for control and instrument product specification requirements. All provided internal RTU/AHU control components and instrumentation shall meet the product specifications outlined in the Section 23 00 01 (ATC) specification.
10. Refer to “Automatic Temperature Controls’ section for additional requirements.

L. VIBRATION ISOLATION
1. An integral all weld steel vibration isolation base shall be provided for the fan and motor.
2. Provide open spring mounts with iso stiff springs, sound deadening pads and leveling bolts.
3. Horizontal stiffness shall be equal to vertical stiffness.
4. Spring deflection shall be two inch for VFD driven Fans
5. Where EC Fans are used in lieu of VFD driven internally isolated plenum fans, the Air Handler Vibration Isolation Curb shall have a two inch minimum isolation.

M. DAMPERS
1. The unit manufacturer shall provide all dampers at units (e.g. outside air, isolation, and bypass).
2. Damper operators shall be provided in the field by the ATC Contractor or shipped directly to factory at request of HVAC Trade Contractor.
3. Dampers shall be equal to Ruskin or Tamco and shall be aluminum airfoil double thickness opposed blade type, with maximum leakage of four cubic feet per minute/square Feet at one inch w.c. differential pressure for the size provided.

N. FAN AIRFLOW MEASURING PROBES
1. Provide on each fan air flow measuring probes capable of continuously monitoring the air handling capacity of the respective scrolled (plenum) fan.
2. Each airflow probe shall contain multiple, averaged velocity pressure taps located symmetrically around the throat of the fan inlet and a single static pressure tap located on the fan housing. The entire airflow monitoring probe must be located outside the inlet throat as to not obstruct airflow.

3. The probes shall be capable of producing steady, non-pulsating signal of the velocity pressure, independent of the upstream static pressure without adversely affecting the performance of the fan. The sensing probes shall be accurate three percent of actual fan airflow.
4. Refer to Specification Section 23 00 01 (ATC) for additional airflow measuring station and probe product specification requirements.

O. FAN AIRFLOW DISPLAY
1. Provide on indicated fans a method of displaying digitally, in real time, the fans current air flow.
2. The display shall be capable of showing the airflow of two independent fans simultaneously.
3. For interaction with a controller, the display shall output one 0-tenVDC signal for each fan being monitored.
4. The output signal shall be accurate to 0.5 percent of Natural Span, including non-linearity, hysteresis and non-repeatability.
5. The display must be water tight allowing for use in outdoor locations. If the display is not water tight it shall be enclosed in a weatherproof housing.
6. Refer to Specification Section 23 00 01 (ATC) for additional airflow measuring station and probe product specification requirements.

P. OUTSIDE AIRFLOW AIR MEASURING STATION
1. Based on Ebtron Gold and typically furnished as an integral part of the OA damper.
2. Provide one thermal dispersion airflow/temperature measuring device (ATMD) for each location. Differential pressure based devices, including pitot tubes and arrays, are not acceptable. Each ATMD shall consist of one or more factory-mounted, multi-point, measuring probes and microprocessor-based transmitter (remotely mounted by HVAC Subcontractor).
3. Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, extruded aluminum (6063T5) tube with aluminum mounting brackets. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable. Thermistors shall be potted in an engineering thermoplastic assembly using water-proof, marine epoxy and not be damaged by moisture or direct contact with water. Signal processing circuitry on or in the sensor probe is not acceptable. Each sensing node shall be individually wind tunnel calibrated at 16 points to NIST traceable airflow standards.
4. All internal wiring between thermistors and probe connecting cables shall be Kynar jacketed.
5. Manufacturer shall provide UL® listed, FEP jacketed, plenum rated cable(s) between sensor probes and the remote transmitter.
6. Each sensing node shall have a temperature accuracy of plus/minus 0.14 deg. Fahrenheit. Each sensing node shall have a calibrated airflow accuracy of plus/minus 2 percent of reading and the overall installed accuracy of the assembly shall be better than plus/minus five percent of reading at any damper position.
7. The ATMD shall be capable of measuring airflow rates over the full range of 0 to 5,000 FPM between -20 degrees Fahrenheit and 160 degrees Fahrenheit.
8. The transmitter shall be powered by 24 VAC, be over-voltage and over-current protected, and have a watchdog circuit to provide continuous operation after power failures and/or brown-outs. The power requirement for the ATMD shall not exceed 22 V-A.
9. The transmitter shall determine the airflow rate and temperature of each sensing node prior to averaging. The transmitter shall have two isolated and fused analog output signals and one RS-485 network connection. The RS-485 network connection shall be field configurable as BACnet® IP. The RS-485 connections shall be capable of transmitting the average airflow rate, average temperature, individual airflow rates of each sensor node, and individual temperatures of each sensor node and system status.
10. Each analog output shall be field configurable as linear 0-5 VDC, 0-10 VDC or 4-20mA signals. One analog output signal shall provide the average airflow rate. One analog output signal shall be field configurable to output the average temperature, the velocity weighted temperature or a binary airflow alarm.
11. All integrated circuits shall be industrial rated. All electrical plugs, receptacles and circuit board interconnects shall be gold-plated.
12. The ATMD shall be UL® 973 and BTL® listed.
13. Refer to Specification Section 23 00 01 (ATC) for additional product specification requirements.

Q. FILTERS
   1. Prefilters shall be two inch MERV 8. Final Filters shall be 12 inch MERV 14 Cartridge type filters.
   2. Filter velocities shall not exceed 500 fpm.
   3. Holding frames shall be factory fabricated of 16 gauge galvanized steel and shall be equipped with gaskets and two heavy duty positive sealing fasteners. Each fastener shall be capable of withstanding 25 pounds. pressure without deflection. They will be capable of being attached or removed without the use of tools.
   4. Provide one gauge flush mounted into the casing of AHU/RTU for each filter bank. Where filter banks are shown back to back, provide one filter gauge.

R. ENERGY RECOVERY WHEEL (Where Indicated)
   1. Provide energy recovery wheel manufactured by SEMCO or SG America.
   2. The control system shall modulate the rotational speed of the wheel based on supply air temperature.
   3. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. These components will form a cassette which shall be removable from the unit.
   4. The energy recovery cassette shall contain a total energy recovery heat wheel constructed of a light weight polymer material with permanently bonded desiccant coating. The energy recovery wheel media shall be capable of removal from the cassettes and replacement without the use of tools.
   5. Wheel media shall be cleanable using hot water or light detergent without degrading the latent efficiency.
   6. A mini-VFD shall be provided by the unit manufacturer and coordinated with ATC Contractor for frost control. Control of VFD shall be by ATC contractor. VFD shall be wired to the unit single point power by the unit manufacturer.
   7. Unit shall be finish painted with two components etch bond primer and finish painted with alkyd enamel. All uncoated steel shall be painted with red oxide primer. All metal surfaces shall be pre-painted with vinyl wash primer to ensure paint bond to metal.
   8. Outdoor units shall be painted with polyurethane. Provide touch-up paint and finish kit to Owner upon completion of work.
   9. As per Massachusetts Stretch Code C403.7.4.2.2 the weighted average of both the summer and winter enthalpy recovery ratios (ERR) across all units with energy recovery on the job must not be less than 70percent.

S. ELECTRICAL
   1. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with unit shall be numbered and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection.
   2. Supply and return fan motors shall have Circuit breakers and built in overload protection. Supply and return fans shall be power wired internally within the unit to a disconnect/termination point within the unit for connection to ATC contractor provided VFD.
   3. For outdoor RT units, manufacturer shall provide 120 v internal heater for each Fan VFD location. Coordinate location of VFD with ATC and Electrical contractors.
   4. Phase failure and under voltage protection on three-phase motors shall be provided to prevent damage from single phasing, phase reversal, and low voltage conditions.
   5. Each Fan shall have a factory furnished and wired VFD provided by ATC contractor. All drives shall be field wired by project Electrical Contractor. In case where fans are EC controlled, manufacturer shall provide all internal power wiring and disconnects to a single point wiring connection for field power wiring connection by Project Electrical Contractor.
   6. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.
   7. Factory installed and wired marine service light, with switch and receptacle, shall be provided in the supply air and return/exhaust fan section. A separate unit service receptacle electrical circuit shall also power the light circuit.
   8. Compact fluorescent lights with vapor-tight enclosure to be provided at every access section.

9. A factory installed and wired 120 volt power supply shall be provided for the GFI receptacle. The power supply shall be wired to the line side of the disconnect so the receptacle is powered when the main unit disconnect is off. This option shall include a weather proof transformer and disconnect for the 120 volt GFI. The 115 volt GFI electrical circuit shall complete with primary fused short circuit protection.
10. Ground fault protection shall be provided to protect against arcing ground faults.
11. Smoke detectors shall be field installed as shown on the drawings. Smoke detectors shall be furnished and wired to the building Fire Alarm system by the Section 260001 Electrical Subcontractor and installed by the HVAC Trade Contractor and ATC Sub-subcontractor shall wire to shut down unit upon activation.
12. All manufacturer provided instrument control wiring shall be located within conduit provided by Unit manufacturer installed in accordance with NEC requirements. All 115–600 voltage wire shall be protected from damage by raceways or conduit.
13. Provide a factory installed empty EMT conduit to be used by the ATC Contractor. Conduit system to include a conduit through all section internal septum walls and to external NEMA 4X external junction boxes in each access section (one per door).
14. The manufacturer shall provide an electrical power panel load center and circuit breakers for each dedicated 120 v circuit that is to be provided by the manufacturer. At a minimum these dedicated 120 v circuits and associated internal power wiring shall be provided for: Unit lighting, Unit Receptables, Unit provided ATC controls and VFD heater circuits. Provide proposed power wiring diagrams for review and approval.

T. WARRANTY:
1. All units shall be provided with two year parts and labor warranty.
2. Defective parts shall be repaired or replaced during the warranty period at no charge.
3. The warranty period shall commence upon project substantial completion date.
4. Provide warranty certificate.

U. START-UP AND FIRST YEAR WARRANTY SERVICE:
1. The installing contractor shall provide authorized start-up and first two years of warranty services either through his own service agency, a sub-contracted service agency or the manufacturer's service agency. In any event, submit only professional factory authorized service technicians shall perform the work. All records of start-up and repairs to the engineer for review.

V. FACTORY TESTING:
1. Testing shall be recorded and provided on DVD. Testing shall include one unit of each of the following airflow ranges for a total of three units to be factory tested:
   a. 2500 CFM – 7,000 CFM
   b. 7,000 CFM - 10,000 CFM
   c. Above 10,000 CFM
2. Air Flow Testing
   a. Unit manufacturer shall factory test each unit to ensure that it meets the specified air flow requirements.
   b. The test shall be carried out in accordance with the guidelines set forth in AMCA 2ten "Laboratory Methods for Testing Fans for Rating". The unit shall be fitted with a long run of straight ductwork with a flow straightener to allow fully developed flow. The airflow shall be measured using a pitot tube traverse or a calibrated flow measuring station in the duct at the location prescribed by the AMCA guidelines. The performance shall be corrected for temperature, pressure and elevation.
   c. An officer of the air handling unit company shall certify test results. Forward copies of certified test results to the consultant (the consultant shall witness the air flow test on the first two units). Provide for all transportation for the consultant and owner to the factory.
3. Air Leakage Testing
   a. Unit manufacturer shall factory pressure test each air handling unit to ensure the leakage rate of the casing does not exceed 0.5 percent of the unit air flow at 1.5 times the rated static pressure. (Leakage test shall be performed with all VFD and humidifier panels installed, all electrical gear installed, and all coil penetrations made).

b. Test shall be conducted in accordance with SMACNA duct construction manual. All external openings shall be blocked off with temporary plates. The unit shall be pressurized to the test pressure using an external blower. A calibrated orifice shall be used to measure leakage airflow into or out of the unit.
c. An officer of the air handling unit company shall certify test results. Forward copies of certified test results to the consultant. (The consultant shall witness the pressure test on the first two units. Provide for all transportation for the consultant and owner to the factory).
d. "Double duct" or "side by side" units shall have each duct or side tested independently.
e. Positive pressure plenums shall be tested positively and negative pressure plenums shall be tested negatively.

4. Sound Testing
   a. Air handling unit sound power levels are not to exceed the levels shown on the schedule.
   b. Furnish sound power levels at supply connection, return connection, outside air opening relief air openings and casing radiation for each air handling unit. Data shall show sound power levels re 10-12 watts for each of eight octave band center frequencies.
   c. The air handling unit manufacturer shall factory test the completed unit casing absorption using the reference sound source method. The consultant shall witness the sound test on the units. Provide for all transportation for the consultant and owner to the factory.
5. Flood Testing
   a. All unit bases shall be flooded with water to a level of 1.5 inch after manufacturing to assure no leakage through the floor and perimeter water barrier. The results of the flood test shall be certified by the manufacturer.
6. Vibration Testing and Balancing
   a. Fans and motors shall be dynamically balanced to exceed a BV-5 criterion as per AMCA 204-96. The test shall be conducted after the fan and motor base assembly has been completed. The entire fan assembly including fan wheels, shafts, bearings, drives, belts, motors, isolation bases shall be tested. During the test, the fan and motor base shall be supported by its isolators which are set in the freely floating operating position. (In cases where a concrete inertia base is provided, the factory poured concrete shall be installed at the time of the vibration test).
   b. The required measurement points are as follows: one horizontal measurement and one vertical measurement shall be taken for each fan and motor bearing and one axial measurement shall be taken for each shaft (A total of 10 points for a typical belt driven fan-motor assembly). The measurements shall be taken using calibrated, magnetically mounted accelerometers and a calibrated measuring instrument.
   c. Vibration measurement locations shall be as close as possible to the bearing or shaft centerlines. Measurements shall be taken from the bearing housings, bearing pedestals, or motor casings. Measurements shall not be taken from flexible covers or shields.
   d. Fans and motors shall be tested at the design RPM and the maximum overall filter-in vibration levels at each measurement point shall be less than or equal to 0.15 in/second peak velocity at the operating speed. If any measurements exceed the above criterion, the assembly shall be rebalanced and re-tested until the criterion is achieved.
   e. Certified measurements shall be provided to the consultant.

2.13 VARIABLE AIR VOLUME BOX & CONSTANT AIR VOLUME REGULATORS (VAV & CVR)

A. General: Provide factory-fabricated and tested air terminals as shown on drawings, selected with performance characteristics which match or exceed those indicated on schedule.

B. Casings: Construct of die-cast aluminum or sheet metal of the following minimum thicknesses:

	Steel	**Aluminum**
1. Upstream Pressure Side:	22-ga.	0.032 inch
2. Downstream Pressure Side;	22-ga.	0.025 inch

3. Provide hanger brackets for attachment of supports.
4. Linings: Line inside surfaces of casings with hospital grade lining material meeting ASTM Standard C1071 to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing. Provide minimum thickness of one inch Secure lining to prevent delamination, sagging or settling. Seal edges of lining to prevent fraying.
   a. Cover liner surfaces and edges with mylar, foil or perforated metal.

5. Leakage: Construct casings such that when subjected to 0.5-inch w.g. pressure for low pressure units, and 3.0-inch w.g. pressure for high pressure units, total leakage does not exceed four percent of specified air flow capacity with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 6.0-inch w.g. inlet pressure with damper closed, total leakage does not exceed ten percent of specified air flow capacity.

C. Air Dampers: Construct of materials that cannot corrode, do not require lubrication, nor require periodic servicing. Provide maximum volume dampers, pressure independent that are calibrated in cfm, factory-adjusted, and marked for specified air capacities. Provide mechanism to vary air volume thru damper from minimum to maximum, in response to signal from thermostat.

D. Controls: Provide controls accurate to 1.5 degrees Fahrenheit (0.8 deg. C) and adjustable from 65 degrees Fahrenheit (22 deg. C) to 85 degrees Fahrenheit (29 deg. C).
   1. ATC Contractor to provide DDC controls, compatible with automatic temperature control system specified in other Division-23 sections, and ship to manufacturer for installation. All testing and commissioning shall be completed in field.

E. Identification: Provide label on each unit indicating Unit Number, cfm range, cfm factory-setting, and calibration curve (if required).

F. Coils: Provide the following coils as indicated on Drawings and schedule:
   1. Hot Water Heating Coils: Provide heating coils constructed of copper tubes and aluminum fins with galvanized steel casing.

G. Silencer:
   1. Silencer section shall consist of 20 gauge solid metal casing, 22 gauage perforated liners, and absorptive acoustic fiberglass liner.
   2. Acceptable methods of silencer construction shall be button lock, Pittsburgh lock, and welds. In situations where these methods are not feasible, rivets can be used. Screws or other mechanical fasteners on the silencer will not be acceptable.
   3. The silencer noses and perforated liners shall be rigidly fastened to the casing of the silencer on both the top and bottom.
   4. The silencer section acoustic media shall be shot free inorganic glass fiber with long, resilient fibers, bonded with thermosetting resin, and contain 50 percent recycled media. Glass fiber shall be packed with a minimum ten percent compression to eliminate voids and settling; density shall consistent with that used to generate catalog test data. Combustion ratings for acoustical media shall be equal to or less than the combustion ratings noted below when tested in accordance with ASTM E84, UL713, and NFPA 255:
      a. Flame Spread Classification: 25
      b. Smoke Development Rating: 50
   5. Silencer shall be Price model SUDQ.

H. Manufacturer: Subject to compliance with requirements, provide variable air volume boxes of one of the following:
   1. Price
   2. Carnes Co.
   3. Titus Products Div.
   4. Or equal

I. CONSTANT AIR VOLUME REGULATORS (CVRs)
   1. General: Constant Air Volume Regulators shall operate solely on duct pressure and require no external power supply. Each regulator shall be capable of being field adjusted to the required airflow set point, as indicated on the schedule, by manual adjustment of the control device using an Allen/ Hex key. The device shall be rated for use in air temperatures ranging from -22 degrees Fahrenheit to 212 degrees Fahrenheit.
   2. Control: Constant Air Volume Regulators shall be capable of maintaining constant airflow within plus/minus ten percent for nominal airflow greater than 60 CFM and plus/minus five CFM for nominal airflow less than 60 CFM throughout the target operating pressure range of 0.2 to 4.0 inch w.g. differential pressure.
   3. Sound: Sound Power levels shall not exceed those for each size and CFM rating as scheduled.

4. Construction: Laser-welded, galvanized steel body, a translucent plastic control device, and a double-lip air-tight seal around the circumference to ensure a no-leak fit. The integral control device shall be comprised of an aluminum damper and a stainless steel spring & shaft fitted to PTFE bearings. A pneumatic piston damper prevents overshoot and oscillation of the control damper and ensures an accurate response and control behavior.
5. Warranty: Constant Airflow Volume Regulators shall require no maintenance and must be warranted for a period of no-less than five years.
6. Manufacturer: Subject to compliance with requirements, provide constant air volume regulators of one of the following:
    a. Aldes
    b. Or Equal

2.14 TERMINAL COOLING/HEATING UNITS (HYDRONIC) (Refer to section 01 91 13 - Requirements for additional contract requirements)

A. Radiant Cooling/Heating Panels
1. Linear radiant panels shall use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face. The linear radiant panel is to radiate or absorb heat from or to the zone below.
2. Water Tubes: Tubes shall consist of ASTM B75 ½ inch nominal copper tubing. Water connections shall be one end only. Water connections shall be suitable for solder, compression fittings, push-on fittings or threaded connection.
3. Heat Sinks: Heat sinks shall be extruded aluminum and copper pipe will be mechanically fastened to the heat sink. A non-hardening heat transfer paste is required between the tubing and the heat sink.
4. Extruded Aluminum Plank: The panel shall be constructed of 1.2 millimeter thick extruded aluminum
5. Paint Finish: All visible components shall be powder-coated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Manufacturer shall provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN 14037 (heating) and DIN 14240 (cooling).
6. Finish Color as selected by Architect.
7. Radiant panel capacity shall be tested and certified by manufacturer in accordance with DIN 14037 (heating) to meet the performance listed on the schedule. Should any performance rating, hot water supply temperature, water pressure drop and/or dimensions deviate from the schedule, manufacturer shall submit updated capacity, as well as computational fluid dynamic modeling demonstrating that any changes do not impact the air distribution in a room that would cause a detriment to the PMV and ADPI rating from the design conditions. Manufacturer shall have factory testing facility available to perform performance test of units in accordance with said standard, as required. Upon request, up to one percent of units for the project can be tested in accordance with the standard. Request will be made with order and prior to shipment of chilled sails. Engineer will have the option of witnessing this test.
8. Water connections shall be shipped sealed to limit the introduction of dust and dirt during shipping and construction.
9. Support: Provide all supports to properly support unit at the wall and at the leading edge of the panel. For light shelf applications installed at curtain walls provide concealed mounting arm. Mounting shall be welded by HVAC to tube steel provided by Construction Manager. For light shelf applications installed at gypsum wall board provide “C” channel bracket with 3/8 inch threaded rod for support. Frequency of mounted arm and threaded rods shall be as required to support ten0 pounds/linear foot of weight handing from the light shelf. Panel manufacturer shall field verify and calculate the required frequency and submit for approval.
10. Panel manufacturer shall provide all necessary inter-connecting piping, fittings, support brackets (arms) installation kits, pipe headers, circuits, accessories, trimmable panels, filler panels and all other necessary components as required for a complete and seamless radiant panel system.
11. Accessories:
    a. Manufacturer shall supply upon request 12 inch/18 inch stainless steel braided hose with isolation ball valves as required.
    b. Insulation (foil backed insulation)
    c. Mitered corners

d. Trim able panel
e. Activated top

12. Paint color as selected by Architect.
13. Manufacturers:
    a. TWA
    b. Sterling
    c. Zender Rittling
    d. or Equal

B. HYDRONIC FAN-COIL UNITS (FC):
1. General: Provide fan-coil units having cabinet sizes, and in locations indicated, and of capacities, style, and having accessories as scheduled. Include in factory assembled unit, chassis, coils, freezestat, fanboard, fans, housing, ECM motor, filter, and insulation. All automatic controls and communication interface board shall be provided and field installed by ATC contractor.
2. Chassis: Construct chassis of galvanized steel with flanged edges.
3. Insulation: Faced, heavy density glass fiber.
4. Cabinet: Construct of 16-gauage steel removable panels, 16-gauge front. Provide insulation over entire coil section. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer and finish paint color as selected by architect.
5. Coils: Construct of 5/8 inch seamless copper tubes mechanically bonded to configured aluminum fins. Design for 300 pounds per square inch working pressure, and leak test at 300 pounds per square inch under water.
6. Fans: Provide centrifugal forward curved double width wheels of reinforced fiberglass, in galvanized steel fan scrolls.
7. Motors: Provide ECM motors with integral thermal overload protection. Run test motors at factory in assembled unit prior to shipping. Provide quickly detachable motor cords. Provide speed dial for speed control.
8. Filters: Provide one inch thick MERV 8 throwaway type filters in fiberboard frames.
9. Outside And Return Air Dampers: Provide 18-guage steel damper blades with polyurethane stop across entire blade length. Provide factory-mounted electronic operators.
10. Accessories: Provide the following accessories as indicated and/or scheduled:
    a. Inlet Grille: Provide 18-guageuge black painted steel with 15 degrees. blade angle.
    b. Recessing Flanges: Provide 18-guage steel flanges for recessing fan-coil units into ceiling.
11. Manufacturer: Subject to compliance with requirements, provide fan-coil units of one of the following:
    a. Rittling
    b. Trane
    c. Carrier Corp.
    d. McQuay Inc.
    e. Or equal

2.15 TERMINAL HEATING UNITS (HYDRONIC) (Refer to section 01 91 13 - Requirements for additional contract requirements)

A. Finned Tube Radiation:
1. General: Provide finned tube radiation of lengths and in locations as shown on drawings, and of capacities, style, and having accessories as scheduled.
2. Cabinets: Minimum 18-guageuge cold-rolled steel full backplate, minimum 14-guageuge front. Brace and reinforce front minimum of four feet-0 inch o.c. without visible fasteners.
3. Elements: Copper tube and aluminum fins, or steel tube and steel fin (as scheduled) with tube mechanically expanded into fin collars to eliminate noise and insure durability and performance at scheduled ratings.
4. Finish: Flat black heat resisting paint for backplate; factory finished baked enamel on fronts and accessories. Color selected by Architect.
5. Provide sample selection chart.
6. Accessories:
    a. End panels, inside and outside corners, and enclosure extension.
    b. Access panels in front of valves, balancing cocks, and traps.
    c. Factory-mounted dampers.

d. Ball bearing hangers.

7. Manufacturer: Subject to compliance with requirements, provide finned tube radiation of one of the following:
   a. Slant/Fin Corp.
   b. Rittling
   c. Sterling Radiator; Div. of Reed National Corp.
   d. Or equal

B. Hydronic Convectors
1. General: Provide convectors having cabinet sizes and in locations as shown on drawings, and of capacities, style, and having accessories as scheduled.
2. Cabinets: Minimum 14-guageuge steel front and top panels, 18-guageuge side panels, and 20-gauge back panels. Phosphatize and galvanize back panels, phosphatize and paint tops, sides, and fronts with one coat of primer and factory finished baked enamel. Color selected by the architect. Secure fronts in place with quick opening slide bolts or camlock fasteners.
   a. Provide sample selection chart.
   b. Recessed Cabinets: One-piece front panel, with hour-side gasketed overlap.
3. Elements: Aluminum fins, ribbed steel side plates, fin tube supports and copper tubes, cast-iron headers. Factory test each element to 150 POUNDS PER SQUARE INCH air pressure under water.
4. Accessories: Provide the following accessories.
   a. Factory-mounted dampers.
   b. 1/2 inch insulation on front
   c. Access doors in front for valve access.
5. Manufacturer: Subject to compliance with requirements, provide convectors of one of the following:
   a. Airtherm Mfg. Co.,
   b. American Air Filter Co.
   c. Sterling Radiator; Div. of Reed National Corp.
   d. Rittling
   e. Trane (The) Co.
   f. Or Equal.

C. Unit Heaters (UH) (Horizontal Type)
1. General: Provide horizontal unit heaters in locations as shown on drawings, and of capacities, style, and having accessories as scheduled.
2. Construction:
   a. Casings: Construct of steel, phosphatized inside and out, and finished with baked enamel. Color selected by the architect. Provide adjustable face air diffuser.
   b. Provide sample selection chart.
   c. Fans: Construct of aluminum and factory-balance. Design so motor and fan assembly is removable through fan outlet panel.
   d. Coils: Construct of plate-type aluminum fins, mechanically bonded to copper tubes. Design coil for use in hot water applications.
   e. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.
3. Manufacturer: Subject to compliance with requirements, provide horizontal unit heaters of one of the following:
   a. Airtherm Mfg. Co.
   b. Rittling
   c. Sterling Radiator; Div. of Reed National Corp.
   d. Modine
   e. Or Equal.

D. Unit Heaters (UH) (Cabinet Type)
1. General: Provide cabinet unit heaters having cabinet sizes and in locations as shown on drawings, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, and insulation.
2. Construction:
   a. Chassis: Galvanized steel wrap-ground structural frame with edges flanged.
   b. Insulation: Faced, heavy density glass fiber.

c. Cabinet: 14-guageuge removable front panel, 18-guage top and side panels. Insulate front panel over entire coil section. Provide access door on coil connection side. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer and baked enamel finish paint with color as selected by Architect.
d. Provide sample selection chart.
e. Water Coils: Construct of 5/eight inch seamless copper tubes mechanically bonded to configured aluminum fins. Design for 300 pounds per square inch and leak test at 300 pounds per square inch under water. Provide same end connections for supply and return.
f. Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass reinforced thermo-plastic material. Construct fan scrolls of galvanized steel.
g. Motors: Provide shaded pole motors with integral thermal over-load protection, and motor cords for plug-in to junction box in unit. Provide three speed switch on fan motor.
h. Filters: Provide one inch thick throwaway type filters in fiberboard frames.

3. Manufacturer: Subject to compliance with requirements, provide cabinet heaters of one of the following:
a. McQuay Inc.
b. Trane (The) Co.
c. Young Radiator Co.
d. Sterling Radiator; Div. of Reed National Corp.
e. Or Equal.

E. Radiant Heating and Cooling Panels
1. Linear radiant panels shall use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face. The linear radiant panel is to radiate or absorb heat from or to the zone below.
2. Provide all required mounting components and accessories to meet size, capacity and characteristics as required on the Equipment Schedule or on the plans. Units shall be installed in a neat and workmanlike manner in accordance with specifications and manufacturer recommendations.
3. Water Tubes: Tubes shall consist of ASTM B75 ½ inch nominal (5/eight inch O.D) Type L copper tubing. Water connections shall be suitable for solder, compression fittings, push-on fittings or threaded connection. snapped into tube saddles and mechanically fastened to the aluminum extrusion. ½ inch nominal copper return bends and interconnectors shall both be provided with flared ends and supplied loose. Quantity shall be based upon the number of tubes wide for each panel. Refer to plans and details for additional requirements.
4. Heat Sinks: Heat sinks shall be extruded aluminum and copper pipe will be mechanically fastened to the heat sink. A non-hardening heat transfer paste is required between the tubing and the heat sink.
5. Extruded Aluminum Panels: The panel shall be constructed of minimum six inch wide and minimum 1.2 millimeter thick extruded aluminum. The extruded aluminum panels shall interlock using tongue and groove connections and mechanically held together with steel cross braces. Tube saddles should be an integral part of the aluminum extrusion. The total width and number of tubes should meet the required design specifications
6. Paint Finish: All visible components shall be degreased after fabrication and chemically phosphatized before application of a durable, attractive electrostatic epoxy powder coating paint finish for optimal radiative properties as well as durability and easy cleaning.
7. Finish Color as selected by Architect.
8. Submittals: Manufacturer shall provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN 14037 (heating) and DIN 14240 (cooling). Submittal drawings shall include supply and return field connection locations along with interconnecting details.
9. Radiant panel capacity shall be tested and certified by manufacturer in accordance with DIN 14037 (heating) and DIN 14240 (cooling) to meet the performance listed on the schedule. Should any performance rating, hot water supply temperature, chilled water supply temperature, water pressure drop, and/or dimensions deviate from the schedule, manufacturer shall submit updated capacity, as well as computational fluid dynamic modeling demonstrating that any changes do not impact the air distribution in a room that would cause

a detriment to the PMV and ADPI rating from the design conditions. Manufacturer shall have factory testing facility available to perform performance test of units in accordance with said standard, as required. Upon request, up to 1 percent of units for the project can be tested in accordance with the standard. Request will be made with order and prior to shipment of radiant panels.

10. Units shall be manufactured in accordance with conformance to ISO 9001:2000 standards.
11. Water connections shall be shipped sealed to limit the introduction of dust and dirt during shipping and construction.
12. Support: Provide all supports to properly support unit at the wall or ceiling as applicable and at the leading edge of the panel. For light shelf applications installed at curtain walls provide concealed mounting arm. Mounting shall be welded by HVAC to tube steel provided by Construction Manager. For light shelf applications installed at gypsum wall board provide “C” channel bracket with 3/8 inch threaded rod for support. Frequency of mounted arm and threaded rods shall be as required to support ten0 lbs/linear foot of weight handing from the light shelf. Panel manufacturer shall field verify and calculate the required frequency and submit for approval.
13. Panel manufacturer shall furnish and HVAC Trade Contractor shall install all necessary inter-connecting piping, fittings, support brackets (arms) installation kits, pipe headers, circuits, accessories, trimmable panels, filler panels and all other necessary components as required for a complete and seamless radiant panel system.
14. Accessories:
    a. Insulation (foil backed insulation) – minimum one inch think 1 pound density fiberglass insulation for ceiling mounted radiant panel application
    b. Mitered corners
    c. Trimmable panel
    d. Activated top (for light shelf application)
15. Paint color as selected by Architect.
16. Manufacturers: Subject to compliance with specification requirements above, radiant panels shall be as manufactured by one of the following manufacturers. Manufacturer shall be regularly involved in the production of linear radiant ceiling panels and have available published performance data. Manufacturer’s proposed selections shall be equal or better than the basis of design selections indicated on the Drawing Schedules and specification requirements in regard to rows of tubes, capacity, water pressure drop, piping connections and finish.
    a. Zehnder Rittling
    b. TWA
    c. Sterling
    d. or Equal

F. Radiation Wall Units (RWU)
1. Double Panel Radiators
    a. General: Provide steel double panel radiators of the lengths and in locations as indicated, and of capacities, style and having accessories as scheduled. The double heating panel radiation shall be of one-piece all-welded steel construction, consisting of a pair of flattened water tube panels welded to headers at each end. Welded to the inside of each panel shall be steel corrugated fins to increase the convective output of the radiator. The fins shall start at no less than three inch from the end of the radiator, and shall have no less than 32 fins per foot. A third set of fins shall be added to the backside of the radiator for maximum convective output. The radiators shall include an integral heavy gauge (0.09 inch minimum) all-welded perforated top grille, which will cover the top of all of the finned areas.
    b. The headers shall include all necessary inlet, outlet and vent connections as required. Standard connection sizes are ½” NPT tapered thread for supply and return piping, and 1/8 inch for the vent connection. Internal baffling is provided where required for proper water flow.
    c. The radiant heating panels shall be available in lengths from 2 feet-0 inch to 29 feet-six inch in two inch even increments without the need for splicing. The panel radiation shall be capable of being mounted to typical stud wall construction without additional blocking or strapping. Appropriate wall mounting brackets shall be provided with the radiation.

d. The panel radiation shall be manufactured in the USA.
e. Panel radiation expansion shall not exceed 1/64 inch per foot of radiation at 215 degrees Fahrenheit . The installer shall provide adequate expansion compensation for each radiator.
f. Finishes: The panel radiation shall be cleaned and phosphatized in preparation for the powder coat finish. The radiation is then finish painted with a gloss powder coat finish, for a total paint thickness of two-three mils (0.002 inch - 0.003 inch). The color shall be selected by the Architect, provide sample selection chart. Provide ribbed pipe cover trims, finished to match the radiator.
g. Warranty: All radiators are covered by a five Year Limited Warranty.
h. Manufacturer: Subject to compliance with requirements, provide flat tube panel radiation as manufactured by:
   1) Runtal North America, Inc.
   2) Rittling
   3) Sterling
   4) Or equal

2. Single Panel Radiators
   a. General: Provide steel panel radiator elements of lengths and in locations as indicated, and of capacities, style and having accessories as scheduled. The wall hung heating panel radiation shall be of one-piece all-welded steel construction, consisting of flattened water tubes welded to headers at each end. The radiator shall include an integral heavy gauge (0.09 inch minimum) all-welded perforated top grille (for curved radiators the grille is omitted). RF models to have steel corrugated fins welded to the rear side of the water tubes to increase the convective output of the unit. There shall be no less than 32 fins per foot. Fins shall start within one inch of the headers, and shall be spotwelded three times per tube.
   b. The radiator's headers shall include all necessary inlet, outlet and vent connections as required. Standard connection sizes are ½ inch NPT tapered thread for supply and return piping, and 1/8 inch for the vent connection. Internal baffling is provided where required for proper water flow. Optional ¾ inch connections shall be available at an additional cost.
   c. The radiant heating panels shall be available in lengths from 2 feet-0 inch to 29 feet-six inch in two inch even increments without the need for splicing. The panel radiation shall be capable of being mounted to typical stud wall construction without additional blocking or strapping. Appropriate wall mounting brackets or optional floor post mounting shall be provided with the radiation. Panel radiation expansion shall not exceed 1/64 inch per foot of radiation at 215 degrees Fahrenheit . The installer shall provide adequate expansion compensation for each radiator.
   d. The panel radiation shall be manufactured in the USA.
   e. Pressure Ratings: Standard: Working pressure-56 POUNDS PER SQUARE INCH maximum, Test Pressure-74 POUNDS PER SQUARE INCH maximum.
   f. Finishes: The panel radiation shall be cleaned and phosphatized in preparation for the powder coat finish. The radiation is then finish painted with a gloss powder coat finish, for a total paint thickness of 2-3 mils (0.002 inch - 0.003 inch). The color shall be selected by the Architect, provide sample selection chart. Provide ribbed pipe cover trims, finished to match the radiator.
   g. Warranty: All radiators are covered by a 5-Year Limited Warranty.
   h. Manufacturer: Subject to compliance with requirements, provide flat tube panel radiation as manufactured by:
      1) Runtal North America, Inc.
      2) Ritting
      3) Sterling
      4) Or equal

2.16 TERMINAL HEATING UNITS (ELECTRIC) (Refer to section 01 91 13 - General for additional contract requirements)

A. Electric Propeller Unit Heaters (UH)
   1. Materials and Equipment:
      a. General: Except as otherwise indicated, provide manufacturer's standard electric propeller unit heater materials and components as indicated by published product

information, designed and constructed as recommended by manufacturer for a complete installation.

2. Heating Elements:
   a. General: Except as otherwise indicated, provide manufacturer's standard heating elements of types, sizes, capacities, and ratings for duty indicated; consisting of resistance elements in steel sheath with extended fins, or with spirally finned sheath.
   b. Heating Capacity: Size elements for indicated fan speed, CFM, room heating load (BTUH), entering air temperature, and electric inputs (watts, voltage, phase).
3. Casings:
   a. General: Provide casings braced and reinforced to provide required stiffness, and with adjustable heating element supports and brackets. Provide rounded corners. Phosphatize and paint casings inside and out with single coat of baked-on enamel; and zinc plate hardware. Include fan orifice (venturi) in casing, as well as threaded hanger connections (weld nuts). Fabricate from 18 guagege galvanized steel.
4. Air Deflectors:
   a. General: Provide manufacturer's standard air deflectors of the following types:
      1) 4-way finned louvers.
      2) Cone diffusers.
      3) Vane outlets.
      4) Louver outlets.
5. Motors:
   a. General: Provide totally enclosed shaded-pole, or permanent-split capacitor motors, Class "B" insulation, resiliently mounted, tap wound with built-in thermal overload protection, and with sleeve type or permanently lubricated ball bearings.
   b. Internal Electrical Wiring: Provide units with high temperature, heat-resistant electrical wiring enclosed in flexible metal conduit extending from terminal junction box to electrical devices. Provide fusing for motor and control circuit wiring.
   c. Devices: Provide propeller unit heaters with the following devices:
      1) Thermally activated fan switch to keep fan motor operating until residual heat is dissipated.
      2) Disconnect switch.
      3) Automatic reset, high limit cut-out switch located in discharge air stream.
      4) Magnetic contractor.
      5) Transformer.
6. Fans:
   a. General: Provide aluminum propeller fans which are balanced statically and dynamically, of indicated capacity. Provide fans suitable for standard or spark-proof application.
7. Manufacturers: Subject to compliance with requirements, provide propeller unit heaters of one if the following:
   a. Chromalox Div.; Emerson Electric Co.
   b. Federal Pacific Electric Co.
   c. Gould Inc.
   d. Markel Nuton Div.; Scoville Inc.
   e. TPI Corporation.
   f. Qmark
   g. Or Equal.

2.17 POWER AND GRAVITY VENTILATORS (Refer to section 01 91 13 - Requirements for additional contract requirements)

A. General: Except as otherwise indicated, provide standard prefabricated power and gravity ventilator units of type and size indicated, modified as necessary to comply with requirements, and for complete installation.
B. Refer to Section 23 00 01 (ATC) - Automatic Temperature Control for control sequence.
C. Roof Fans (EF)
   1. Type: Centrifugal fan, direct or belt driven as scheduled. Provide aluminum, or galvanized steel, weatherproof housings as scheduled. Provide square base to suit roof curb. Provide permanent split-capacitor type motor for direct driven fans; capacitor-start, induction-run type motor for belt driven fans.

2. Electrical: Provide factory-wired non-fusible type disconnect switch at motor in fan housing. Provide thermal overload protection in fan motor. Provide conduit chase within unit for electrical connection. Provide shaft grounding ring similar to AEGIS.
3. Bird Screens: Provide removable bird screens, 1/2 inch mesh, 16-gauge. aluminum or brass wire.
4. Motor Operated Dampers: Provide louvered dampers with linkage below curb base (maximum of six inch). Provide hinged curb access with restraint cable for service.
5. Manufacturer: Subject to compliance with requirements, provide centrifugal roof ventilators of one of the following:
   a. Carnes Co., Div. of Wehr Corp.
   b. Cook Co., Loren.
   c. Greenheck Fan Corp.
   d. Penn Ventilator Co., Inc.
   e. Power Line Fans; Div. of Torin Corp.
   f. Swartwout Industries Inc.
   g. Or Equal.

D. Centrifugal In-Line Fans (EF)
1. General: Fans shall be of the centrifugal belt or direct driven in-line type. Units shall bear AMCA label.
2. Fan Housing: Shall be of the square design constructed of heavy gauge galvanized steel and shall include square duct mounting collars. Unit shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components.
3. Fan Wheel: Shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
4. Motors: Shall be heavy duty ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase, and enclosure. Motors and drives shall be mounted out of the airstream. Motors shall be readily accessible for maintenance.
5. Shafts and Drives: Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor pulleys shall be adjustable for final system balancing. A NEMA 1 disconnect switch shall be provided, factory wired.
6. Manufacturer: Subject to compliance with requirements, provide centrifugal in-line fans of one of the following:
   a. Greenheck Fan Corp.
   b. Carnes CO., Div. of Wehr Corp.
   c. Cook Co., Loren.
   d. Penn Ventilator Co., Inc.
   e. Power Line Fans; Div. of Torin Corp.
   f. Or Equal.

E. Roof Hoods (RH)
1. Type: Stationary, natural draft type. Provide weatherproof housings to match power ventilators in materials and finish. Provide square or rectangular base to suit roof curb.
2. Bird Screens: Provide removable bird screens, 1/2 inch mesh, 16-gauge aluminum or brass wire.
3. Motor Operated Dampers: Provide dampers with linkage below curb base (maximum of six inch). Refer to Section 230923 Automatic Temperature Control for control sequence.
4. Manufacturer: Subject to compliance with requirements, provide gravity ventilators of the following:
   a. Carnes Co., Div. of Wehr Corp.
   b. Cook Co., Loren.
   c. Penn Ventilator Co,. Inc.
   d. Power Line Fans; Div. of Torin Corp.
   e. Greenheck Fan Corp.

f. Or Equal.

F. Prefabricated Roof Curbs
1. Manufacturer of ventilating unit shall provide insulated 24 inch high roof curb compatible with unit being provided. Curb shall be insulated and sloped to allow for level installation of device. Provide all necessary nailers and cants for a complete installation.

2.18 METAL DUCTWORK (Refer to section 01 91 13 - Requirements for additional contract requirements)

A. Reference Standards: Material, construction and installation shall meet requirements of most recent editions of the following standards and references, and latest adopted editions of codes. unless more stringent requirements specified or shown on Drawings:

Standard	As Applicable To:
IMC & SMACNA HVAC Duct Construction Standards Metal and Flexible	Sheet Metal Ductwork; Duct Liners; Adhesives; Fasteners; Flexible Ductwork.
SMACNA HVAC Air Duct Leakage Test Manual	Duct Leakage Testing
SMACNA Fibrous Glass Duct Construction Standards	Fibrous Glass Ductwork; Tapes
SMACNA Thermaoplastic Duct (PVC) Construction Manual	PVC Ductwork
ADC and TIMA Flexible Duct Performance Standards	Flexible Ductwork
IMC & NFPA (latest adopted editions)	Kitchen Hood Exhaust Ductwork
SMACNA Guidelines for Welding Sheet Metal	Welded Galvanized, Black Iron and Stainless Steel Ductwork

B. General
1. Provide supporting and hanging devices necessary to attach entire HVAC system including ductwork and equipment, and to prevent vibration.
2. Provide vertical and horizontal supports as required by codes to meet minimum applicable earthquake resistance standards.
3. Ductwork shall be free from vibration under all conditions of operation. Dimensions shown on Drawings for lined ductwork are net inside dimensions. Increase ductwork to accommodate lining requirements.
4. Pipe or conduit crossing duct:
   a. No pipe, conduit, hanger, Architectural element nor structural member shall pass through duct without Designer ’s written approval.
   b. Where it is impossible to reroute pipe or conduit and when written approval has been obtained, increase duct size to maintain constant cross sectional area at point of interference. Provide streamlined enclosure for pipe or conduit, as illustrated in SMACNA.
5. When making offsets and transformations necessary to accommodate structural conditions, preserve full cross sectional area of ductwork shown on Drawings.
6. Ductwork shall have pressure velocity classifications as follow:

DUCT CONSTRUCT-ION CLASS	STATIC PRESSURE RATING	PRESSURE	SMACNA SEAL CLASS	SMACNA LEAKAGE CLASS	VELOCITY
four inch	four inch	Pos.*	A	3	4000 fpm or less
three inch	three inch	Pos. or Neg.	A	3	4000 fpm or less
two inch	two inch	Pos. or Neg.	A	6	2500 fpm or less
one inch	one inch	Pos. or Neg.	A	6	2500 fpm or less

½ inch	½ inch	Pos. or Neg.	A	6	2000 fpm or less

*for negative pressures over three inch w.g., refer to SMACNA Round and Rectangular Industrial Duct Construction Standards for joint and intermediate reinforcement requirements.

a. Unless otherwise specified or shown on the drawings, the following pressure and construction classifications shall be used for the types of ductwork listed below:
   1) four inch Class: All supply ductwork from discharge of air handling units to inlets of VAVs and terminal (fan coil, induction, chilled beam) units.
   2) three inch Class: All kitchen hood exhaust, all kiln, laboratory and other specialty exhaust. All return ductwork. All supply ductwork between VAV terminal boxes and constant volume regulators and supply diffusers.
   3) two inch Class: All other ductwork.

7. Sealing Requirements for Class A, Leakage Class 3, Galvanized, Non-Welded Aluminum or Non-Welded Stainless Steel Ductwork:
   a. Transverse Joints
      1) During assembly seal all flanged transverse joints with sealing tape of quality equal to Hardcast Inc. 1902-FR. Corners shall be sealed as described by SMACNA and when applicable per manufacturer's published procedures. After sealant has cured, seal entire joint with Hardcast Inc. RTA-50 adhesive on to Hardcast Inc. DT tape or approved equal.
      2) Seal all non-flanged transverse joints with Hardcast Inc. RTA-50 adhesive on to Hardcast Inc. DT tape or approved equal.
   b. Longitudinal Seams
      1) Seal all longitudinal seams during ductwork fabrication with Hardcast Inc. Cold Seal ten01 or approved equal.
   c. Joints and Ductwall Penetrations
      1) Seal all duct joints at takeoffs, access doors, damper bearing penetrations, flexible duct connections and ductwork components requiring joints/fittings, with Hardcast Inc. Versa Grip 102 or approved equal.
      2) Note, access doors and damper rod penetrations shall be equipped with proper hardware for sealing.
8. Sealing Requirements for Class A, Leakage Class 6, Galvanized, Non-Welded Aluminum or Non-Welded Stainless Steel Ductwork.
   a. Transverse Joints
      1) During assembly seal all flanged transverse joints with sealing tape of quality equal to Hardcast Inc. 1902-FR. Corners shall be sealed as described by SMACNA and when applicable per manufacturer's published procedures.
      2) Seal all non-flanged transverse joints with Hardcast Inc. Versa Grip 102 or approved equal.
   b. Longitudinal Seams
      1) Seal all longitudinal seams during ductwork fabrication with Hardcast Inc. Cold Seal ten01 or approved equal.
   c. Joints and Ductwall Penetrations
      1) Seal all duct joints at takeoffs, access doors, damper bearing penetrations, flexible duct connections and ductwork components requiring joints/fittings with Hardcast Inc. Versa Grip 102 or approved equal.
9. Sealing Requirements for Class B, Leakage Class 12, Galvanized, Non-Welded Aluminum or Non-Welded Stainless Steel, Ductwork.
   a. Transverse Joints
      1) During assembly seal all flanged transverse joints with sealing tape of quality equal to Hardcast Inc. 1902-FR. Corners shall be sealed as described by SMACNA and when applicable per manufacturer's published procedures.
      2) Seal all non-flanged transverse joints with Hardcast Inc. Versa Grip 102 or approved equal.
   b. Longitudinal Seams

1) Seal all longitudinal seams during ductwork fabrication with Hardcast Inc. Cold Seal ten01 or approved equal.

10. Support
    a. Space hangers as required by SMACNA (8 feet max) for horizontal duct on 8 feet centers, unless concentrated loadings require closer spacing.
    b. Support vertical duct on each floor or slab it penetrates.
    c. Supports for ductwork and equipment shall be galvanized unless specified otherwise.
11. Connections
    a. Connect inlets and outlets of air handling units and fans to ductwork with flexible connections unless fan has vibration isolator mounts inside unit with flexible connections and no external vibration isolators. Exception: Do not use flex on life safety smoke exhaust fans.
    b. Indoors, flexible connections shall be neoprene coated fibrous glass fire retardant fabric, by Ventfabrics, or Durodyne. Outdoors, flexible connections shall be Dupont hypalon coated fibrous glass fire, weather, and UV resistant by Ventfabrics or Durodyne.
    c. Secure flexible connections tightly to air handlers with metal bands. Bands shall be same material as duct construction.
    d. Connections from trunk to branch ducts shall be as detailed on Drawings.
12. Construction
    a. No sharp metal edges shall extend into air streams.
    b. Install drive slips on air leaving side of duct with sheet metal screws on six inch centers.
    c. Spin in collars shall NOT be used for branch connections in three inch or higher pressure class ductwork.
13. Joints
    a. Longitudinal lock seams shall be double locked and flattened to make tight joints.
    b. Make transverse joints, field connections, collar attachments and flexible connections to ducts and equipment with sheet metal screws or bolts and nuts. Do not use rivets and staples.
14. Prefabricated Transverse Duct Joints
    a. Transverse joints in galvanized sheet metal ductwork may be made with galvanized gasketed frame and angle duct joint system by Ductmate, TDF, TDC or approved equal. Angles shall be at least 20 gauge. Prefabricated transverse duct joints shall not be used for duct 16 Guage. and heavier, nor for duct 23 Guage. or lighter.
    b. Secure angles to duct with screws (using clutched arbor) or spot welds spaced as recommended by manufacturer for duct pressure class.
15. Elbows and Bends
    a. Elbows and bends for rectangular ducts shall have centerline radius of 1 1/2 times duct width wherever possible. Elbows for grease exhaust and fume hood exhaust shall be full radius. Vanes or mitered duct are not allowed.
    b. Where centerline radius is less than 1 1/2 times duct width (on supply, return and exhaust ductwork), elbows shall be radius throat (square throat allowed when turning around column or other close objects) with radius heel. For elbows whose width is greater than 48 inches and/or where shown on plans, provide splitter vanes. Install vanes in accordance with SMACNA. Where multiple elbows are separated by less than ten duct diameters use splitter (full length) vanes.
    c. For round ductwork provide stamped elbows, with centerline radii equal to 1 1/2 times duct diameter, or gored elbows as follows:

Elbow Angle	**No. of Gores**
0 deg. - 36 deg.	**2**
37 deg. - 72 deg.	**3**
73 deg. - 90 deg.	**5**

    d. Elbows for flat oval ducts shall have centerline radii equal to 1 1/2 times duct diameter in plane of bend, or gored elbows with gores as specified for round ducts.
16. Access Panels/Doors
    a. Provide proper pressure and leakage rated, gasketed, duct mounted access panels/doors for the following items with minimum sizes, as indicated. Access doors shall be of double wall construction doors in insulated ducts shall be insulated. Gauges of door materials, no. of hinges, no. and type of door locks shall be as required by the SMACNA Duct

Construction Standards. Hinged doors are not acceptable, screwed or bolted access panels are not acceptable. Doors shall be chained to frame with a minimum length of six inch to prevent loss of door. For seal Class A, access doors shall be leakage rated, neoprene gasketed UL 94 HF1 listed, DUCTMATE "sandwich" or approved equal. Door metal shall be the same as the attached duct material. For grease and high temperature ducts, door assembly shall be rated for 2300 degrees Fahrenheit . The minimum sizes are:

1) Fire dampers 12 inch by 12 inch, or larger.
2) Combination Fire/Smoke dampers 12 inch by 12 inch, or larger.
3) Smoke dampers six inch by six inch minimum.
4) Automatic control dampers six inch by six inch minimum.
5) Manual volume dampers two square feet and larger six inch by six inch minimum.
6) Inlet side to all coils 12 inch by 12 inch, or larger.
7) Suction and discharge sides of inline fans 24 inch by 24 inch minimum.
8) At additional locations indicated on drawings, or specified elsewhere 12 inch by 12 inch minimum.

b. Generally access doors are not shown on the drawings, but shall be provided in accordance with the above.

17. Extractors shall have adjusting rod and locknut on outside of duct.
18. Connections to roof fans:
    a. Shall be at least 22 gauage. galvanized steel soldered watertight.
    b. Solder side seams at least 12 inch up from bottom.
    c. Provide suitable dielectric gaskets to join dissimilar materials.
19. Plenums and connections to louvers:
    a. Shall be 18 gauage. minimum cross broken and properly reinforced with galvanized angle irons to SMACNA requirements.
    b. Shall have bottom and corner seams soldered watertight at least 12 inch up from bottom.
    c. Shall have neoprene gaskets or other non corrosible material to make connections to louvers watertight.
    d. Shall pitch connection back towards the louver. Provide half coupling drain connection at bottom of plenum unless noted otherwise Pipe drain to nearest floor drain.
    e. Shall have unused portions of louvers blocked-off with sheet metal; sealed air and water tight; insulated with two inch thick six pound. density rigid or board insulation.
20. Duct Pressure Tests
    a. Pressure test all duct classes after takeoffs and wall penetrations are in place and before applying exterior insulation. Correct any leaks.
    b. Pressure and leak test ten0 percent of all duct work according to SMACNA procedures and as indicated below. Duct shall be constructed so there is no joint or structural failure at the test pressure.
21. Duct Leakage Tests
    a. Leak testing shall be provided for all ductwork and testing shall be performed per SMACNA HVAC Air Duct Leakage Test Manual procedures and in accordance with the leakage class 3 as minimum requirements for all ductwork. Provide orifice assembly including straightening vanes, orifice plate mounted in straight tube with properly located pressure taps, and U tube manometer or other device as indicated in SMACNA Air Duct Leakage Test Manual. Orifice assembly shall be calibrated accurately and shall come with calibration curve. Leakage classes shall be as specified within these specifications. Submit leak test report (per SMACNA format) for Designer review. Drawings of ductwork tested shall also be submitted with report, indicating presence of takeoffs, wall penetrations, joints, fittings, sound attenuators, terminal boxes, and dampers.
    b. Provide duct testing plan as part of shop drawing submittal.
22. Materials
    a. Sheet metal ducts shall be constructed of hot dipped galvanized sheet metal with G90 Commercial coating according to ASTM 527 unless specified otherwise.
    b. Stainless steel (SS) ductwork shall be 18 gauge for kitchen hoods and kiln exhaust/hood; and as required by SMACNA for other ducts. Materials shall be 316/No. 4 finish for exposed duct, 304/No. 1 finish for concealed ducts. Joints and seams shall be welded as required by SMACNA Guidelines for Welding Sheetmetal.

c. Aluminum ductwork for acid neutralization, chlorine, dishwashers, locker, shower, and pool equipment rooms shall be Alclad 3003 1414 or alloy 5052 H32, of thickness required by the SMACNA duct construction standards with Alloy 6061 bracing angles, and Pittsburgh lock longitudinal corner and double side seaming.

d. Flexible Ductwork
   1) Flexible ductwork, connecting to uninsulated or unlined duct, shall be polyester core with corrosion resistant helical wire reinforcing. The polyester core shall be minimum two ply and shall have a minimum thickness of 0.0017 inch. Flex duct shall be U.L. rated for six inch W.C. positive pressure, two inch W.C. negative pressure with a maximum velocity of 4000 FPM. Flexduct must be listed as a Class 1 Connector according to UL 181 and shall meet the requirements of NFPA 90A maximum ASTM E 84 fire hazard rating shall be 25 flame spread, 50 fuel contributed and 50 smoke developed. Uninsulated flexible duct shall be equivalent to Wiremold, Type WB, or Flexmaster Types 2 and 4 (not type 9).
   2) Flexible duct connected to insulated or lined duct shall also be insulated and shall be equivalent to Wiremold Type WK or Flexmaster Types 2 or 4 (not type 9), with 1 1/2 inch, 3/4 pounds density fiberglass insulation and an aluminized reinforced vapor barrier.
   3) Submittals shall include data on no. of polyester plies and minimum thickness of polyester core, in addition to other data listed above required to ensure that submitted product meets the requirements of these specifications.
   4) If flexduct other than the model numbers of the vendors listed above is submitted, a sample of the flex shall be submitted to the Designer. The Designer shall have sole discretion in determining whether the submitted flex is equivalent to that of the named vendors above.
   5) Unless otherwise indicated, flexible duct shall not exceed 5 feet-0 inch long.

e. Kitchen Grease Exhaust:
   1) Materials: Kitchen grease exhaust ductwork shall be constructed of minimum 18 gauge stainless steels or 16 gauge Black Iron steel welded construction. All kitchen exhaust ductwork, access panels, and fire rated wrap shall be provided and tested in accordance with IMC (latest adopted edition) and NFPA Standard 96 (latest edition). Duct cleaning and service access panels shall be installed in an accessible manner without the need to cut or damage the fire wrap system.
   2) At Contractor Option Factory Fabricated Round Grease Exhaust Ductwork that meets IMC and NFPA-96 (latest adopted edition) and the following specifications requirements may be provided:

      FACTORY FABRICATED GREASE DUCTS - ROUND

      a) Factory fabricated grease duct system shall meet all IMC code and specification requirements.
      b) ZERO CLEARANCE: Prefabricated system listed to UL-1978 and UL-2221 Standard for Factory Built Grease Ducts and Integral 2-Hour Rated Shaft Assembly, with stainless steel inner liner, minimum four inch fiber insulation, stainless steel outer jacket, and all-stainless steel supports and accessories for ten0 percent maintenance free system. Duct shall be designed for internal 500 degrees Fahrenheit continuous and 2000 degrees Fahrenheit for 30 minutes (simulating a grease fire) and external 2000 degrees Fahrenheit for two-hours with through penetration firestops.
      c) Manufacturer shall provide certificate of code compliance for all required local and national codes for the installation with the scheduled appliances.
      d) Provide complete with: no-weld hood transitions, no-tool access panels, supports, guides, expansion joints, and connection to fans. All items as specifically required by National and Local Codes. Duct Cleaning access doors shall be installed at locations and intervals required per IMC and NFPA 96.
      e) Submit electronic CAD Drawings with Sizing/Balancing Calculations showing that the grease duct exhaust system is in complete compliance with Code, the hood manufacture(s), and the fan manufacture(s) installation instructions.

f) Warranty: Provide manufacturer's limited 2five year product warranty.
g) Installation: Inner joints shall be sealed by use of factory supplied overlapping vee bands (protected by an overlapping inner extension) and sealant as specified in the manufacturer's installation instructions. Roof and wall penetrations shall be factory insulated and UL listed as not to require air ventilation for safe installation around combustible materials. Entire exhaust system from the appliance outlet to the termination point, including accessories shall be from one manufacturer, except where noted. Exterior support bands and hardware shall be stainless steel construction.
h) Manufacturers/Models: Subject to compliance with specification requires, manufacturers shall include: Jeremias Inc., Selkirk Corp., DuraVent, Van Packer or Equal.

3) At Contractor Option Factory Fabricated Rectangular Grease Exhaust Ductwork that meets IMC and NFPA-96 (latest adopted edition) and the following specifications requirements may be provided

FACTORY FABRICATED GREASE DUCTS - RECTANGULAR

a) General: Factory fabricated grease duct system shall meet all IMC code and specification requirements.
b) Zero Clearance: Prefabricated Rectangular system listed to UL-1978 and UL-2221 Standard for Factory Built Grease Ducts and Integral 2-Hour Rated Shaft Assembly, with stainless steel inner liner, minimum 4" fiber insulation, stainless steel outer jacket, and all-stainless steel supports and accessories for ten0percent maintenance free system. Duct shall be designed for internal 500°F continuous and 2000°F for 30 minutes (simulating a grease fire) and external 2000°F for 2-hours with through penetration firestops.
c) Manufacturer shall provide certificate of code compliance for all required local and national codes for the installation with the scheduled appliances.
d) Provide complete with: no-weld hood transitions, no-tool access panels, supports, guides, expansion joints, and connection to fans. All items as specifically required by National and Local Codes. Duct Cleaning access doors shall be installed at locations and intervals required per IMC and NFPA 96.
e) Submit electronic CAD Drawings with Sizing/Balancing Calculations showing that the grease duct exhaust system is in complete compliance with Code, the hood manufacture(s), and the fan manufacture(s) installation instructions.
f) Warranty: Provide manufacturer's limited 2five year product warranty.
g) Installation: Inner joints shall be sealed by use of factory supplied overlapping vee bands (protected by an overlapping inner extension) and sealant as specified in the manufacturer's installation instructions. Roof and wall penetrations shall be factory insulated and UL listed as not to require air ventilation for safe installation around combustible materials. Entire exhaust system from the appliance outlet to the termination point, including accessories shall be from one manufacturer, except where noted. Exterior support bands and hardware shall be stainless steel construction. Exterior support bands and hardware shall be stainless steel construction.
h) Manufacturers/Models: Jeremias, Inc., Van Packer or Equal."

C. Two inch and Lower Pressure Class Ductwork, Rectangular:
1. Ducts wider than 19 inch with more than ten square feet of unbraced panel shall be beaded or cross broken.
2. Internal stiffening struts shall only be used upon prior written approval of the Designer.
3. Make changes in duct size with tapered connections as required by SMACNA. Changes shall NOT exceed 30 degrees Fahrenheit rom line of air flow. Take off to the diffusers shall be 45 degrees. leading edge type or Bellmouth type.
4. Transverse joints shall be TDF/TDC or slip joints; use flat or standing seam according to SMACNA. Where duct size requires standing seam but space restrictions dictate flat seam, notify Designer prior to fabrication.

D. Two inch and Lower Pressure Class Ductwork, Round:
   1. Joints
      a. Longitudinal joints shall be spiral seam, butt welded, lap and seam welded, or ACME lock grooved seam. Snap lock seams shall be used on ½ inch w.g. pressure class duct only.
      b. Transverse joints shall be beaded sleeve joint or other approved joints listed in SMACNA. Use three or more sheet metal screws at 15 inch uniform intervals along circumference of joints.
   2. Branch fittings shall be conical tee (Buckley or equal) or combination tee as shown in SMACNA.

E. Three inch and four inch Pressure Class Ductwork Rectangular
   1. Joints
      a. Joints shall be prefabricated type by TDC, TDF or Ductmate. See Prefabricated Joints paragraph for specific requirements.
   2. Duct reinforcement spacing and type shall comply with SMACNA.
   3. Ductwork on both sides of transitions shall be run in same horizontal axis.
   4. Diverging section slope shall be 1 1/2 inch per foot or less if possible.
   5. Contraction section slope shall not exceed seven inch per foot.
   6. Takeoffs shall be 45 deg. leading edge type except that Bellmouths (Buckley or equal) may be used for takeoffs to terminal boxes if the distance between the box and point of takeoff is less than 8 feet
   7. Ducts with an aspect ratio greater than 3:1 shall be minimum of 18 gauge unless a thicker gauge is required by SMACNA.

F. Three inch and four inch Pressure Class Ductwork, Flat Oval, Single Wall
   1. Joints
      a. Ducts shall have spiral lock seams or longitudinal seams. Seams and joints in fittings shall be continuously welded. If coating is damaged during welding, repair joints to prevent corrosion.
      b. Transverse joints shall be slip or flanged.

G. Three inch and four inch Pressure Class Ductwork, Round, Single Wall
   1. Joints
      a. Longitudinal seams shall be lock spiral, lock longitudinal or butt welded longitudinal.
      b. Transverse joints shall be slip joints. Draw band joints shall be used on longitudinal seam duct only. Loose flange Vanstone joints may be used on ducts over 36 inch in diameter.
      c. Seams and joints in fittings shall be continuously welded. If coating is damaged during welding, repair joints to prevent corrosion.
   2. Branch fittings shall be conical tee or combination tee as detailed in SMACNA.

H. Double Wall Ductwork
   1. Duct and fitting shall be United Sheet Metal Co., Acousti K27, type P or equal consisting of:
      a. External pressure tight shell of zinc coated steel.
      b. Uniformly packed, 1-1/2 inch layer of fire resistant fibrous glass acoustic insulation with R-6 value with mylar or foil liner meeting 25/50 flame spread/smoke developed rating.
      c. Internal perforated protective metal liner of zinc coated steel, with holes sized and spaced to give acoustic impedance of noise reduction characteristic of Acousti K27 duct.
   2. Pressure shell of round duct shall be United or approved equal spiral pipe and pressure shell of fittings shall be zinc coated steel, as follows:

Item	Size	Gauge of Pressure Shell
Duct	3 inch to 6 inch	26
	7 inch to 20 inch	24
	21 inch to 34 inch	22
	36 inch to 48 inch	20
Fitting	3 inch to 34 inch	20
	36 inch to 48 inch	18

3. Fittings shall be continuous, corrosion resistant welds made by certified welders.
4. Joints between straight duct sections shall be made with pre fabricated couplings with four inch shoulder inserted into duct.

I. Flexible Rigid Duct
1. Flexible ductwork shall be Flexmaster Triple Lock Buck Duct Flexible Air Duct (insulated) as manufactured by Buckley Associates or equal (617 878 5000). Flexible duct, non insulated, shall be Underwriters Laboratory Listed UL 181 Class 0 air duct and constructed in accordance with NFPA Standards 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
2. Duct shall be made from a tape of dead soft aluminum sheet, spiral wound into a tube and spiral corrugated to provide strength and stability. The joint shall consist of a triple lock mechanically performed without the use of adhesives to make a durable airtight seam. A double lock is not acceptable.
3. Flexible duct connected to insulated or lined duct shall also be insulated. Flexmaster insulated flex shall have a gray Fire Retardant Polyethylene outer jacket with a ½ pounds. density, 1 1/2 inch thick fiberglass insulation blanket, factory wrapped. Flexible Duct, insulated, shall be Underwriters Laboratory Listed and constructed in accordance with NFPA standards 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
4. The flexible duct shall be supported as required.
5. Flexible duct work shall be rated at 12 inch positive pressure. Duct from three to 16 inch shall have a negative pressure of 12 inch, eight inch for duct work 18 and 20.
6. All flexible duct shall be individually cartooned and labeled for delivery to the job site for maximum protection.
7. Submittals shall include data on minimum thickness of aluminum core, in addition to other data listed above, required to ensure that submitted product meets the requirements of these specifications.
8. Provide sealing compound for installation. See further paragraphs in this specification and details for other installation requirements.

J. Volume Dampers
1. Provide Young Regulator manual adjustable rectangular opposed blade dampers for duct heights less than 12 inch with factory installed locking hand quadrants extended two inch for all dampers installed in externally insulated duct:
   a. On each supply, return and general exhaust duct take off.
   b. At each take off to register, grille or diffuser (not all are shown on Drawing).
2. Dampers are manufactured approximately 5/16 inch smaller in width and 1/8 inch smaller in height than size of duct in which they are installed; e.g., nominal damper size is 24 inch by ten inch; actual size is approximately 23 11/16 inch x 9 7/8 inch.
3. Damper frame shall be constructed of #6063 extruded aluminum reinforced channel with minimum thickness of .050 inch. Opposed damper blades shall be #6063 extruded aluminum with minimum thickness of .050 inch and shall include reinforcing ribs. Each blade shall be supported in the damper frame by individual Teflon axle bearings, and shall be driven by stainless steel connecting slide linkage controlled by 3/8 inch square steel control shaft
4. Note: All required volume dampers may not be indicated on drawings but dampers shall be provided as necessary for systems balancing.
5. Dampers 12 inch and larger in height shall be opposed multi blade equal to Greenheck, Nailor, or Vent Products.

6. Where dampers are inaccessible, use Young Regulator locking type ceiling regulators and miter gear or worm gear for all horizontal dampers. Bearing coupling for bottom duct control may be used for shaft on vertical blade dampers. The 3/8 inch rod between ceiling regulator and damper shall be provided by contractor.
7. Damper blades shall be two gauges heavier than adjoining ductwork, and shall be riveted to supporting rods. Hem over edges parallel to rods.
8. Brackets shall be galvanized metal, secured to ductwork with sheet metal screw with locking quadrant arms (see seal class section for additional requirements). Provide two inch handle extension for all dampers on externally insulated ductwork.
9. Note: All required volume dampers may not be indicated on Drawings but dampers shall be provided as necessary for system balancing.
10. Volume dampers shall have leakage Class I dampers in accordance with AMCA Standard 511 and ASHREA 90.1 – 2016 requirements.

K. Automatic Dampers: Install automatic dampers furnished under Automatic Temperature Control Paragraph of this Section, as shown on Drawings, and as specified. Provide sealed wall penetrations for Seal Class A ductwork.

L. Locker Room Exhaust or Return Ductwork
1. Ductwork shall be aluminum, of types as detailed in this specification above and constructed in accordance with SMACNA except that Seal Class shall be "A" regardless of duct pressure rating.

M. Branch Duct Take off Fittings
1. Contractor shall provide Buckley Bellmouth Take offs at all branch duct locations.
2. Bellmouth Fitting shall be Model BMD with damper. In areas where sufficient duct height is not available, the HVAC Sub-contractor shall provide the Buckley Mini mouth fitting, Model M BMD with damper or the flat oval Bellmouth, Model FOBMD with damper.
3. Bellmouths shall be constructed of heavy duty galvanized steel. Bellmouths shall include an air tight Neoprene gasket to ensure a tight fitting with minimal leakage. Pre drilled holes shall be provided for quick mounting. Bellmouth shall be as manufactured by Buckley Associates or equal (617 878 5000).
4. Standard damper hardware to be constructed of 26 gauge galvanized material with a quadrant damper and tight fitting gasketing to ensure minimal leakage at damper pivot points.
5. Optional heavy duty hardware shall be provided at locations of higher static pressure where shown on the drawings.
6. Ninety degree take offs are not permitted on this project.

2.19 DUCTWORK ACCESSORIES (Refer to section 01 91 13 - for additional contract requirements)

A. Dampers:
1. Low Pressure Manual Dampers: Provide dampers of single blade type or multi-blade type, constructed in accordance with SMACNA "HVAC Duct construction Standards".
2. Automatic Control Dampers: Refer to Section 230923 section "Automatic Temperature Control" for control dampers; not work of this section.
3. Backdraft Relief Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to relieve at .0/5 inch static pressure. Construct blades of 16-ga. aluminum; provide 1/2 inch diameter ball bearings, 1/2 inch diameter steel axles spaced on nine inch centers. Construct from two inch x 1/2 inch x 1/8 inch steel channel for face areas 25 square feet and under: four inch by 1-1/4 inch by 16 gauge channel for face areas over 25 square feet Provide galvanized steel finish on frame with aluminum touch-up. Provide felted or rubber trim to assure tight, leak-proof seal when closed.
4. Dampers shall have leakage Class I dampers in accordance with AMCA Standard 511 and ASHREA 90.1 – 2016 requirements.
5. Manufacturer: Subject to compliance with requirements, provide dampers of one of the following:
   a. Air Balance, Inc.
   b. Airguarde Corp.
   c. American Warming & Ventilating, Inc.
   d. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.
   e. Louvers & Dampers, Inc.
   f. Penn Ventilator Co.
   g. Ruskin Mfg. Co.

h. Or Equal.

B. Fire Dampers and Fire/Smoke:
   1. Fire Dampers: Provide fire dampers, of types and sizes indicated. Construct casings of 11-gauge galvanized steel. Provide fusible link rated at 160 to 165 degrees Fahrenheit (71 to 74 degrees. Celsius) unless otherwise indicated. Provide out of air stream type damper in open position and with positive lock in closed position with stainless steel heat treated type 301 closure spring, and with the following additional features:
      a. Damper Blade Assembly: Curtain type.
      b. Blade Material: Steel, match casing.
      c. Blade Material: Stainless steel.
      d. Class II Minimum Construction
   2. Combination Fire/Smoke Dampers: Provide fire/smoke dampers, of types and sizes indicated. Construct casing of 11-gauge. galvanized steel with bonded red acrylic enamel finish. Provide fusible link rated at 160 to 165 degrees Fahrenheit (71 to 74 degrees. Celsius) unless otherwise indicated. Provide additional frangible link containing explosive charge, connected in series with fusible link. Provide stainless steel spring loaded leakage seals in sides of casing, and 36 inch long wire leads for connecting smoke link to smoke detector, and the following additional features:
      a. Damper Blade Assembly: Single-blade type.
      b. Damper Blade Assembly: Multi-blade type.
      c. Damper Blade Assembly: Curtain type.
      d. Blade Material: Steel, matching casing.
      e. Blade material: Stainless steel.
      f. Class II Minimum Construction
   3. Motor-Driven Fire/Smoke Dampers: Provide motor-driven fire/smoke dampers in types and sizes indicated, with casing constructed of 11-ga. galvanized steel with bonded red acrylic enamel finish, fusible link 160 to 165 degrees Fahrenheit (71 to 74 degrees Celcius), unless otherwise indicated, and curtain type stainless steel interlocking blades, with electric motor equipped with instant closure clutch, stainless steel cable damper blade linkage, motor mounting bracket, and 32 inch long wire leads for connecting to smoke detector, and with the following construction features:
      a. Unit Assembly: Motor mounted outside air stream.
      b. Class II Minimum Construction
   4. Dampers shall have leakage Class I dampers in accordance with UL 555S requirements.

   5. Manufacturer: Subject to compliance with requirements, provide fire and smoke dampers of one of the following:
      a. Air Balance, Inc.
      b. American Warming & Ventilating, Inc.
      c. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.
      d. Louvers & Dampers, Inc.
      e. Greenheck
      f. Phillips-Aires
      g. Ruskin Mfg. Co.
      h. Or Equal.

C. Turning Vanes:
   1. Manufactured Turning Vanes: Provide double thickness airfoil turning vanes constructed of 1-1/2 inch wide curved blades set at 3/4 inch o.c., supported with bars perpendicular to blades set at two inch o.c, and set into side strips suitable for mounting in ductwork.
   2. Manufacturer: Subject to compliance with requirements, provide turning banes of one of the following:
      a. Aero Dyne Co.
      b. Airsan Corp.
      c. Anemostat Products Div.; Dynamics Corp. of America.
      d. Barber-Colman Co.
      e. Duro Dyne Corp.
      f. Environmental Elements Corp.; Subs, Koppers Co., Inc.
      g. Hart & Cooley Mfg. Co.

h. Register & Grille Mfg. Co., Inc.
i. Souther, Inc.
j. Or Equal.

D. Duct Hardware:
1. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:
a. Test Holes: Provide in ductwork at fan inlet and outlet, duct test holes, consisting of slot and cover, for instrument tests.
b. Quandrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12 inch Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.
2. Manufacturer: Subject to compliance with requirements. Provide duct hardware of one of the following:
a. Ventfabrics, Inc.
b. Young Regulator Co.
c. Or Equal.

E. Duct Access Doors:
1. General: Provide duct access doors of a size as required to service and maintain device in duct. Refer to list for access door sizes. All access doors shall be gasketed and installed air tight. Provide one access door at each control damper, humidifier, coil, fire damper, and any device that requires attention.

Duct Depth	Access Door Size
8 inch	6 x 6 inch
10-12 inch	8 x 8 inch
14-18 inch	12 x 12 inch
20-30 inch	14 x 14 inch
30+ inch	18 x 18 inch

2. Construction: Construct of same or greater gage as ductwork served, provide insulted doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. Provide one side hinged, other side with one handle-type latch for doors 12 inch high and smaller, two handle-type latches for larger doors.
3. Manufacturer: Subject to compliance with requirements, provide duct access doors of one of the following:
a. Air Balance, Inc.
b. Duro Dyne Corp.
c. Register & Grille Mfg. Co., Inc.
d. Ruskin Mfg. Co.
e. Ventfabrics, Inc.
f. Zurn Industries, Inc.; Air Systems Div.
g. Or Equal.

F. Flexible Connectors:
1. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibration of connected equipment.
2. Manufacturer: Subject to compliance with requirements, provide flexible connections of one of the following:
a. American/Elgen Co.; Energy Div.
b. Duro Dyne Corp.
c. Flexaust (The) Co.
d. Ventfabrics, Inc.
e. Or Equal.

2.20 ACOUSTIC DUCT LINING

A. Lining for Rectangular Metal Ducts: All ducts, where shown or noted on the drawings, shall be lined with 1 ½ inch (R-5) thick hospital grade liner similar to Johns Manville "Permacote Linacoustic HP" fiberglass duct liner with factory-applied surface and edge coating. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B, FHC 25/50 and Limited

Combustibility and the airstream surface coating should contain an immobilized, EPA-registered, anti-microbial agent so it will not support microbial growth as tested in accordance with ASTM G21 and G22. The duct liner shall conform to the requirements of ASTM C 1071 and C1104, with an NRC not less than .75 as tested per ASTM C 423 using a Type "A" mounting, and a thermal conductivity no higher than .24 at 75EF mean temperature.

B. Material Handling and Storage: Liner shall be kept clean and dry during transportation, storage and installation. Care should be taken to protect the liner from exposure to the elements or damage from mechanical abuse.

C. Manufacturer: Subject to compliance with the above provide duct sound lining in accordance with the above performance criteria description.

2.21 SOUND ATTENUATORS (SA)

A. General: Provide factory-fabricated and tested duct silencers as scheduled on drawings, select with performance characteristics which match, or exceed those indicated on schedule.

B. Casings: Construct of sheet metal, with gage and seam construction equal or greater than that recommended by SMACNA-Duct Construction Standards for ductwork of same size and pressure class; but not less than gauge dimension recommended by manufacturer based upon application or as otherwise indicated. RTU main supply and return sound attenuators shall be minimum 16-gage for outer casing (unless otherwise scheduled with heavier gauge) and 22-guage for inner casing. Elbow silencers shall be constructed of minute 16 gauge exterior/22 gauge interior liner unless otherwise scheduled with heavier gauge.

C. Acoustic Fill: Provide inorganic mineral or glass fiber filler material, inert, vermin and moisture proof, of sufficient density to obtain specified acoustic performance. Pack under not less than 5 percent compression to eliminate voids due to vibration and settling. Acoustic fill shall be covered and protected with hospital grade polymer/mylar film type liner.

D. Acoustic Performance: Provide silencer ratings that have been determined in such to reverberative room test facility. Test silencer with air flow in both directions through silencer, in accordance with ASTM E477-13, "Methods of Testing Duct Liner Materials and Prefabricated Silencers for Acoustical and Airflow Performance."

1. For acoustic ratings, include Dynamic Insertion Loss and Self Noise Power Levels for both forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) with airflow of at least 2,000 FPM face velocity.

E. Aerodynamic Performance: Provide silencers with static pressure loss equal to or less than that scheduled.

F. Certification: Provide certified test data on Dynamic Insertion Loss, Self-Noise Power Levels, and Aerodynamic Performance. Conduct all rating tests at same NVLAP-Accredited laboratory facility with current certification for ASTM E477 testing. Open testing facility for inspection by Architect/Engineer if requested.

G. Manufacturers: Subject to compliance with requirements, provide duct silencers of one of the following:

1. Vibro-Acoustics
2. Aeroacoustic Corporation
3. Price
4. Or Equal.

2.22 AIR OUTLETS AND INLETS (Refer to section 01 91 13 - for additional contract requirements)

A. Ceiling Air Diffusers:

1. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components for a complete installation. Stamped face diffusers will not be acceptable.
2. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw, drop and noise criteria ratings for each size device as listed in manufacturer's current data.
3. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.
4. Types: Provide ceiling diffusers of type, capacity, throw, blow and with accessories as listed on diffuser schedule.

a. Ceiling Diffusers shall be of the restricted multi-orificed jet induction and air mixing type consisting of louver sections with built-in diffusing vanes. The vanes shall be arranged to discharge air from adjacent louvers at an angle of 45 degrees in opposite directions to insure rapid mixing of primary and room air. Diffusing vanes shall be welded and mechanically fastened to the adjacent louver sections to make a rigid unit. The vanes shall extend to the discharge edges of the louvers. Where louver sections join the core frame, the louver ends shall be welded to the core frame. The leading edge of each louver shall be hemmed and the louver ends shall be rounded and hemmed before welding to the core frames.
b. Diffusers shall be fabricated of aluminum or steel-welded construction, and shall be provided with a removable core permitting easy access to the neck connection. The diffuser neck shall extend no less than one inch above the core to accommodate an internal duct connection to prevent leakage into the ceiling space.
c. Finish shall be painted baked enamel. Color as selected by A/E.

5. Diffuser Dampers:
   a. Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of diffuser. Provide in each ceiling diffuser.
6. Manufacturer: Subject to compliance with requirements, provide diffusers of one of the following:
   a. Price
   b. Metalaire – “5000 IV”
   c. Nailor
   d. Or Equal.

B. Wall Registers and Grilles:
1. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicted, for a complete installation.
2. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer's current data.
3. Compatibility: Provide registers and grilles with border styles that are compatible with adjacent systems, and that are specifically manufactured to fit into wall and ceiling construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of construction which will contain each type of register and grille.
4. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule:
5. Pattern: Register and grille patterns shall have style as identified on Drawings:
6. Dampers: Opposed Blade adjustable assembly, key operated from face of register.
7. Accessories:
   a. Plaster Frame: Perimeter frame designed to act as plaster stop and register or grille anchor. Provide where required.
   b. Operating Keys: Tools designed to fit through register or grille face and operate volume control device and/or pattern adjustment.
8. Finish: Register and Grille Finishes shall be baked enamel color as selected by the Architect.
9. Manufacturer: Subject to compliance with requirements, provide registers and grilles of one the following:
   a. Price
   b. Metalaire
   c. Nailor
   d. Or Equal.

C. Ceiling Registers and Grilles:
1. General: Except as otherwise indicated, provide manufacturer's standard "Egg-Crate" type registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components for a complete installation.
2. Compatibility: Provide registers and ceiling grilles with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling construction.

3. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule.
4. Register and Grille Materials:
   a. Aluminum Construction: Manufacturer's standard extruded aluminum frame and core.
5. Register and Grille Faces:
   a. 1/2 inch by 1/2 inch "Egg-Crate" with one inch border frame.
6. Register and Grille Dampers:
   a. Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of register (provide for registers only).
7. Register and Grille Finishes shall be baked enamel color as selected by the Architect.
8. Manufacturer: Subject to compliance with requirements, provide registers and grilles of one of the following:
   a. Price
   b. Metalaire
   c. Nailor
   d. Or Equal.

D. In Wall Displacement Diffuser
1. Description: Furnish and install in wall displacement diffusers with the sizes and capacities indicated on the plans and air outlet schedule.
2. Performance: Air shall be delivered to the space at low noise levels and low velocities that are even across the diffuser face, in all ducting configurations and without the use of nozzles.
3. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE Standard 70-2006. Performance data for Draft Rate (percent DR) shall be provided based on tests in accordance with ASHRAE Standard 55-2004. A manufacturer software program that allows room comfort evaluation for specific operating conditions and diffuser locations shall be available to aid in performance assessment If such a computer program is not available from the manufacturer, the manufacturer shall supply, free of charge, a CFD model of the representative spaces completed by a modeling contractor who has demonstrable qualifications to model such spaces. These shall include no less than ten years of experience in the modeling of displacement ventilation systems, thorough validation of the code through comparison to empirical data as well as a list of references.
4. Construction: The one way flat faced in-wall displacement diffuser, shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Plastic nozzle arrays or any plastic components are unacceptable. The diffuser frames shall be constructed of 20 gauge steel for rigidity and protection of the operative face. The operative face shall be constructed of painted 18 gauge perforated steel (16 gauge when installed in gymnasiums), and the frame shall be provided in painted 20 gauge steel. The plenum shall be 24 gauge steel. The internal baffling elements shall be constructed of aluminum. The diffuser shall be available for duct connection at the top. The paint shall be powder coat polyester, color as selected by architect, provide sample selection chart. Epoxies and their derivatives are unacceptable. Visible non-metallic components are unacceptable.
5. Mounting/Fastening: The diffuser front panel shall be bolted to the plenum through the wall with factory provided fasteners.
6. Manufacturer: Subject to compliance with requirements, provide flat faced displacement diffusers of one of the following:
   a. Price
   b. Metalaire
   c. Trox
   d. Krueger
   e. Or Equal.

E. Flat Face Recessed Displacement Diffusers
1. Description: Furnish and install flat face displacement diffuser with the configurations and mounting types indicated on the plans and air outlet schedule.
2. Performance: Air shall be delivered to the space at low noise levels and low velocities that are even across the diffuser face, in all ducting configurations and without the use of nozzles. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE Standard 70-2006.Performance data for Draft Rate (percent DR)

shall be provided based on tests in accordance with ASHRAE Standard 55-2004. A software program that allows room comfort evaluation for specific operating conditions and diffuser locations shall be available to aid in performance assessment. If such a computer program is not available from the manufacturer, the manufacturer shall supply, free of charge, a CFD model of the representative spaces completed by a modeling contractor who has demonstrable qualifications to model such spaces. These shall include no less than ten years of experience in the modeling of displacement ventilation systems, thorough validation of the code through comparison to empirical data as well as a list of references.

3. Construction: The one way flat faced recessed displacement diffuser shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Plastic nozzle arrays or any plastic components are unacceptable. There shall be no visible fasteners on the front panel. The operative face shall be constructed of painted 18 gauge perforated steel (16 gauge when installed in gymnasiums). The installation frame shall be constructed of 24 gage steel. The internal baffling elements shall be constructed of aluminum. The paint shall be powder coat polyester, color as selected by architect, provide sample selection chart.. Epoxies and their derivatives are unacceptable. Visible non-metallic components are unacceptable. The diffuser shall be supplied with an installation frame for recessed installation that is not visible from the room. (The diffuser shall be supplied with an installation frame for recessed installation which allows the diffuser to be installed in areas where plaster is required).
4. Mounting/Fastening: The diffuser shall be installed within the manufacture provided plenum, refer to details sheet for further information. Plenum to be provided with mounting clips, all by diffuser manufacture. The diffuser shall have no visible fasteners or framing, and shall be held within the supplied plenum via secure mounting clips. Provide with non-visible internal screw fasteners for gymnasium applications.
5. Manufacturer: Subject to compliance with requirements, provide flat faced displacement diffusers of one of the following:
   a. Price
   b. Metalaire
   c. Trox
   d. Krueger
   e. Or Equal.

F. Ceiling Mounted Displacement Diffusers
1. Description: Furnish and install ceiling mounted displacement diffuser with the sizes and capacities indicated on the plans and air outlet schedule.
2. Performance: Air shall be delivered to the space at low noise levels and low velocities that are even across the diffuser face in all ducting configurations and without the use of nozzles. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE Standard 70-2006. Performance data for Draft Rate (percent DR) shall be provided based on tests in accordance with ASHRAE Standard 55-2004. A manufacturer software program that allows room comfort evaluation for specific operating conditions and diffuser locations shall be available to aid in performance assessment. If such a computer program is not available from the manufacturer, the manufacturer shall supply, free of charge, a CFD model of the representative spaces completed by a modeling contractor who has demonstrable qualifications to model such spaces. These shall include no less than ten years of experience in the modeling of displacement ventilation systems, thorough validation of the code through comparison to empirical data as well as a list of references.
3. Construction: The one way flat faced ceiling mounted Displacement diffuser shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Plastic nozzle arrays or any plastic components are unacceptable. The diffuser frames shall be constructed of high strength aluminum extrusion for rigidity and protection of the operative face and side panels. There shall be no visible fasteners on the front or side panels. The operative face shall be constructed of painted 18 gauge perforated steel, and the frame shall be provided in painted 20 gauge steel. The internal baffling elements shall be constructed of Aluminum. The diffuser shall be available for duct connection at the top, bottom, side or rear of the diffuser with a factory inlet. The paint shall

be powder coat polyester, color as selected by architect, provide sample selection chart. Epoxies and their derivatives are unacceptable. Visible non-metallic components are unacceptable.

4. Mounting/Fastening: The diffuser shall integrate into standard T-Bar ceilings and shall have no visible fasteners.
5. Manufacturer: Subject to compliance with requirements, provide flat faced displacement diffusers of one of the following:
   a. Price
   b. Metalaire
   c. Trox
   d. Krueger
   e. Or Equal.

G. Corner Displacement Diffuser
1. Description: Furnish and install corner displacement diffuser with the sizes and capacities indicated on the plans and air outlet schedule.
2. Performance: Air shall be delivered to the space at low noise levels and low velocities that are even across the diffuser face in all ducting configurations and without the use of nozzles. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE Standard 70-2006. Performance data for Draft Rate (percent DR) shall be provided based on tests in accordance with ASHRAE Standard 55-2004. A manufacturer software program that allows room comfort evaluation for specific operating conditions and diffuser locations shall be available to aid in performance assessment. If such a computer program is not available from the manufacturer, the manufacturer shall supply, free of charge, a CFD model of the representative spaces completed by a modeling contractor who has demonstrable qualifications to model such spaces. These shall include no less than ten years of experience in the modeling of displacement ventilation systems, thorough validation of the code through comparison to empirical data as well as a list of references.
3. Construction: The 1 way flat faced corner displacement diffuser shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Plastic nozzle arrays or any plastic components are unacceptable. There shall be no visible fasteners on the front panel. The operative face shall be constructed of painted 18 gauge perforated steel (16 gauge when installed in gymnasiums). The installation frame shall be constructed of 24 gage steel. The internal baffling elements shall be constructed of aluminum. The paint shall be powder coat polyester, color as selected by architect, provide sample selection chart.. Epoxies and their derivatives are unacceptable. Visible non-metallic components are unacceptable. Displacement Diffuser shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE standard 70-2006.
4. Base: Supply and install a base under each displacement diffuser. The base shall be manufactured by the displacement diffuser manufacturer. The base shall have an extruded alumni mum frame and 22 gauge solid steel face. Base heights shall be as indicated on the drawings. Finish shall match adjacent Diffuser color.
5. Manufacturer: Subject to compliance with requirements, provide flat faced displacement diffusers of one of the following:
   a. Price
   b. Metalaire
   c. Trox
   d. Krueger
   e. Or Equal.

H. Linear Diffusers
1. Linear slot diffusers shall be furnished and installed as indicated on the drawings.
2. Provide shop drawings accompanied by itemized list indicating units' location and appropriate product submittal drawings provided by the manufacturer.

3. Exact dimensions and curved angles (as applicable) of walls and ceiling are as per the architectural drawings. Install diffusers so they fit properly in the ceiling system with suspension wire (48 inch o/c MAX.) and/or attachment plates.
4. Coordinate installation with Construction Manager and other sub-contractors.
5. The linear slot diffuser shall utilize heavy wall extruded aluminum air deflector frames. These frames shall be designed to accommodate notched compressible space bars, complete with integral hanger, spaced approximately 24 inch on center. The steel air pattern controllers are fully adjustable and can be moved from side to side to create various air pattern configurations. These dual pattern controllers shall be fully adjustable to allow shut-off without adding any blank-off devices. The spacer bars and pattern controllers shall be removable for on-site modification and trimming.
6. The Linear slot diffuser shall be complete with factory end conditions as shown or indicated.
7. Supply air engineered plenums shall be provided and manufactured of heavy gauge wipe coat steel. These units shall be insulated with a side inlet collar.
8. When engineered plenum end caps cannot positioned directly over the linear spacer bar due to field conditions, install MB Blank-Off from plenum end cap to next spacer bar.
9. MB Blank-Off shall be manufactured of heavy gauge steel painted black.
10. Manufacturer: Subject to compliance with requirements, provide flat faced displacement diffusers of one of the following:
    a. Price
    b. Halton
    c. Trox
    d. Or Equal.

I. Drum Type Diffusers
1. Furnish and install Price model HCD2D or Equal supply outlets of the sizes and models indicated on the plans and outlet schedule.
2. The outlets shall consist of individually adjustable spread control vanes housed within a rotatable drum.
3. The vanes shall be bisected by a center divider allowing separate adjustment of top and bottom blades. The end panels of the drum shall incorporate spread control members to enhance pattern control.
4. Curved outer drum and vanes extruded aluminum, other components are steel. The drum pivot mechanism shall incorporate a positive positioning, detent device to hold field adjusted drum angles of up to 30 degrees off center.
5. Adjustable vanes are to pivot and maintain blade setting border shall be constructed of formed steel with welded, reinforced corners for extra strength. Screw holes shall be countersunk for aesthetic appeal.
6. The integral volume control damper shall be of the opposed blade type and shall be constructed of cold rolled steel. Damper shall be operable from the register face. The damper shall be coated steel. The unit shall be finished in (B12 White Powder Coat / B15 Aluminum Powder Coat) in color as determined by the architect.
7. Manufacturer: Subject to compliance with requirements, provide drum type diffusers of one of the following:
    a. Price
    b. Halton
    c. Trox
    d. Or Equal.

2.23 DUCTLESS COOLING UNITS (Refer to section for additional contract requirements)

A. Evaporator (Stand-Alone):
1. General: The unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board, and fan motor. The unit in conjunction with the wired, wall mounted controller shall have a self-diagnostic function, three-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from factory.
2. Cabinet: The casing shall be ABS plastic factory finish. Cabinet shall be designed for suspension mounting and horizontal operation. The rear cabinet panel shall have provisions for a field installed filtered outside air intake connection.

3. Fan: The evaporator fan shall have three high performance, double inlet, forward curve sirocco fans driven by a single motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of four speeds: Low, M1, M2 and Hi.
4. Vane: There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall provide a choice of five vertical airflow patterns selected by remote control. There shall also be a set of vertical vanes to provide horizontal swing airflow movement selected by remote control.
5. Filter: Return air shall be filtered by means of an easily removable washable filter.
6. Coil: The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.
7. Control: The control system shall consist of two microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. For A-Control, a three conductor 14 gauge AWATER GUAGE wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units. Where separate power is supplied to the indoor and outdoor units, a two 20 gauge AWATER GUAGE wire shall be run between the units to provide forbid-directional control communication. The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.

B. Condensing (Stand Alone):
1. General: The outdoor unit shall be equipped with a control board that inferfaces with the indoor unit to perform all necessary operation functions. The outdoor unit shall be capable of operating at 0 degrees Fahrenheit , (-18 degrees. Celsius) ambient temperature without additional low ambient controls. The outdoor unit shall be able to operate with a maximum height difference of ten0 feet and have maximum refrigerant tubing length of 165 feet between indoor and outdoor units without the need for line size changes, traps or additional oil. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.
2. Cabinet: The casing shall be constructed from galvanized steel plate, coated with a finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection and have a factory finish. The fan grille shall be of ABS plastic.
3. Fan: The fan motor shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across if from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent contact with moving parts.
4. Coil: The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up. The coil shall be protected with an integral metal guard. Refrigerant flow from the condenser shall be controlled by means of linear expansion valve (LEV) metering orifice. The LEV shall be control by a microprocessor controlled step motor.
5. Compressor: The compressor shall be a scroll compressor with variable speed inverter technology. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which results in vast energy savings. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be intermittently applied to the compressor motor to maintain enough heat. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.
6. Electrical: The electrical power of the unit shall be as indicated on the drawings. The outdoor unit shall be controlled by the microprocessor located in the indoor unit. The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC. The unit shall have Pulse Amplitude Modulation circuit to utilize 98 percent of input power supply.

2.24 CONDENSATE DISCHARGE PUMPS (Refer to various equipment schedules for locations and section 01 91 13 - for additional contract requirements)

A. General: Provide where indicated, condensate pumps of capacity as scheduled, to be field installed in various air handling equipment drain pans, consisting of ABS housing, pump, check valve, safety switch, and thermal overload protection. Factory assembled unit must be UL/CSA listed.

B. High-Capacity Pumps
   1. Reservoir: Construct of ABS plastic with a 3/10 capacity volume.
   2. Pump: 25 GPH at 15TDH vertical type pump with stainless steel motor shaft, rustproof, ABS volute, with safety switch.
   3. Housing and Cover: Each shall be ABS plastic.
   4. Manufacturers: Subject to compliance with requirements, provide high-capacity condensate pump from one of the following:
      a. Little Giant
      b. Sauermann
      c. Or equal

C. Low-Capacity Pumps
   1. Pump: 8 GPH at 33TDH reciprocating piston pump direct discharge with no storage reservoir.
   2. Detection Unit: Low-maintenance filter free with a three level float (on/off/alarm).
   3. Pump Housing and Detection Unit: Each shall be ABS plastic.
   4. Manufacturers: Subject to compliance with requirements, provide high-capacity condensate pump from one of the following:
      a. Little Giant
      b. Sauermann
      c. Or equal

2.25 FIRESTOP SYSTEMS

A. General: Provide firestopping at all fire-rated construction where penetrated by the Work of this Section. Provide smoke sealing at all penetrations through smoke rated partitions and/or smoke barriers. Utilize smoke sealing products as required for its intended use and install per manufactures recommendation and installation instructions.

B. Refer to Section 078413 - Penetration Firestopping, for all product requirements for maintaining integrity of fire and/or smoke rated construction at penetrations.

2.26 WALL AND CEILING ACCESS DOORS

A. General: Furnish access panels for installation Division 08, at all new and existing construction where required for access to the Work of this Section. Furnish access doors for access to all concealed control valves, motor operated dampers, fire doors, fire dampers, smoke dampers, combination fire/smoke dampers and all other concealed parts of the HVAC system that require accessibility for the proper operation and maintenance of the system.

B. Refer to Division 08 – Openings, for all product requirements for furnishing access panels.

C. Coordinate locations and schedule with the work of trades involved with construction in which access panels will be installed.

D. Access doors shall be heavy gage steel with one inch frame. Door shall be fastened to frame with continuous piano hinge. Entire door and frame assembly shall be prime painted and be completed with cylinder lock and two keys. Door and frame shall match fire rating of wall or ceiling installed into.

E. Manufacturer: Subject to compliance with requirements, provide access doors of one of the following:
   1. Inland Steel Products Company, "Milcor"
   2. Walsh-Hannon-Gladwin Inc., "Way Loctor"
   3. Or Equal.

2.27 FREESTANDING EQUIPMENT SUPPORT SYSTEM

A. Manufacturers:
   1. Acceptable Manufacturer: PHP Systems/Design, Bigfoot Systems, Erico Caddy Pyramid Systems, Eberl Iron Works, or equal.
   2. Requests for substitutions will be considered in accordance with provisions of Section 013300.

B. Applications: Base size and spacing shall be designed by the weight of the supported item, the anticipated live load and the bearing capacity of roof insulation. HVAC contactor to coordinate approved equipment with support manufacturer.

1. Equipment Platform Access:
   a. Support Spacing: Per manufacturer's recommendation.
   b. Bases High Density Polypropylene plastics with additives for UV protection.
   c. Substructure: 12 gauge back-to-back channel G-1012A, or approved equal supported directly from the bases.
   d. Grating: Mill-galvanized carbon steel in accordance with ASTM A525:
      1) Gauge 14-guage. Steel
      2) Section Width: 12 inch (305 mm) (standard)
      3) Channel Height: 2 inch (51 mm) (standard)
      4) Flange Options: FM
      5) Flange Options: MM
      6) Surface Condition: MG-traction grip
      7) Surface Condition: MS-smooth
      8) All substructures shall be galvanized steel. Spring nuts, and bolts for spring nuts will be electro-plated.
2. Portable Support System: Engineered, portable system specifically designed for installation without the need for roof penetrations, or flashings, and without causing damage to the roofing membrane.
   a. Design system using high density, high impact polypropylene bases with carbon black, anti-oxidants for UV protection, and steel framing of 1-5/8 inch (41 mm) B22TH or 1-7/8 inch (48 mm) BTS22TH for support.
   b. Custom design system to fit piping, conduits, equipment, or walkways to be installed and actual conditions of service and loading.
   c. Piping Supports: Provide suitable hangers and supports.
   d. Duct and Equipment Supports: Factory fabricated to support exact duct sizes and equipment to be installed.
   e. Walkways and Platforms: Provide galvanized slotted metal grating, in configurations as indicated, and tubular handrails where indicated.
3. Bases: Injection molded high density, high impact polypropylene with UV-inhibitors and anti-oxidants, conforming to the following:
   a. Moisture Content: Negligible.
   b. Shrinkage/Swelling Due to Moisture: Negligible.
   c. Density: 55.8 pounds/cubic feet (894 kg/cu m).
   d. Insect Resistance: No known insect damage potential.
   e. Chemical Resistance (oil, brake fluid, gasoline, diesel, antifreeze, battery acid, and sulfuric acid) No visual or physical change apparent.
   f. Flammability: No ignition after ten minutes, 25 kW/m, when tested in accordance with ASTM D 1929.
   g. Sized as required by loading conditions and as indicated on the drawings.
   h. Shop fabricated with inserts for square tubing or threaded rods as required.
   i. Color: Integral black color as molded.
   j. Bases for Mechanical Attachment: Sealant chamber around penetration point, with injection port for sealing after fastening; beveled lip for sealant bead around entire diameter.
   k. Do not use bases containing carbonated plastics, press molded recycled rubber and plastics, steel, stainless steel, or any injection molded threaded receivers.
4. Steel Framing:
   a. Channel Types: 1-5/8 inch (41.3 mm) B22TH or 1-7/8 inch (47.6 mm) BTS22H, as required for loading conditions.
   b. Thickness: 12 gauge (2.7 mm).
   c. Form: Roll-formed 3-sided or tubular channel, perforated with 9/16 inch (14.3 mm) holes at 1-7/8 inch (47.6 mm) centers on three sides.
   d. Finish: Hot dip galvanize in accordance with ASTM A 123 after fabrication, free of roughness, whiskers, unsightly spangles, icicles, runs, barbs, sags, droplets, and other surface blemishes.
   e. Do not use tubing or tube steel.
5. Pipe Supports and Hangers: Conform to MSS SP-58 and MSS SP-69 and as follows:

a. Fabricated of carbon steel where framing is carbon steel; fabricated of stainless steel where framing is stainless steel; finished same as framing.
b. Sizes 2-1/2 inch (63 mm) and smaller: Single roller supports for piping subject to expansion and contraction; 3-sided channels and pipe clamps.
c. Sizes three inch (76 mm) and larger: Rollers, clevis hangers, or band hangers, to allow for expansion and contraction without movement of the bases or framing.

6. Accessories: Clamps, bolts, nuts, washers, and other devices as required for a complete system.
   a. Carbon Steel: Hot-dip galvanized in accordance with ASTM A 153/A 153M.
   b. Stainless Steel: Mill finish.
   c. For Mechanical Fastening to Deck: On wood and steel decks, use bolts with steel plate to attach to deck; on concrete decks use threaded rods and adhesive anchors, with rod embedded at least 1-3/4 inch (44 mm) into concrete."

2.28 ARCHITECTURAL LOUVERS & VENTS

A. Manufacturers
   1. Acceptable Manufacturers: Greenheck, Ruskin Company, Airolite, Or equal.
B. Wind-Driven Rain Louver
   1. Fabrication: Heavy Gauge extruded aluminum stationary louver style.
      a. Frame: Double frame design.
         1) Frame Depth: Overall combined frame depth is 9.25 inches nominal.
         2) Wall Thickness: 0.081 inch nominal.
         3) Material: Extruded aluminum, Alloy 6063-T6.
      b. Blades:
         1) Style: Sight proof.
         2) Material: Extruded aluminum, Alloy 6063-T6.
         3) Wall Thickness: 0.080 inch (2.1 mm) and 0.062 inch (1.6 mm) nominal.
         4) Blade Depth: Exterior blades are two inches (51 mm) deep, interior blades are six inches (153 mm) deep.
      c. Sill: Sill Flashing: Formed aluminum, 0.081 inch (2.0 mm), upturned sides to prevent water leakage.
      d. Minimum assembly size: 12 inches length by 12 inches high for standard installation.
      e. Maximum assembly size: Standard EHV-90ten shall not exceed 60 inches width by 120 inches high. Louvers larger than the maximum factory assembly size will require field assembly of smaller sections.
   2. Performance Data:
      a. Performance Ratings: AMCA licensed.
         1) Based on testing 48 inches by 48 inches (1219 mm by 1219 mm) size unit in accordance with AMCA 500.
      b. Free Area: 54 percent, nominal.
      c. AMCA 540 and AMCA 550 Listing with the Air Movement and Control Association Certified Ratings Program, maximum wind-load: plus/minus 130 PSF.
      d. Maximum Pressure Drop (Intake): 0.45 inches w.g. (0.11 KPa).
      e. Louver shall be certified to Miami-Dade standards TAS 201 (Large Missile Impact), TAS 202 (Uniform Static Air Pressure) and TAS 203 (Cyclic Wind Loading).
      f. Wind load Test Performance: Maximum wind load of ±130 PSF (6.22 kPa) design wind loads tested per Miami-Dade County Uniform Wind Pressure Test TAS 202.
      g. Wind-driven Rain Performance:
         1) Effectiveness Ratio: 99.9 percent effective at preventing water penetration through louver when tested at 50 miles per hour (81 km/h) wind with eight inches per hour (203 mm/h) rainfall and 2261 feet per minute (11.5 m/sec) airflow through the free area. Penetration Class 'A' in accordance with AMCA 500-L Wind Driven Rain Test.
         2) Effectiveness Ratio: 99.9 percent effective at preventing water penetration through louver when tested at 29 miles per hour (46.4 km/h) wind with three inches per hour (76 mm/h) rainfall and 2247 feet per minute (11.4 m/sec) airflow through the free area. Penetration Class 'A' in accordance with AMCA 500-L Wind Driven Rain Test.
   3. Design Windload: +130 PSF (6.2 kPa) and -130 PSF (-6.2 kPa).
   4. Design Windload: Per Code.
C. Accessories

1. Aluminum Blank-Off Panels: 0.040 inch (1 mm) aluminum sheet, factory installed with removable screws and neoprene gaskets.
2. Aluminum Insulated Blank-Off Panels: two inches aluminum skin, insulated core, installed by HVAC Contractor with removable screws and neoprene gaskets.
3. Hinged Frame: Continuous piano hinge attached to angle subframe.
4. Hinged Frame: Continuous piano hinge attached to channel subframe.
5. Bird Screen:
   a. Aluminum: Aluminum, 5/8 inch by 0.040 inch (16 mm by 1 mm), expanded, flattened metal.
   b. Frame: Removable, re-wireable.
6. Insect Screens:
   a. Aluminum: 18-16 mesh, mill finish, .011 inch (0.3 mm) wire.
   b. Frame: Aluminum.
7. Extended Sills:
   a. Formed aluminum, Alloy 3003. Minimum nominal thickness 0.081 inch.
   b. Extruded aluminum, Alloy 6063-T6. Minimum nominal thickness 0.060 inch.
   c. Mullions: Manufacturer's decorative mullions for architectural accent.

D. Finishes
1. Finish: Mill finish.
2. Finish: 70 percent PVDF: Finish shall be applied at 1.2 mil total dry film thickness.
   a. Coating shall conform to AAMA 2605. Apply coating following cleaning and pretreatment. Cleaning: AA-C12C42R1X.
      1) 3-coat metallic.
   b. 20-year finish warranty.
   c. Color: Custom metallic color finish. Color by Architect.
3. Color: Custom. Refer to Drawings.

2.29 AUTOMATIC TEMPERATURE CONTROLS (DDC) (Refer to section 01 91 13 - for additional contract requirements)

A. Basic Components and Systems:
1. General: Provide control products in sizes and capacities indicated, consisting of dampers, thermostats, clocks, sensors, controllers, and other components as required for completed installation. Except as otherwise indicated, provide manufacturer’s standard materials and components as published in their product information, designed and constructed as recommended by manufacturer and as required for application indicated. All equipment and systems shall be installed by factory trained contractors with the following functional and construction features.
2. The building automation system shall be based on the latest version open protocol BACnet system infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard ie BACnet, Lon, Modbus or software) into a unified platform that can be read and written to and easily managed in real time using a standard Web browser. The building automation system shall not require licensing fees and shall be licensed indefinitely to the Owner for use at the project site.
3. ATC manufacturer shall provide written confirmation that installing ATC Sub-Contractor is an authorized dealer and service provider. The ATC system provided must be capable of being serviced by three or more local authorized vendors/contractors.
4. Provide all required control wiring including CAT6 Ethernet wiring for any controllers requiring Ethernet connectivity. Terminate Ethernet cable in MDF and IDF closets on patch panels proceed under Technology Section 270000.
5. Install an open-protocol (BACNet-IP Based) building energy management system to monitor and trend the energy consumed by the following systems throughout the school:
   a. Boilers
   b. Hot and cold domestic water systems
   c. Main electric service meter
   d. Building electric meters/submeters
   e. Air Source to Water Heat Recovery Heat Pump Chillers
   f. HVAC hot and chilled water pumps

6. The ATC control and building EMS system shall have the following attributes with characteristics and performance as specified within this Specification section, related Electrical and Plumbing section specifications and the Control Diagram drawings:
   a. Sensors as follows:
      1) Sensors to trend outdoor air temperature
      2) Indication and trending of damper and valve commanded positions.
      3) Sensors to monitor building electrical consumption and demand. Electrical meters shall be provided by the Electrical Sub-Contractor and control wiring from the meters to the EMS system shall be provided by the ATC Sub-contractor. The ATC Sub-contractor shall provide control wiring from the meters to the BMS. Flow meters for building cold water consumption will be installed by the Plumbing Sub-Contractor and furnished and wired to the BMS by the ATC Sub-Contractor. Domestic hot water shall include relays on each domestic water heater burner and through BMS programming utilizing burner on/off operation domestic hot water consumption will be determined, all provided by the ATC Sub-Contractor.
      4) Sensors to monitor indoor and outdoor CO2.
      5) Sensors to monitor and trend (create trend logs) controlled variables at the operator interface. Control variables may include air and/or water flow, temperature, pressure, CO2, and pump or fan speed. Relevant multiplexed data from microprocessors located in boilers, variable speed drives and other equipment with multiplexing capabilities may be used in lieu of specifying separate sensors.
      6) All densely occupied spaces, with occupant density of 25 people or more per ten00 s.f. must be provided with CO2 sensors per LEED IEQC1 requirements. Provide multi functioning sensors with temperature, humidity and CO2 for all spaces except for storage rooms and toilet rooms.
   b. Points matrix – including all hardwired input and output devices connected to the automation system, all set points, upper and lower control limits.
   c. Trend capabilities – including a trend point list and preprogrammed sample of point (performed by controls sub-contractor), sample rate, storage interval, upload interval, custom trend abilities, alarms, and automated trend data review and notification (automated diagnostics).
   d. System architecture – capable of allowing sampling of these points to facilitate building commissioning and diagnostics without significantly affecting system performance.
   e. Data storage system – with adequate capacity to record trend data for use by building operators. Data export requirements must facilitate user-friendly data access and manipulation.
   f. Operator interface – designed for remote/web access, monitoring requirements, trend-log reporting and diagnosing building problems through a user-friendly interface. This includes providing a visual (non text based) operations and reporting interface to facilitate rapid system assessment that utilizes color-coding, diagrams of floor plans and graphing capabilities.
   g. The remote access shall use a web browser only and not require a VPN with remote desktop application.
7. Store all HVAC, ATC, Electrical (including lighting) Plumbing and Fire Protection system operation and maintenance manuals, final approved shop drawings, as-built drawings and Owner Training Videos on BMS server. Provide a graphical user interface web-page with hyperlinks organized by trade, equipment and system type for east of owner access to this information.
8. Provide uninterruptible power supply (UPS) for supervisory network controller as indicated within these specifications.
9. Electric Wiring: All electric wiring and wiring connections, either line voltage or low voltage, from the emergency electric panels to the ATC panels, and from the ATC related panels to the individual control devices i.e. rooftop units, exhaust fans, boilers, valves, and dampers required for the installation of the control system, as herein specified shall be provided by the control sub-contractor unless specifically shown on the electrical drawings or called for in the electrical specifications.
   a. The wiring installation shall be in accordance with National and Local Codes and with the Electrical portion of these specifications. All wiring shall be run concealed wherever

possible. Exposed wiring in occupied areas shall be run in raceways. Raceways shall be Wiremold 200 series with all elbows, raceways, covers, mounting stops, box extensions and wiring for a complete and neat installation. All wiring located in mechanical spaces, boiler rooms, and fan rooms shall be installed in metal conduit

b. All wiring above ceilings, in boiler rooms, and all mechanical spaces shall follow routing of piping and where not possible shall be in conduit. All exposed wire shall be bundled and wire tied and shall be supported to adjacent piping. Draped and free floating wire will not be allowed.
c. All terminations of wire at control devices shall be looped and supported adequately.
d. All wiring shall comply with the requirements of the electrical section of the specification.

B. Controls Systems Wiring
1. All conduit raceways, wiring, accessories and wiring connections required for the installation of the Controls Systems shall be provided by the Controls Sub-Contractor except as shown on the Electrical Drawings. All wiring shall comply with the requirements of applicable portions of the Electrical Section 26 00 01 and all local and national electric codes and the requirements of the AHJ.
2. All Controls Systems wiring materials and installation methods shall comply with the original equipment manufacturer recommendations and standards.
3. The sizing type and provision of cable, conduit, cable trays and raceways shall be the design responsibility of the Controls Sub-Contractor.
4. Class 2 Wiring
   a. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
   b. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5feet from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines.
5. Class 2 signal wiring and 24VAC power may be run in the same conduit. Power wiring 120VAC and greater shall not share the same conduit with Class 2 signal wiring.
6. Perform circuit tests using qualified personnel only. Provide necessary instruments and equipment to demonstrate that:
   a. All circuits are continuous and free from short circuits and grounds.
   b. All circuits are free from unspecified grounds; that resistance to ground of all circuits is no less than 50 megaohms.
   c. All circuits are free from induced voltages.
7. Provide complete testing for all cables and wiring. Provide all equipment, tools, and personnel as necessary to conduct these tests.
8. Provide for complete grounding of all signal and communication cables, panels and equipment so as to ensure integrity of Controls Systems operation. Ground cabling and conduit at panel terminations. Do not create ground loops.

C. Line Voltage Power Sources
1. 120-volt AC circuits for the Controls Systems shall be taken by the Controls Sub-Contractor from electrical emergency panelboards and circuit breakers as designated on the electrical drawings.
2. Circuits used for the Controls Systems shall be dedicated to these Controls Systems and shall not be used for any other services.
3. Controls DDC terminal unit controllers may use 120-volt AC power from motor power circuits.

D. Controls Systems Raceways
1. All wiring shall be installed in conduit or raceway except as noted elsewhere in the Specification. Minimum conduit size 3/4 inch
2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the supporting surface.
4. UL/ULC Listed Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls and for final connection to equipment.

E. Penetrations

1. Firestopping for all penetrations used by dedicated Controls Systems conduits and raceways shall be by other trades.
2. All openings in fire proofed or fire stopped components shall be closed by other trades using approved fire resistive sealant.
3. All wiring passing through penetrations, including walls, shall be in sleeves, conduit or enclosed raceway.
4. No penetrations through building structural elements, slabs, ceilings and walls shall be made before receipt of written approval from the Architect.

F. Controls Systems Identification Standards
1. Node Identification: All nodes shall be identified by a permanent label fastened to the outside of the enclosure. Labels shall be suitable for the node environmental location.
2. Cable shall be labeled at every termination with cross-referencing to record documentation.
3. Raceway Identification: Exposed covers to junction and pull boxes of the FMS raceways shall be identified at primary points.
4. Wire Identification: All low and line voltage wiring shall be identified by a number, as referenced to the associated shop and record drawing, at each termination.
5. Wires and cabling shall not be spliced between terminations. Cable shields shall be single end grounded – typically at the panel end outside the panel.
6. Suggested color coding, for use at the Contractors option, are:
   a. Analog Input Cable Yellow
   b. Analog Output Cable Tan
   c. Binary Input Cable Orange
   d. Binary Output Cable Violet
   e. 24 VAC Cable Gray
   f. General Purpose Cable Natural
   g. Tier 1 Comm Cable Purple
   h. Other Tier Comm Cable Blue
   i. Ethernet cable Blue
7. Provide permanent identification labels at all valve and damper actuators to indicate open and closed positions.

G. Field Panel And Device Installations And Locations
1. The Controls Systems panels, enclosures and cabinets shall be located as coordinated with the Architect at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
2. All field devices shall be installed per the manufacturer recommendation and in accessible locations as coordinated with the Architect.
3. Panels to be located in damp areas or areas subject to condensation shall be mounted with wall standoffs.
4. Conduit configurations entering or leaving panels and devices shall be such as to preclude condensation traps.
   a. Networking Communications
5. The design of the BAS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of multiple levels for communication efficiency, a campus-wide (Management Level Network) Ethernet network based on TCP/IP protocol, high performance peer-to-peer building level network(s) and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs.
6. System shall communicate with a BACnet network over Ethernet or BACnet/IP (according to Annex J). The intent is to use the system provided under this contract to communicate with control systems and/or devices provided by other vendors. A PICS must be provided describing the BACnet, ANSI/ASHRAE 135-95, implementation. The product shall be Network Application Engine level 1 controllers with field equipment controller for level 2 controllers no substitutions. Minimum system functionality must include monitoring, commanding, and alarming for daily operator functions from a common workstation.
   a. System shall have the capability to be an OPC Client and Server for dynamic communication with OPC Clients or Servers over an Ethernet network. At a minimum, the following must be supported:
      1) Data Access 1.0 (96), 1.0A (97) and 2.0 (11/98)

2) Alarms & Events 1.0 (1/99)

7. Network Switches
   a. Provide HP ProCurve 29ten al series 29ten-48G al 48 ports network switch Brocade, Cisco or equal in MDF/IDF rooms as required.
8. Ethernet Wiring
   a. Ethernet wiring shall be CAT6 UTP cable plenum rated. CAT6 UTP cables shall conform to ANSI/TIA/EIA-568-B1, B2, B3 Commercial Building Telecommunications Cabling Standard (latest amendment and including all applicable addenda) and ISO/IEC 11801 (International) Generic Cabling for Customer Premises standard (latest amendment and including all applicable addenda).
9. Building Data Network:
   a. All operator devices shall either be network resident or shall have the ability to access all point status and application report data to execute control functions for any and all other devices via the network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.
   b. The network shall support a minimum of ten0 DDC controllers and PC workstations
   c. The system shall support integration of third party systems (fire alarm, security, lighting, PLC, boiler) via panel mounted open protocol processor. This processor shall exchange data between the two systems for interprocess control. All exchange points shall have full system functionality as specified herein for hardwired points.
   d. Field panels must be capable of integration with open standards including Modbus, BACnet, and Lonworks as well as with third party devices via existing vendor protocols.
   e. The Building Network shall use the TCP/IP over Ethernet. All devices must:
      1) Auto-sense 10/100/1000 Mbps networks.
      2) IP Address will be assigned by Owner's IT staff.
      3) DNS and Gateway IP address will be provided by Owner's IT staff. A VLAN will be setup by Owner's IT staff.
      4) Allow access using Telnet.
10. Internet access
   a. Web Based Operator Interface
      1) The BAS shall provide a web based graphical interface that allows users to access the BAS data via the Internet. The interface shall use HTML based ASP pages to send and receive data from the BAS to a web browser.
      2) All information exchanged over Internet shall be encrypted and secure via SSL.
      3) Access to the web interface will be password protected. A users rights and privileges to points and graphics will be the same as those assigned at the BAS workstation. An option shall exist to only allow users "read" access via the web browser, while maintaining "command" privileges via the BAS workstation.
      4) Commissioning of the Web interface shall not require modification or creation of HTML or ASP pages. All graphics available at the BAS graphical workstation shall be available to users via a web browser.
      5) The web-based interface shall provide the following functionality to users, based on their access and privilege rights:
         a) Logon Screen – allows the user to enter their user name, password and Domain name for logging into the web server.
         b) Alarm Display – a display of current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge and erase active alarms, and link to additional alarm information including alarm messages, and informational and memo text. Any alarm acknowledgements initiated through the web interface will be written to the BAS central workstation activity log.
         c) Graphic Display – Display of system graphics, including animated motion, available in the BAS workstation will be available for viewing over the web browser. Software that requires creation of dedicated "web" graphics in order to display them via the browser interface will not be acceptable. A graphic selector list shall allow users to select any graphics to which they have access. Graphic displays shall automatically refresh with the latest change of values. Users will have the ability to command and override points from the graphic display as determined by their user accounts rights. ATC/BMS Contractor shall provide

graphic displays for all HVAC equipment and systems indicated on the HVAC control drawings. ATC/BAS Contractor shall provide Sample Graphics within the ATC Shop Drawing for Owner and Engineer review and approval.

d) Point details – users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.

e) Point Commanding – users will be able to override and command points they have access to via the web browser interface. Any commands or overrides initiated via the web browser interface will be written to the BAS central workstation activity log.

11. The web server licensing shall allow concurrent access by 10 browser connections.
12. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the web access feature.

H. DDC Controller Floor Level 2 Network
1. This level communication shall support a family of application specific controllers and shall communicate with the network through DDC Controllers for transmission of global data.

I. DDC & HVAC Mechanical Equipment Controllers
1. The DDC and HVAC Mechanical Equipment Controllers shall reside on the Building Level Network.
2. DDC and HVAC Mechanical Equipment Controllers shall use the same programming language and tools. DDC and HVAC Mechanical Equipment Controllers which require different programming language or tools on a network are not acceptable.
3. DDC and HVAC Mechanical Equipment Controllers which do not meet the functions specified are not acceptable.

J. DDC Controller
1. DDC Controllers shall be a 16-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of three Floor Level Application Specific Controller Device Networks.
2. Each DDC Controller shall have 72 Megabytes of memory to support its own operating system and databases, including:
   a. Control processes
   b. Energy management applications
   c. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
   d. Historical/trend data for points specified
   e. Maintenance support applications
   f. Custom processes
   g. Operator I/O
   h. Dial-up communications
   i. Manual override monitoring
3. Each DDC Controller shall support firmware upgrades without the need to replace hardware.
4. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
5. DDC Controllers shall provide a RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
6. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.
   a. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.

b. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

7. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.
8. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
9. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
   a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC ten00-4-6) at 3 V
   b. Electro Static Discharge (ESD) Immunity per EN 6ten00-4-2 (IEC ten00-4-2) at 8 kV air discharge, 4 kV contact
   c. Electrical Fast Transient (EFT) per EN 6ten00-4-4 (IEC ten00-4-4) at 500 V signal, 1 kV power
   d. Output Circuit Transients per UL 864 (2,400V, tenA, 1.2 Joule max)
   e. Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:
      1) IEEE Standard 587-1980
      2) UL 864 Supply Line Transients
      3) Voltage Sags, Surge, and Dropout per EN 6ten00-4-11 (EN ten00-4-11)
10. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.
    a. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
    b. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
11. Provide a separate DDC Controller for each AHU and all major HVAC equipment and systems shown on the drawings as specified within It is intended that each unique system be provided with its own point resident DDC Controller.

K. HVAC Mechanical Equipment Controllers
   1. HVAC Mechanical Equipment Controllers shall be a 12-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors.
   2. Each HVAC Mechanical Controller shall have 72 Megabytes of memory to support its own operating system and databases, including:
      a. Control processes
      b. Energy management applications
      c. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
      d. Historical/trend data for points specified
      e. Maintenance support applications
      f. Custom processes
      g. Operator I/O
      h. Remote communications
   3. HVAC Mechanical Equipment Controllers shall provide a RS-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals.
   4. HVAC Mechanical Equipment Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

5. Each HVAC Mechanical Equipment Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all components. The HVAC Mechanical Equipment Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
6. In the event of the loss of normal power, there shall be an orderly shutdown of all HVAC Mechanical Equipment Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
   a. Upon restoration of normal power, the HVAC Mechanical Equipment Controller shall automatically resume full operation without manual intervention.
   b. Should HVAC Mechanical Equipment Controller memory be lost for any reason, the user shall have the capability of reloading the HVAC Mechanical Equipment Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

L. DDC and HVAC Mechanical Equipment Controller Resident Software Features
   1. General:
      a. The software programs specified in this Section shall be provided as an integral part of DDC and HVAC Mechanical Equipment Controllers and shall not be dependent upon any higher level computer for execution.
      b. All points shall be identified by up to 30 character point name and 16 character point descriptor. The same names shall be used at the PC workstation.
      c. All digital points shall have user defined two-state status indication (descriptors with minimum of eight characters allowed per state (i.e. summer/winter).
   2. Control Software Description:
      a. The DDC and HVAC Mechanical Equipment Controllers shall have the ability to perform the following pre-tested control algorithms:
         1) Two-position control
         2) Proportional control
         3) Proportional plus integral control
         4) Proportional, integral, plus derivative control
         5) Automatic tuning of control loops
   3. DDC and HVAC Mechanical Equipment Controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.
      a. Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by time of occupancy. The SSTO program shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.
         1) The SSTO program shall operate in both the heating and cooling seasons.
            a) It shall be possible to apply the SSTO program to individual fan systems.
            b) The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.
         2) The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.
      b. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.
         1) It shall be possible to individually command a point or group of points.
         2) For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start or stop within that group.
         3) The operator shall be able to define the following information:
            a) Time, day
            b) Commands such as on, off, auto, and so forth.
            c) Time delays between successive commands.
            d) There shall be provisions for manual overriding of each schedule by an appropriate operator.
         4) It shall be possible to schedule events up to one year in advance.
            a) Scheduling shall be calendar based.

b) Holidays shall allow for different schedules.
c) Enthalpy switchover (economizer) The Energy Management Control Software (EMCS) will control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover set point the EMCS will modulate the dampers to provide ten0 percent outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.
d) Temperature-compensated duty cycling.
    a. The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.
    b. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.
e) Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.
f) Night setback control: The system shall provide the ability to automatically adjust setpoints for night control.
g) The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
    a. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
    b. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
    c. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
    d. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.

4. DDC and HVAC Mechanical Equipment Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
    a. A single process shall be able to incorporate measured or calculated data from any and all other DDC and HVAC Mechanical Equipment Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC and HVAC Mechanical Equipment Controllers on the network. Database shall support 30 character, English language point names, structured for searching and logs.
    b. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
    c. DDC and HVAC Mechanical Equipment Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.
    d. DDC and HVAC Mechanical Equipment Controller shall be capable of comment lines for sequence of operation explanation.
5. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC and HVAC Mechanical Equipment Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC and HVAC Mechanical Equipment Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
    a. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
    b. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority

levels shall be combined with user definable destination categories (PC, printer, DDC Controller) to provide full flexibility in defining the handling of system alarms. Each DDC and HVAC Mechanical Equipment Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

c. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hours destinations) or based on priority.
d. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
e. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.

6. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.
   a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC and HVAC Mechanical Equipment Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of l minute to seven days shall be provided. Each DDC and HVAC Mechanical Equipment Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a sufficient number of data samples. All trend data shall be available for transfer to a Workstation without manual intervention.
   b. DDC and HVAC Mechanical Equipment Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.
      1) Loop tuning shall be capable of being initiated either locally at the DDC and HVAC Mechanical Equipment Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
7. DDC and HVAC Mechanical Equipment Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.
8. The peer to peer network shall allow the DDC and HVAC Mechanical Equipment Controllers to access any data from or send control commands and alarm reports directly to any other DDC and HVAC Mechanical Equipment Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC and HVAC Mechanical Equipment Controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device. The peer to peer network shall also allow any DDC and HVAC Mechanical Equipment Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.
9. The network shall allow the DDC and HVAC Mechanical Equipment Controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

M. Floor Level Network Application Specific Controllers (FEC)
1. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (FECs) through Floor Level LAN Device Networks.
2. Each FEC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each FEC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Each FEC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.

3. Terminal Equipment Controllers:
    a. Provide for control of each piece of equipment, including, but not limited to, the following:
        1) Fin Tube Radiation
        2) Convectors
        3) Radiant Heating and Cooling Panels
        4) Unit Heaters, Cabinet Unit Heaters
        5) Exhaust Fan Systems
        6) Duct Collector Systems
        7) Split system AC and heat pump system
        8) Fan Coils
        9) VAV's
    b. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 3-15 pounds per square inch pneumatic, 0-tenv, allowing for interface to a variety of modulating actuators.
    c. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the FLN, BLN or MLN is not acceptable.

N. Local User Display
1. Where specified in the sequence of operation or points list, the controllers on the peer to peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.
2. The display shall use the same security password and access rights for points in the display as is used in the associated controller.
3. The LCD display shall be a minimum of a two line 40 character display.
4. The LCD display shall include the full point name, value (numeric, digital or state text),
5. point priority and alarm status on one screen.
6. The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.
7. The display shall be mounted either on the door of the enclosure or remote from the controller.

O. Personal Computer Operator Workstation Hardware
1. Personal computer operator workstations shall be provided for command entry, information management, system monitor, alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater distribution, fault tolerance and reliability of the building automation control.
    a. Provide workstation(s): Manufactured by Dell, HP, Lenovo or equal.
    b. Workstation shall consist of a personal computer with minimum 10.0GB RAM, hard drive with 2 TB available space, video card capable of supporting 1024 × 768 resolution with a minimum of 32 Bit color (Windows 11 Pro), DVD-ROM Drive, mouse and 101-key enhanced keyboard. Personal computer shall be a Windows 10 Professional Compatible PC and shall include a minimum latest generation Intel Core i7 3.40 GHz processor.
    c. The PC monitor shall support a minimum display resolution of no less than 1900 X 1280 pixels and shall be minimum 19 inch LCD display. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective.
    d. Also provide separate file server with available storage capacity to accommodate trending 15 min interval of each control point for a period of one year for data archives, minimum 1 TB capacity.
2. Provide an HP LaserJet Pro 400 Color M451dn, Cannon, Brother or equal printer at each workstation location or on the network (Ethernet) for recording alarms, operator transactions and systems reports.
3. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.
4. Intranet/Internet access
    a. Web Based Operator Interface
        1) The BAS shall provide a web based graphical interface that allows users to access the BAS data via the Internet, extranet, or Intranet. The interface shall use HTML based ASP pages to send and receive data from the BAS to a web browser.

2) A web server computer will be supplied. The web server shall support browser access via Microsoft Internet Explorer 9.0 (or higher), or Navigator Netscape 6.0 (or higher).
3) All information exchanged over Internet shall be optionally encrypted and secure via SSL (provided by Owner).
4) Access to the web interface may be password protected. A users rights and privileges to points and graphics will be the same as those assigned at the BAS workstation. An option will exist to only allow users "read" access via the web browser, while maintaining "command" privileges via the BAS workstation.
5) Commissioning of the Web interface shall not require modification or creation of HTML or ASP pages. All graphics available at the BAS graphical workstation shall be available to users via a web browser.
6) The web-based interface shall provide the following functionality to users, based on their access and privilege rights:
    a) Logon Screen – allows the user to enter their user name, password and Domain name for logging into the web server.
    b) Alarm Display – a display of current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge and erase active alarms, and link to additional alarm information including alarm messages, and informational and memo text. Any alarm acknowledgements initiated through the web interface will be written to the BAS central workstation activity log.
    c) Graphic Display – Display of system graphics, including animated motion, available in the BAS workstation will be available for viewing over the web browser. Software that requires creation of dedicated "web" graphics in order to display them via the browser interface will not be acceptable. A graphic selector list will allow users to select any graphics to which they have access. Graphic displays will automatically refresh with the latest change of values. Users will have the ability to command and override points from the graphic display as determined by their user accounts rights.
    d) Point details – users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.
    e) Point Commanding – users will be able to override and command points they have access to via the web browser interface. Any commands or overrides initiated via the web browser interface will be written to the BAS central workstation activity log.
7) The web server licensing options shall allow concurrent access by a minimum of 10 browser connections.
8) Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the web access feature.

P. Operators Laptop
1. A Lap Top Operators Terminal shall be provided for operator readout of system variables, override control and adjustment of control parameters and display graphics as called for in paragraphs following. Computer specification shall be similar to fixed station computer in Paragraph P.
2. Functionality to include ability to automatically display a sequential all point summary and a sequential alarm summary. The Lap Top shall also allow display and/or changing of digital point state, analog point value, time and date, application and DDC parameters, analog limits, time schedules, runtime counts and limits, daylight savings time changeover, time/event initiation, and programmable offset values. The Lap Top shall allow access into DCP initialization routines and diagnostics and enable/disable of points, initiators and programs, all similar to the fixed computer. Laptop shall have a minimum 15 inch color screen, 4GB ram, 500GB hard drive and Windows 11 Professional operating system.

Q. Workstation Operator Interface
1. Basic Interface Description
    a. Operator workstation interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 30 character English language point identification, on-line help, and industry standard Windows application software. Interface software shall simultaneously communicate with existing system and share data between

the dedicated, modem autodial, and Ethernet-connected building level networks. The software shall provide, as a minimum, the following functionality:

1) Real-time graphical viewing and control of the BAS environment
2) Reporting
3) Scheduling and override of building operations
4) Collection and analysis of historical data
5) Point database editing, storage and downloading of controller databases.
6) Utility for combining points into logical Point Groups. The Point Groups shall then be manipulated in Graphics, trend graphs and reports in order to streamline the navigation and usability of the system.
7) Alarm reporting, routing, messaging, and acknowledgment
8) "Collapsible tree," dynamic system architecture diagram application:
   a) Showing the real-time status and definition details of all workstations and devices on a management level network
   b) Showing the real-time status and definition details of all DDC and HVAC Mechanical Controllers at the building level
   c) Showing the status and definition details of all field-level application controllers
9) Definition and construction of dynamic color graphic displays.
10) Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
11) On-screen access to User Documentation, via online help or PDF-format electronic file.
12) Automatic database backup at the workstation for database changes initiated at DDC Controller operator interface terminals.

b. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a "drag and drop" approach to inter-application navigation. Selection of applications within the workstation software shall be via a graphical toolbar menu – the application toolbar menu shall have the option to be located in a docked position on any of the four sides of the visible desktop space on the workstation display monitor, and the option to automatically hide itself from the visible monitor workspace when not being actively manipulated by the user.

c. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BAS software shall run on a Windows 10 Professional bit operating system. System database parameters shall be stored within an object-oriented database, which is compliant with the Open Database Connectivity (ODBC) or Structured Query Language (SQL) standards. Standard Windows applications shall run simultaneously with the BAS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information
   1) Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via adjustable user-sized windows. Operator shall be able to drag and drop information between the following applications, reducing the number of steps to perform a desired function (e.g., Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend on the desired point):
      a) Dynamic color graphics application
      b) Alarm management application
      c) Scheduling application
      d) Dynamic trend graph data plotter application
      e) Dynamic system architecture diagram application
      f) Control Program and Point database editing applications
      g) Reporting applications
   2) Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.

d. Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported). The administrator/manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BAS workstation application. And each BAS workstation user account shall use a Windows 7 user account as a foundation.
e. Dynamic Color Graphics application shall include the following:
    1) Must include graphic editing and modifying capabilities
    2) A library of standard control application graphics and symbols must be included
    3) Must be able to command points directly off graphics application
    4) Graphic display shall include the ability to depict real-time point values dynamically with animation, picture/frame control, symbol association, or dynamic informational text-blocks.
    5) Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure
    6) Graphics viewing shall include zoom capabilities
    7) Graphics shall automatically display the HAND status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
    8) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls), internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
f. Reports shall be generated on demand or via pre-defined schedule, and directed to CRT displays, printers or file. As a minimum, the system shall allow the user to easily obtain the following types of reports:
    1) A general listing of all or selected points in the network
    2) List of all points currently in alarm
    3) List of all points currently in override status
    4) List of all disabled points
    5) List of all points currently locked out
    6) List of user accounts and access levels
    7) List all weekly schedules and events
    8) List of holiday programming
    9) List of control limits and deadbands
    10) Custom reports from 3rd party software
    11) System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
    12) List of programs
    13) List of point definitions
    14) List of logical point groups
    15) List of alarm strategy definitions
    16) List of DDC Control panels
    17) Point totalization report
    18) Point Trend data listings
    19) Initial Values report
    20) User activity report
g. Scheduling and override
h. Provide a calendar type format for simplification of time and date scheduling and overrides of building operations. Schedule definitions reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line -- PC is not required to execute time scheduling. Provide override access through menu selection, graphical mouse action or function key. Provide the following capabilities as a minimum:
    1) Weekly schedules
    2) Zone schedules

3) Event schedules – an event consists of logical combinations of equipment and/or zones
4) Report schedules
5) Ability to schedule for a minimum of up to 365 days in advance
6) Additionally, the scheduling application shall:
   a) Provide filtering capabilities of schedules, based on name, time, frequency, and schedule type (event, zone, report)
   b) Provide sorting capabilities of schedules, based on name, time and type of schedule (zone, event, report)
   c) Provide searching capabilities of schedules based on name – with wildcarding options

i. Collection and Analysis of Historical Data
   1) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals (up to four time-based definitions per point) or change of value, both of which shall be user-definable. Trend data shall be collected stored on hard disk for future diagnostics and reporting. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of zones, events, and reports. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
   2) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of selected points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. DDC Sub-contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. DDC Sub-contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.

j. The ATC Sub-contractor shall provide an additional 120 hours of ATC/BMS system programming time to assist the owner/engineer with customized programming of the ATC/BMS system due to any changes and/or modifications.

2. Dynamic Color Graphic Displays
   a. Create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units and hot water boiler systems, and room level terminal units, shall be provided by the BAS Sub-contractor as indicated in the point I/O schedule of this specification to optimize system performance, analysis and speed alarm recognition.
   b. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or text-based commands. Graphics software shall permit the importing of Autocad or scanned pictures for use in the system.
   c. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations within the system schematics or graphic floor plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
      1) Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Picture Control shall depict various positions in relation to assigned point values or ranges. A library (set) of animation and picture control symbols shall be included within the workstation software's graphics application. Animation shall reflect, ON or OFF conditions, and shall also be configurable for up to five rates of animation speed.
      2) Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
      3) Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.

4) Equipment state or values can be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or setpoint.
5) State text for digital points can be user-defined up to eight characters.

d. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
e. Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls), internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
f. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
g. Off the shelf graphic software, html web-based graphic software shall be provided to allow the user to add, modify or delete system graphic background displays.
h. A clipart library of HVAC application and automation symbols shall be provided including fans, valves, motors, AHU systems, standard ductwork diagrams. The user shall have the ability to add custom symbols to the clipart library. The clipart library shall include a minimum of 400 application symbols. In addition, a library consisting of a minimum of 700 graphic background templates shall be provided.
i. The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.

3. System Configuration & Definition
   a. A "Collapsible tree," dynamic system architecture diagram/display application of the site-specific BAS architecture showing status of controllers, PC workstations and networks shall be provided. This application shall include the ability to add and configure workstations, DDC Controllers or HVAC Mechanical Equipment controllers, as well as 3rd-party integrated components. Symbols/Icons representing the system architecture components shall be user-configurable and customizable, and a library of customized icons representing 3rd-party integration solutions shall be included. This application shall also include the functionality for real-time display, configuration and diagnostics of dial-up modems to DDC Controllers.
   b. Network wide control strategies shall not be restricted to a single DDC Controller or HVAC Mechanical Equipment controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
   c. Provide automatic backup and restore of all DDC controller and HVAC Mechanical Equipment controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller or HVAC Mechanical Equipment Controller. Changes made at the user-interface of DDC Controllers or HVAC Mechanical Equipment Controllers shall be automatically uploaded to the workstation, ensuring system continuity.
   d. System configuration, programming, editing, graphics generation shall be performed on-line. If programming and system back-up must be done with the PC workstation off-line, the BAS Sub-contractor shall provide at least 2 operator workstations.
   e. Point database configuration shall be available to the user within a dedicated point database editor application included in the workstation software. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database. The point editor shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the option for editing the point database in an online or offline mode with the DDC Controllers.
      1) The workstation software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points. This function shall allow the user to choose the properties to copy from a selected point to another point or set of points. The selectable attributes shall include, but are not limited to, Alarm management definitions and Trend definitions.

4. Alarm Management
   a. Alarm Routing shall allow the user to send alarm notification to selected printers or workstation location(s) based on time of day, alarm severity, or point type.
   b. Alarm Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each alarm point: name, value, alarm time and date, alarm status, priority, acknowledgement information, and alarm count. Each alarm point or priority shall have the ability to sound a discrete audible notification.
   c. Alarm Display shall have the ability to list and sort the alarms based on alarm status, point name, ascending or descending alarm time.
   d. Directly from the Alarm Display, the user shall have the ability to acknowledge, silence the alarm sound, print, or erase each alarm. The interface shall also have the option to inhibit the erasing of active acknowledged alarms, until they have returned to normal status. The user shall also have the ability to command, launch an associated graphic or trended graphical plot, or run a report on a selected alarm point directly on the Alarm Display.
   e. Each alarm point shall have a direct link from the Alarm Display to further user-defined point informational data. The user shall have the ability to also associate real-time electronic annotations or notes to each alarm.
   f. Alarm messages shall be customizable for each point, or each alarm priority level, to display detailed instructions to the user regarding actions to take in the event of an alarm. Alarm messages shall also have the optional ability to individually enunciate on the workstation display via a separate pop-up window, automatically being generated as the associated alarm condition occurs.
   g. Alarm Display application shall allow workstation operators to send and receive real-time messages to each other, for purposes of coordinating Alarm and BAS system management.
   h. Remote notification of messages
      1) Workstation shall be configured to send out messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition.
      2) There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices which can receive messages from the system.
      3) On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.
      4) Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.
      5) System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.
      6) Message detail shall be configurable on a per user basis.
      7) During a "flood" of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.
      8) Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.
      9) Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.
5. Field Devices
   a. Provide instrumentation as required for monitoring, control or optimization functions.
   b. Room Temperature Sensors
      1) All temperature sensors shall be BACnet compatible network type. Auditorium, Stage, Café, Gym and Office areas shall be provided with digital combination room sensors for temperature, humidity and CO2 (two sensors may be provided in lieu of one) and shall have LCD display, day / night override button, and setpoint slide adjustment. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment. All other areas/spaces including but not limited to classrooms and teaching room areas shall have combination room sensors for

temperature, humidity and CO2 (two sensors may be provided in lieu of one) and shall have day / night override button, and setpoint slide adjustment options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment. Public areas such as corridors, entry areas, vestibules, restrooms shall have chrome cover plate without adjustment or override occupied/unoccupied capability. Sensors located in Gymnasiums, Café, Auditorium, Alternate PE, Tech Shops, Kitchen and Locker rooms shall be provided with tamper proof guard.

Temperature monitoring range +20/120 degrees Fahrenheit -13 deg. to 49 deg. C)
Output signal Changing resistance
Accuracy at Calibration point +0.5 degrees Fahrenheit (plus/minus 0.3 deg. C)
Set Point and Display Range 55 deg. to 95 degrees Fahrenheit (13 deg. to 35 deg. C)

2) Liquid immersion temperature:

Temperature monitoring range +30/250 degrees Fahrenheit (-1 deg. /121 deg. C)
Output signal Changing resistance
Accuracy at Calibration point +0.5 degrees Fahrenheit (plus/minus0.3 deg. C)

3) Duct (single point) temperature:

Temperature monitoring range +20/120 degrees Fahrenheit (-7 deg. /49 deg. C)
Output signal Changing resistance
Accuracy at Calibration point +0.5 degrees Fahrenheit (plus/minus0.3 deg. C)

4) Duct Average temperature:

Temperature monitoring range +20 deg.+120 deg.F (-7 deg./+49 deg. C)
Output signal 4 – 20 mA DC
Accuracy at Calibration point +0.5 degrees Fahrenheit (+03 deg. C)
Sensor Probe Length 25 feet L (7.3m)

5) Outside air temperature:

Temperature monitoring range -58deg.+122deg.F(-50deg.Cto 50deg.C)
Output signal 4 – 20 mA DC
Accuracy at Calibration point +0.5 degrees Fahrenheit (plus/minus0.3 deg. C)

c. Liquid Differential Pressure Transmitter

Ranges	0-5/30 inch H20 -25/150 inch H20 0-125/750 inch H20
Output	4 – 20 mA DC
Calibration Adjustments	Zero and span
Accuracy	+-0.2 percent of span
Linearity	+-0.1 percent of span
Hysteresis	+-0.05 percent of span

d. Differential pressure:

1) Unit for fluid flow proof shall be Penn P74.

Range	8 to 70 pounds per square inch
Differential	3 pounds per square inch
Maximum differential pressure	200 pounds per square inch

Maximum pressure 325 pounds per square inch

2) Unit for air flow settings.
3) Set point ranges: 0.5 inch water gauge to 1.0 inch water gauge (124.4 to 248.8 Pa)

1.0 inch water gauge to 12.0 inch water gauge (248.8 to 497.6 Pa)

e. Static pressure sensor:

Range	0 to .5 inch water gauge (0 to 124.4 Pa) 0 to 1 inch water gauge (0 to 248.8 Pa) 0 to 2 inch water gauge (0 to 497.7 Pa) 0 to 5 inch water gauge (0 to 1.2 kPa 0 to 10 inch water gauge (0 to 2.5 kPa)
Output Signal	4 – 20 mA VDC
Combined static error	0.5 percent full range
Operating Temperature	-40 deg. to 175 degrees Fahrenheit (-40 deg. C to 79.5 deg. C)

f. Air Pressure Sensor:

Range:	0 to 0.1 inch water (0 to 24.9 Pa) 0 to 0.25 inch water (0 to 63.2 Pa) 0 to 0.5 inch water (0 to 124.5 Pa) 0 to 1.0 inch water (o to 249 Pa) 0 to 2.0 inch water 90 to 498 Pa) 0 to 5.0 inch water (0 to 1.25 kPa) 0 to 10.0 inch water (0 to 2.49 kPa)
Output signal	4 to 20 mA
Accuracy	+1.0 percent of full scale

g. Humidity Sensors: All room/zone humidity sensors shall be BACnet compatible network type.

Range	0 to 100 percent RH
Sensing Element	Bulk Polymer
Output Signal	4 – 20 mA DC
Accuracy	At 77 degrees Fahrenheit (25 deg. C) + 2 percent RH
Humidistat:	
Range	0 to 100 percent RH
Sensing Element	Bulk Polymer
Output Signal	4 – 20 mA DC
Accuracy	At 77 degrees Fahrenheit (25 deg. C) + 2 percent RH

h. Insertion Flow Meters (Equal to Onicon F-5300)

Sensing Method	Impedance Sensing
Accuracy	+2 percent of Actual Reading
Maximum Operating Pressure	400 pounds per square inch
Output Signal	4 – 20 mA
Bi-directional where required.	

i. Pressure to Current Transducer

Range	3 to 15 pounds per square inch (21 to 103 kPa) or 3 to 30 pounds per square inch (21 to 207 kPa)
Output signal	4 – 20 mA
Accuracy	+ 1 percent of full scale (+ 0.3 pounds per square inch)

j. Carbon Dioxide Sensor : All room/zone CO2 & duct mounted sensors shall be BACnet compatible network type and shall have a minimum five year calibration period.

Range	0 to 1500 Parts per Minute
Accuracy	20+ Parts per Minute

CO2 sensors located in gymnasiums and locker rooms shall be provided with tamper proof guard.

6. Control Valves (all control valves shall have electric actuators with position feedback to provide confirmation of valve position).
   a. Electric Control

Rangeability	40:1
Flow Characteristics	Modified. Equal percentage
Control Action	Normal open for hot water and normal closed for cooling
Medium	Steam, water, glycol
Body Type	Screwed ends two inch and smaller, flanged Valves 2½ inch and larger
Body Material	Bronze
Body Trim	Bronze
Stem	Stainless Steel
Actuator	0-10 VDC, 4-20 MA or 2 position 24 VAC/120VAC – Modulating for all hot water valves with a GALLONS PER MINUTE value of 1 or above, 2 position valves for all GALLONS PER MINUTE's under 1.

   b. All automatic temperature control valves in water lines shall be provided with Characterized throttling plugs and shall be sized for minimum 25 percent of the system pressure drop or three pounds per square inch, whichever is less.
      1) Positive positioning relays shall be provided on pneumatic control when required to provide sufficient power for sequencing.
      2) Two position valves shall be line size.
7. Damper Actuators
   a. Electric control shall be direct coupled actuators with position feedback to BMS.
   b. Damper actuators shall be Brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.
      1) The actuator assembly shall include the necessary hardware and proper mounting and connection to a standard ½ inch diameter shaft or damper blade.
   c. Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages.
   d. All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of the actuator's output coupling with the damper shaft The self-centering clamp shall have a pair of opposed "v" shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft
   e. All actuators having more than a 100 lb-in torque output shall accept a one inch diameter shaft directly, without the need for auxiliary adapters.
   f. All actuators shall be designed and manufactured by Belimo or approved equal using ISO900 registered procedures, and shall be Listed under Standards UL873 and CSA22.2 No. 24-93 I.

R. Ultra-Low Leakage HVAC Control Dampers
   1. Model: CD60 as manufactured by Ruskin Company or equal.
   2. Ratings:
      a. Leakage: Damper shall have a maximum leakage of three cubic feet per minute/square. feet at one inch water gauge and shall be AMCA licensed as Class 1A.
      b. Size: Damper widths from 12 inches (305 mm) to 60 inches (1524 mm) meeting Class 1A as scheduled or required.
      c. Differential Pressure: Damper shall have a maximum differential pressure rating of 13 inch w.g. (3.2 kPa) for a 12 inches (305 mm) blade.
      d. Velocity: Damper shall have a maximum velocity rating of 6,000 fpm (1,829 m/min).

e. Temperature: Damper shall be rated for -72 to 275 degrees F (-58 to 135 degrees C) or as required for its intended application (ie. smoke rated, high temperature rated, fire rated, etc.)

3. Construction:
   a. Frame: five inches x minimum 16 gage (127 x minimum 1.6 mm) roll formed, galvanized steel hat-shaped channel, reinforced at corners. Structurally equivalent to 13 gage (2.3 mm) U-channel.
   b. Blades:
      1) Style: Airfoil-shaped, single-piece.
      2) Action: Parallel.
      3) Action: Opposed.
      4) Orientation: Horizontal.
      5) Orientation: Vertical with thrust washers.
      6) Material: Minimum 14 gage (2.0 mm) equivalent thickness, galvanized steel.
      7) Width: Nominal six inches (152 mm).
   c. Bearings: Self-lubricating stainless steel sleeve, turning in extruded hole in frame.
   d. Seals:
      1) Blade: Extruded Ruskiprene TPV type for ultra-low leakage from -76 to 350 degrees F (-60 to 177 degrees C). Mechanically attached to blade edge.
      2) Jamb: Flexible metal compression type.
   e. Linkage: Concealed in frame.
   f. Axles: Minimum 1/2 inches (13 mm) diameter plated steel, hex-shaped, mechanically attached to blade.
   g. Mounting: Vertical.
   h. Mounting: Horizontal.
   i. Finish: Mill galvanized.
   j. Finish: Stainless steel.

S. Meters: Meters shall be provided to monitor and trend the energy consumed by the HVAC (heating, cooling, ventilation, fans) and Hot water (Heating and Domestic), and Chilled serving the building. Provide the following meters (or connection to meters) and network these devices into the Building Management System.
   1. Provide hydronic BTU Energy Meters (Ultrasonic, strap on type flow meters and temperature sensors) with BACnet IP protocol BMS integration for the following systems. Hydronic system energy data obtained from meters and sensors shall be input to the building automation system for calculating, trending and storing energy consumption information of the following systems:
      a. Heating Hot Water **and** Chilled Water
      b. Cold Water Make-Up (Building Water Use)
   2. Provide all necessary components and accessories required for connection to main electrical main buildingmeters and building sub-meters. Meters shall be provided by Section 26 00 01 and shall be BACnet IP compatible. Refer to Electrical Drawings for meter location.
   3. The energy consumption data obtained from all the meters shall be stored by the building automation system which shall export this data in real-time fashion to an energy dashboard software program, similar to" Building Dashboard" by Lucid Design Group Inc. or equal, which shall be provided by the ATC Sub-Contractor for public viewing on a digital kiosk by I&E or equal.
   4. The ATC Sub-Contractor shall provide and program a digital interactive kiosk which shall display building graphics, energy consumption meters, HVAC equipment, outdoor air temperature, humidity, wind speed, wind direction, and barometric pressure. Provide 60 inch LCD screen model podium HD manufactured by Industrial Computing Products from I&E or equal. Provide all necessary programming wiring and software for a complete and functional interactive kiosk. The following items shall also be displayed at the public Kiosk and at the BMS operator workstation:
      a. Hourly forecast from NOAA and USNO including temperate, apparent temperature, relative humidity, dew point, wind speed, wind direction, precipitation probability for the next 24 hours in one-hour increments.

b. Weather alert information such as “air stagnation advisor”, “brisk wind advisory” with alert status, description, effective date, expiration date, category, certainty, severity and urgency.
c. Provide 7-day forecast with daily weather conditions, high temp, low temp, relative humidity high/ low, and precipitation probability.

5. Domestic hot water consumption shall be determined and calculated by the ATC Sub-contractor. Relays shall be installed on the domestic water heater burner to calculate usage. ATC SubContractor shall provide relays and programming required to achieve consumption.
6. DOMESTIC WATER SUB-METER
   a. MA Approved BACnet IP compatible Domestic water meters shall be furnished and installed by Plumbing Sub Contractor.
   b. All BACnet IP control wiring shall be by ATC Sub-Contractor.

T. Miscellaneous Devices
1. Thermostats (Stand-alone electric type - only where specified or indicated on drawings)
   a. Room thermostats shall be of the gradual acting type with adjustable sensitivity.
   b. They shall have a bi-metal sensing element capable of responding to a temperature change of one-tenth of one degree. (Provide all thermostats with limit stops to limit adjustments as required.)
   c. Thermostats shall be arranged for either horizontal or vertical mounting.
   d. In the vertical position thermostat shall fit on a mullion of movable partitions without overlap.
   e. Mount the thermostat covers with tamper-proof socket head screws.
2. Freezestats:
   a. Install freezestats on each coil that mixes outside and return air (air handling units, fan coils, unit ventilators) and provide protection for every square foot of coil surface area with one linear foot of element per square foot of coil.
      1) Upon detection of low temperature, the freezestats shall stop the associated supply fans and return the automatic dampers to their normal position close outside air dampers and open coil valve for full flow. Freezestats shall be auto reset type.
3. Firestats:
   a. Provide manual reset, fixed temperature line voltage type with a bi-metal actuated switch.
      1) Switch shall have adequate rating for required load.
4. Electronic Airflow Measurement Stations and Transmitters (Where indicated on Control Drawings).
   a. Provide air flow monitoring stations as shown on drawings.
   b. Duct and Plenum Mounted Air Flow Measuring Stations.
      1) Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube. Sensor probe mounting brackets shall be constructed of 304 stainless steel.
      2) Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy with sensor housing constructed of glass-filled polypropylene.
      3) Sensor nodes shall operate from -20 to 160 degrees Fahrenheit. Sensor nodes shall be capable of reading velocity on a scale of 0-5,000 fpm with an accuracy of plus/minus 2percent of actual reading.
      4) A remotely located microprocessor-based transmitter shall be provided for each measurement location, local readout shall be provided on unit. The transmitter shall be provided with two field selectable analog outputs (0-10 VDC or 4-20 mA) as well as an isolated RS-485 BACnet network connection.
      5) Provide Ebtron GTx116-P+ or Paragon FE-ten00.
   c. Fan Inlet Style Air Flow Measuring Stations
      1) Provide fan inlet and outdoor airflow measuring devices for air handling units as shown on drawings. Each airflow measuring device shall consist of multiple measuring probes.
      2) Fan inlet probes shall not be mounted in the smallest diameter of the inlet of the fan, the probes shall not have a negative effect on the performance of the fan or the noise generated by the fan. In instances where access to the air handling units’ fans is restricted utilize duct mounted airflow measuring probes. A remotely located microprocessor-based transmitter shall be provided for each measurement location,

local readout shall be provided on unit. The transmitter shall be provided with two field selectable analog outputs (0-10 VDC or 4-20 mA) as well as an isolated RS-485 BACnet network connection.

3) ATC Subcontractor shall consult factory trained manufacturer's representative as part of this contract to assist in design and to inspect all outside air measurement installations and assist in calibrating and adjusting the air flow measuring stations as required to meet final balancing setting to provide accurate BMS monitoring and control.
4) Provide Ebtron GTx108-F or Paragon Model FE-1050.

5. Current Sensing Relay:
   a. Provide solid-state, adjustable, current operated relay. Provide a relay which changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.
   b. Adjust the relay switch point so that the relay responds to motor operation under load as an "on" state and so that the relay responds to an unloaded running motor as an "off" state. A motor with a broken belt is considered an unloaded motor.
   c. Provide for status device for all fans and pumps.

U. UNINTERRUPTIBLE POWER SUPPLY
   1. Provide uninterruptible power supply (UPS) for each Field Supervisory Controller.
   2. UPS shall have sufficient temporary backup power capacity and duration to allow for equipment to safely and correctly shut down. Follow all power ratings and load requirement limitations for best results.
   3. Features:
      a. 550 VA/330 W UPS output
      b. Full-time surge protection and battery backup
      c. Compact form factor Eight outlets with USB port and registered jack (RJ11) protection
      d. Electromagnetic interference (EMI) or radio frequency interference (RFI) filters
      e. Vented cabinet 10 A circuit breaker
      f. NEMA type 1 enclosure
      g. 120 V receptacle with dual outlets
      h. Terminal block connections
   4. Manufacturer/Model: Provide similar to Johnson Controls UPSPNL500 or equal, meeting above specification requirements.

V. Building Energy Dashboard
   1. The building energy dashboard will showcase the schools commitment to energy conservation, raise the profile of the facility by highlighting energy savings, and educate the students on energy efficient systems and building energy consumption. ATC Subcontractor to provide the necessary software, hardware and engineering to develop the building energy dashboard.
   2. 3D application programming interface
      a. Furnish, setup, configure and install one API device.
      b. The device shall be installed directly to the schools Controls automation system network. It shall be an embedded appliance and use a robust BACnet protocol. The device will automatically scan the Controls network finding all devices and trend logs. the device shall have enough memory to store ten00 trend-logs for a period of five years.
   3. Scope of work
      a. Custom theme – custom theme for building energy dashboard.
      b. Custom sensors – custom dashboard screens for requirements of this project.
      c. Screen reader support – implement support for screen reading applications
      d. Green fact copywriting – generate content for Green Fact screens.
      e. Deployment – install and confiture software for project specific components.
   4. Deliverables
      a. Custom theme
         1) Create a custom building dashboard theme for use at the site, based on project specific requirements and feedback from owner/architect. Provide sample graphic screens.
      b. Custom Screens
         1) Resource Homepage:

a) For a selected resource, list all meter groups of this type. E.g. when water is selected, show HW, CHW, DCW, DHW, and Field Irrigation. For each meter group:
   a. Show a gauge with the current day's min demand, max demand, and live demand value.
   b. Show a spark chart of the current day's consumption values.
   c. Allow users to drill down to the Resource Breakdown page for a single meter group
b) Green Fact – Homepage
   a. List all green facts as tiles
   b. Show a thumbnail of the green facts image, green fact title and link to open the green fact
c) Green Fact - System Homepage
   a. Show standard green fact information (title, description, and image) about this system (hot water, chilled water, etc)
   b. When applicable, show a breakdown of the last seven days of consumption by the sub-meters for the selected resource/system as a pie chart (e.g. for Mechanical Electricity, show pumps chillers, AHUs and RTUs)
d) Green Fact – Resource Harvesting/Production
   a. Show standard green fact information (title, description, and image) about this green initiative.
   b. Allow the administrator to specify one or more consumption meter groups, and one or more production meter groups.
   c. Allow the administrator to specify the resource type.
   d. Compare resource consumption and harvesting/production for the last 7 days – for example, gallons of water consumed versus gallons of water harvested using the green roof.
   e. Show a comparison of the harvested/produced value in other units based on the resource type – for example, bottles of water, swimming pools, etc.
e) Green Fact – Occupant Activity
   a. Educate the building occupants - how to save resources based on their actions in the building.
   b. Allow the administrator to specify content for the screen.
   c. Show a prediction of daily energy usage for a month, based on the values set in the BMS.
   d. Show the additional consumption or potential savings in the chart, as well as in a summary at the bottom of the screen.
   e. The data model used for prediction will not be editable within Dashboard.

c. Screen Reader Support
   1) Add support to building energy dashboard for screen reading.
   2) For each building energy dashboard screen, add the necessary HTML tags and adjust the content order so that screen reading works properly.
d. Green Fact Copywriting
   1) Using data provided by the Contract Documents with specific details about the equipment and installation at the site, generate green fact content for the following systems:
      a) Hot water plant
      b) Chilled water
      c) Domestic hot water
      d) Domestic cold water
      e) Field Irrigation
      f) Building Electricity
      g) Hot Water Pumps
      h) Chilled Water Pumps
      i) Heat Pump Chiller Plant
      j) Energy recovery Units
      k) Air Handling Units
      l) Lighting Control System

e. Deployment
   1) Install building energy dashboard on the site with DDC server.
   2) Create and configure all energy meters, including virtual meters, as described in Meter Summary.
   3) Create and configure all Building Energy Dashboard screens.
   4) Create and configure dashboard instances for the slideshows and for the touch screen kiosk

5. Meter Summary
   a. Refer to HVAC control drawings for additional metering requirements.
   b. To provide a simple to use interface, the meters on site will be grouped as described in the following table. As per Design Mockups, the main navigation will list each resource type, selecting a resource type will list the grouped meters for that resource, and green facts will further breakdown the individual meters for a grouped meter.
      1) Electricity
         a) Building – total meter
         b) Mechanical – summation of chillers, ERUs and RTUs
         c) Submeters
      2) Water
         a) Domestic cold water
         b) Field irrigation
      3) Thermal
         a) Hot water system
         b) Chilled and Compensated Chilled water system
         c) Domestic (cold) water
         d) Domestic hot water
   c. Meter

System	Meter Type	Meter Furnished	Notes
Hot Water Plant	Physical	Yes ATC	
Chilled Water Plant	Physical	Yes ATC	
Domestic Hot Water	Physical	Division 22	
Domestic Cold Water	Physical	Division 22	
Field Irrigation	Physical	No Division 22	
Building Electricity and Building Submeters	Physical	Section 260001	
Hot Water Pumps	Via VFD	HVAC/ATC	
Chilled Water Pumps	Via VFD	HVAC/ATC	
RTU/Air Handling Units	Via VFD	HVAC/ATC	
Lighting Control System	Physical	Section 260001	BACnetIP integration

W. VARIABLE FREQUENCY DRIVES (Note: VFD's provided by ATC Sub-contractor)
1. Section Includes: Variable Frequency Drives (VFD).
2. Related Sections: Section 26 00 01-Electrical.
3. References:
   a. NEMA ICS 3.1: Safety Standards for Construction and Guide for Selection, Installation and Operation of Variable Frequency Drive Systems.
   b. NEMA 250- Enclosures for Electrical Equipment (ten00 Volts Maximum).
   c. UK, UL, and cUL approved.
   d. IEEE Standard 444 (ANSI-C343)
   e. IEEE Standard 519-1992
   f. EC: 146A
   g. IL 508C (Power Conversion)
   h. CSA 22.2 No. 14-95 (Industrial Control Equipment)
   i. UL 1995 (Plenum rating)
   j. EN 50178 (LVD)

k. EN 61800-3, 6ten00-3-12, A11 (2,000) (Category C2)
l. IEC 529
m. FCC CRF 47 Part 15 Subpart B
n. NEMA ICS 7.0

4. Submittals:
   a. Submit under provisions of Section 01 3 00 Administrative Requirements.
   b. Shop drawings shall include: Wiring diagrams, electrical schematics, front and side views of enclosures, overall dimensions, conduit entrance locations and requirement, nameplate legends, physical layout, enclosure details, and heat output.
   c. Product Data: Provide data sheets showing: voltage, ratings of customer use switching and over-current protective devices, short circuit ratings, and weights.
   d. Manufacturer's Installation Instructions and Technical Manuals: Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of adjustable speed drive. Document the sequence of operation, cautions and warnings, troubleshooting procedures, spare parts lists and programming guidance.
   e. Harmonic analysis for compliance with IEEE 519, shall be provided. Electrical Contractor shall provide transformer specs and one line diagram of the system to help the manufacturer complete the analysis.
   f. Tuning and deadband report, as necessary.
5. Quality Assurance: VFD shall have a minimum MTBF (mean time between failure) rating of 2eight years (245,280 hours).
6. Operations and Maintenance Data:
   a. Submit under provisions of Section 01 70 00.
   b. Include instructions for starting and operating VFD, and describe operating limits, which may result in hazardous or unsafe conditions.
7. Qualifications: Manufacturer must have a minimum of 2five years of documents experience, specializing in variable frequency drives.
8. Delivery, Storage, and Handling:
   a. Deliver, store, protect and handle products to site, under provisions of Division 01.
   b. Accept VFD on site in original packing. Inspect for damage.
   c. Store in a clean, dry space. Maintain factory wrapping, or provide an additional heavy canvas or heavy plastic cover, to protect units from dirt, water, dust, construction debris and traffic.
   d. Handle carefully, in accordance with manufacturer's written instructions, to avoid damage to components, enclosure and finish.
9. Warranty: Provide VFD warranty, for three years parts and labor from date of startup. Warranty shall include parts, and labor allowance for repair hours.
10. Manufacturers:
    a. VFD shall be manufactured by Danfoss, Toshiba, ABB, Eaton, or equal.
    b. All drives shall be by the same manufacturer. Motors shall be inverter duty rated, per NEMA MG1 parts 30 and 31, for motor-drive compatibility.
    c. Manufacturer shall provide start-up service.
11. Description: Provide enclosed variable frequency drives suitable for operation at the current, voltage, and horsepower indicated on the schedule. Conform to requirements of NEMA ICS 3.1
12. Ratings:
    a. A VFD must operate, without fault or failure, when voltage varies plus ten percent or minus 15 percent from rating, and frequency varies plus or minus 5 percent from rating.
    b. VFD shall be 480 or 208 volts, 60 Hz, 3 phase.
    c. Displacement Power Factor: 0.98 over entire range of operating speed and load.
    d. Operating Ambient Temperature: -10 degrees Celsius, to 40 degrees Celsius (14 degrees Fahrenheit to 104 degrees Fahrenheit).
    e. Humidity: 0 percent to 95 percent non-condensing.
    f. Altitude: to 3,300 feet, higher altitudes achieved by derating.
    g. Minimum Efficiency: 96 percent at half speed; 98 percent at full speed.
    h. Starting Torque: ten0 percent staring torque shall be available from 0.5 Hz to 60 Hz.

i. Overload Capability: 1ten percent of rated FLA (full load amps) for 60 seconds; 180 percent of rated FLA instantaneously.
j. The VFD must meet the requirements for Radio Frequency Interference (RFI) above 7 MHz as specified by FCC regulations, Part 15, Subpart J, Class A devices.
k. Total Harmonic Distortion (THD) Compliance: Given the information provided by the customer's electric power single line diagram and distribution transformer data, the VFD manufacturer shall carry out an analysis of the system. The analysis reviews the potential for the proposed equipment and any existing equipment, to meet IEEE 519 (tables 10.2 and 10.3) recommendations at the Point of Common Coupling (PCC). F the results determine that additional power quality measures are required, these measures shall be provided at no additional cost.
l. VFD's must have a minimum short circuit rating of 65K amps RMS (ten0K amps RMS with a DC bus reactor) without additional input fusing.

13. Design:
    a. A VFD shall employ microprocessor based inverter logic, isolated from all power circuits.
    b. VFD shall include surface mount technology with protective coating.
    c. VFD shall employ a PWM (Pulse Width Modulated) power electronic system, consisting of:
        1) Input Section:
        2) VFD input power stage shall convert three-phase AC line power into a fixed DC voltage via a solid state full wave diode rectifier, with MOV (Metal Oxide Varistor) surge protection.
        3) Intermediate Section:
        4) Dc bus as a supply to the VFD output section shall maintain a fixed voltage with filtering and short circuit protection.
        5) DC bus shall be interfaced with the VFD diagnostic logic circuit, for continuous monitoring and protection of the power components.
        6) 5 HP to 150 HP at 208 VAC, and 5 HP to 500 HP 480 VAC, VFD's shall include a DC bus reactor to minimize reflected harmonics.
        7) Output Section:
        8) Insulated Gate Bipolar Transistors (IGBT's) shall convert DC bus voltage to variable frequency and voltage.
        9) The VFD shall employ PWM sine coded output technology to power the motor.
    d. The VFD must be selected for operation at carrier frequencies at or above 5 kHz without derating to satisfy the conditions for current, voltage, and horse power as indicated on the equipment schedule. Exception to this requirement is allowed only for VFDs providing 506 amps or more.
    e. The VFD shall have an adjustable carrier frequency. The carrier frequency shall have a minimum of six settings to allow adjustment in the field.
    f. VFD shall have embedded BTL tested Building Automation System (BAS) protocols for network communications; BACnetIP. These protocols shall be accessible via a RS 422/485 communication port.
    g. VFD shall have a quick disconnect, removable control I/O terminal block to simplify control wiring procedures.
    h. VFD shall include two independent analog inputs. One shall be 0-10 VDC. The other shall be programmable for either 0-ten VDC or 4-20 mA. Either input shall respond to a programmable bias and gain
    i. VFD shall include a minimum of seven multi- function digital input terminals, capable of being programmed to determine the function on a change of state. These terminals shall provide up to 30 functions, including, but not limited to:
        1) Remote/local operation selection
        2) Detection of external fault condition
        3) Remote reset
        4) Multi-step speed commands
        5) Run permissive
        6) Floating control

j. VFD shall include two 0-10 VDC or 4-20 mA analog output for monitoring, or “speed tracking” the VFD. The analog output signal will be proportional to output frequency, output current, output power, PI (Proportional & Integral control) feedback or DC bus voltage.
k. VFD shall provide terminals for remote input contact closure, to allow starting in the automatic mode.
l. VFD shall include at least one external fault input, which shall be programmable for a normally open or normally closed contact. These terminals can be used for connection of firestats, freezestats, high pressure limits or similar safety devices.
m. VFD shall include two form “A” contacts and on form “C” contact, capable of being programmed to determine conditions that must be met in order for them to change state. These output relay contacts shall be rated for at least 5A at 120 VAC and shall provide up to 18 functions, including, but not limited to:
    1) Speed agree detection
    2) Low and high frequency detection
    3) Missing frequency reference detection
    4) Overtorque/undertorque detection
    5) Drive running
    6) Drive faulted
n. VFD shall include a power loss ride through of 2 seconds.
o. VFD shall have DC injection braking capability, to prevent fan “wind milling” at start or stop, adjustable, current limited.
p. VFD shall have a motor preheat function to prevent moisture accumulation in an idle motor.
q. VFD shall include diagnostic fault indication in selected language, last 10 faults storage and heatsink cooling fan operating hours.
r. VFD shall have a digital operator with program copy and storage functions to simplify set up of multiple drives. The digital operator shall be interchangeable for all drive ratings.
s. VFD shall include a front mounted, sealed keypad operator, with an English language (or one of 6 additional international languages) illuminated LCD display. The operator will provide compete programming, program copying, operating, monitoring, and diagnostic capability. Keys provided shall include industry standard commands for Hand, Off and Auto functions.
t. VFD plain language display shall provide readouts of: output frequency in hertz, PI feedback in percent, output voltage in volts, output current in amps, output power in kilowatts, DC bus voltage in volts, interface terminal status, heatsink temperature and fault conditions. All displays shall be viewed in an easy-to-read illuminated LCD with International language selectablility.
u. VFD unit shall include the following meters to estimate use of energy and shall be accessible via VFD keypad.
    1) Elapsed Time Meter
    2) Kilowatt Meter
    3) Kilowatt Hour Meter
v. VFD shall include PI control logic, to provide closed loop set point control capability, from a feedback signal, eliminating the need for closed loop output signals from a building automation system. The PI controller shall have a differential feedback capability for closed loop control of fans and pumps for pressure, flow or temperature regulation in response to dual feedback signals.
w. VFD shall include loss of input signal protection, with a selectable response strategy including speed default to a percent of the most recent speed.
x. VFD shall include electronic thermal overload protection for both the drive and motor. The electronic thermal motor overload shall be approved by UL. If the electronic thermal motor overload is not approved by UL, a separate UL approved thermal overload relay shall be provided in the CFD enclosure.
y. VFD shall include the following program functions:
    1) Critical frequency rejection capability: three selectable, adjustable deadbands.
    2) Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.
    3) Ability to close fault contact after the completion of all fault restart attempts.
    4) Stall prevention capability.

5) "S" curve soft start capability.
6) Bi-directional "Speed Search" capability, in order to start a rotating load.
7) 14 preset and one custom volt per hertz pattern.
8) Heatsink over temperature speed fold back capability.
9) Terminal status indication.
10) Program copy and storage in a removable digital operator.
11) Current limit adjustment capability, from 30 percent to 200 percent of rated full load current of the VFD.
12) Motor pre-heat capability.
13) Input signal or serial communication loss detection and response strategy.
14) Anti "wind-milling" function capability.
15) Automatic energy saving function.
16) Undertorque/Overtorque detection
17) Preset speeds

z. VFD shall include factory settings for all parameters, and the capability for those settings to be reset.
aa. VFD shall include user parameter initialization capability to re-establish project specific parameters.
bb. VFD shall include the capability to adjust the following functions, while the VFD is running:
1) Speed command input
2) Acceleration adjustment from 0 to 6000 seconds.
3) Deceleration adjustment from 0 to 6000 seconds.
4) Select from five preset speeds.
5) Analog monitor display
6) Removal of digital operator
cc. Provide a built in timer clock. The clock shall have a battery back-up with minimum ten years life span.

14. Additional Product Features to be Provided:
a. Two contactor manual bypass shall be provided. VFD and by pass components shall be mounted inside a common NEMA 1 enclosure, fully pre-wired, and ready for installation as a single UL listed device. Bypass shall include the following:
1) Input service switch for the drive, output, and bypass contactors, to disconnect power to the VFD, when the motor is running in the bypass mode.
2) 120 VAC control transformer, with fused primary.
3) Magnetic overload relay, to protect the motor while operating in the bypass mode.
4) Circuit breaker or fused disconnect switch, with a pad-lockable through-the-door handle mechanism, that will disconnect all input power to the drive.
5) Control and safety circuit terminal strip.
6) Drive/bypass selector switch. Hand/OFF/Auto selector switch, Normal/Test selector switch.
7) Switch selectable smoke purge, auto transfer to bypass and remote transfer functions.
8) Pilot lights for Control Power, Drive Ready, Drive Run, Drive Selected, Drive Fault, Drive Run, Drive Test, Bypass Selected, Bypass Run. Motor OL, Safety Fault, Damper Closed, Auto Run, Auto Transfer and Smoke Purge.
9) Normal/test selector switch, shall allow testing and adjustment of the VFD, while the motor is running in the bypass mode.
10) Hand Off/ Auto selector switch shall provide the following operation:
11) Hand Position: The drive is given a start command, operation is via the local speed input (digital operator or speed pot). If in bypass mode, the motor is running.
12) Off Position: The start command is removed, all speed inputs are ignored, power is stilled applied to the drive. If in bypass mode, the motor is stopped.
13) Auto Position: the drive is enabled to receive a start command and speed input from a building automation system. If in bypass mode, the motor start/stop is controlled by the building automation system.
14) Annunciation contacts for drive run, drive fault, bypass run and motor OL/safety fault.
15) Damper control circuit with end of travel feedback capability.
16) VFD operator/keypad, LCD type.

a) Manual bypass switch shall force motor to start and run at full speed in event of LCD keypad failure

17) H/O/A/ control panel section, touch pad or rotary switch types.
18) VFD circuit breaker shall be provided only for the VFD without affecting the bypass. Service switch to protect drive from bypass mode voltage.

b. Soft start on transfer to bypass shall be provided for motors 50 HP and above.
c. Enclosure:
   1) NEMA 1 extended enclosure, to house additional equipment within the VFD enclosure for VFD's not requiring bypass, for dry, clean interior installation.
   2) NEMA 1 FVFF (Forced Ventilation Inlet Filter and Outlet Filter) enclosures with filters and blower for AHU service vestibules.
   3) NEMA 3 R enclosures for outdoor installations; include alternate sun shade.
d. Oversized control transformer shall be provided to power customer supplied logic circuits.
e. RFI (Radio Frequency Interference) filters to further attenuate possible VFD generated noises shall be provided. VFD shall meet the requirements RFI above 7MHZ as specified by FCC regulations. Part 15, Subpart J, Class A devices.
f. Current limiting input fusing or DC bus fuse and MDV's for short circuit protection of VFD semiconductor devices shall be provided.
g. Line reactors (2.5 percent minute) shall be provided on the input side of the drive for harmonic suppression.
h. Output reactors (2.5 percent minute) shall be provided on the output side of the drive for motor protection in long motor lead length (above 300 feet) situations. Output motor protection (dv/dt) filter shall be provided to accomplish, long motor lead length solutions.
i. DC bus reactor, to attenuate harmonic distortion shall be provided on: 20 HP and below at 208 VAC, and 30 HP and below at 480 VAC.
j. 6 Pulse VFD's shall be provided on five HP to 20 HP at 208 VAC, and 5 HP to 30 HP at 480 VAC models to minimize THD generated by the VFD.
k. 12 pulse phase shifting transformer shall be provided on: 25 HP to 150 HP at 208 VAC, and 40 HP to 500 HP at 480 VAC models to minimize THD generated by the VFD.
l. Analog output (4-20 mA), shall be provided to make available two analog current outputs.
m. Serial communication shall be provided via an isolated RS-422/485 circuit board with the following features:
   1) Command and monitor in excess of 64 points.
   2) Ability to integrate into BYPASS configuration without losing end switch and/or safety interlock functionality.
   3) Serial communication board self test.
   4) Drive parameter storage within communication board.
   5) Drive parameter download capability.
   6) Drive parameter comparison feature.
   7) 5 indication LED's to indicate power, reception, transmission, fault and service of serial communications (Power, Rxd, Txd, Fault, Service).
   8) Polarity insensitive.
   9) Network connection through RJ-45J plug/jack.
n. Remote digital operator, with keypad and display, to control and monitor the VFD from a remote location shall be provided.
o. H/O/A/ selector switch shall be provided in addition to the digital keypad operation selection capabilities.
p. Local/remote selector switch shall be provided in addition to the digital keypad operation selection capabilities.
q. Analog meter shall be provided in addition to the digital keypad monitoring capabilities.
r. Relays, motor overload or time delay shall be provided.
s. PC software and cable for parameter upload/download/ graphing shall be provided.
t. VFD Input MCP circuit breaker or fused disconnect shall be provided.
u. VFD bypass manual disconnect shall be provided.
v. Engraved cabinet nameplates shall be provided.
w. Provide a fireman's override input. Upon receipt of a contact closure preset signal from fireman's control station, the CGD shall operate at an adjustable preset speed. This mode

shall override all other inputs. Override mode shall be displayed on the key pad. VFD shall resume normal operation upon removal of the signal.

15. Communication capacity
    a. Built in Communication capability for interface with (BACnet/IP) BTL tested BMS integration.
    b. Provide manufacturer certified installation and start-up resulting in 39 month parts and labor warranty.
16. Fabrication: All standard and optional features shall be included in a single NEMA 1, 12 or 3R, plenum rated enclosure with a UL certification label.
17. Source Quality Control:
    a. In circuit testing of all printed circuit boards shall be conducted, to insure proper mounting and correct value of all components.
    b. Final printed circuit board assemblies shall be functionally tested, via computerized test equipment. All tests and acceptance criteria shall be preprogrammed. All test results shall be stored as detailed quality assurance data.
    c. All fully assembled controls shall be functionally tested, with fully loaded induction motors. The combined test data shall then be analyzed, to insure adherence to quality assurance specifications.
    d. Inspect and production test, under load, each completed VFD assembly.
18. Examination:
    a. Verify that surface is suitable for VFD installation.
    b. Do not install VFD until the building environment can be maintained, within the service conditions required by the manufacturer.
19. Installation:
    a. Install VFD where indicated, in accordance with manufacturer's written instructions and NEMA ICS 3. Verify compliance with NEC Section 70 for panelboard clearance.
    b. Tighten accessible connections and mechanical fasteners after placing VFD.
    c. Provide a nameplate label on each VFD, identifying rated horsepower, full load amperes, model number, service factor and voltage/phase rating.
20. Field Quality Control:
    a. Field inspection and testing to be performed under provisions of Section 014000.
    b. Inspect completed installation for physical damage, proper alignment, anchorage and grounding.
21. Manufacturer's Field Services:
    a. The manufacturer's representative shall provide start up services and a verification report that all systems are operational and comply with the intent of the specifications.
    b. The VFD manufacturer shall conduct on site harmonic measurements before and after start up of the VFD's. Results of the measurements, showing harmonic contribution of the VFDs shall be provided to the Engineer one month after start up.
22. Adjusting: Carry out adjusting work under provisions of Division 01. Make final adjustments to installed. VFD, to assure proper and quiet operation of HVAC systems. VFD vendor to tune out excessive noise/vibration frequencies creating a deadband. Submit report to Engineer of these frequencies.

X. City Energy Management System Integration
1. The ATC/BMS Contractor shall integrate the Pickering School ATC/BMS system into the City-Wide EMS system that is currently manufactured and maintained by Trane.
2. It is mandatory that any ATC Subcontractor bidders shall completely familiarize themselves with the existing City Wide EMS hardware and software so that the integration of the ATC/BMS installed at the Wildwood School communicates to the City EMS in a standardized and seamless fashion. The ATC Subcontractor shall submit for approval, a detailed integration plan/checklist detailing the steps that will be taken to meet this requirement. The ATC Subcontractor shall coordinate with the Wilmington Facilities and IT (Information Technology) departments as required to install and incorporate any required new network equipment and components. Arrangements to view the existing system must be made by contacting the Project Construction Manager or Owner's Project Manager.
3. The ATC Subcontractor shall familiarize his/her self with operator interface features and functions so that graphical representations and operator control and monitoring functions are fully integrated into the local and global representations and functions currently standardized

and employed by the Wilmington Facilities department. Development of the graphics and interfaces shall be programmed and tested off line. The ATC Subcontractor shall then review with and obtain approval from Wilmington Facilities department for the complete graphical operator interface for the Pickering School ATC/BMS system before incorporating it into the city wide system.

4. Specifically, the graphics are generated using scalable vectors. For ease of operator use, terminal unit graphics shall use indirect I/O so that one graphic screen can be directed to look at any number of terminal devices. Graphics shall incorporate Owner's standard colors, representations and point viewing/monitoring/control capabilities.
5. All Pickering School hardware points shall be incorporated into the following features of Control Suite.: Alarm Management, Scheduling, Overrides and Trending as indicated below and here within these specifications.
6. Alarm Management – Local: All points scheduled to be alarmed shall be incorporated into the Wilmington Alarm Management System. All points will be programmed by the ATC Subcontractor to present to the Wilmington Energy department personnel, standard alarm notifications based on the point status. Standard point alarm conditions are:
   a. Low Alarm
   b. Low Low Alarm
   c. Hi Alarm
   d. Hi Hi Alarm
   e. Rate of Change Alarm
   f. Major Deviation Alarm (e.g. wrong command state, etc.)
7. Alarm Management - Remote Notification:
   a. Remote alarming shall be accomplished through the use of the existing city telephony, pager, text messaging and email messaging software systems.
   b. Alarms shall be sent to any combination of telephones, cell phones, two-way radios, pagers, emails, etc.
   c. Restricted logins based on the caller's phone number
   d. Restricted access if no caller ID presented
   e. Hacker detection.
8. The EMS system shall be programmed to contact Wilmington Facility Staff as directed by the Owner's Facility Staff during programming.
9. The selection of alarm points to utilize this remote alarming system shall be at the sole discretion of the Wilmington Facilities department personnel. The ATC Subcontractor shall properly program and incorporate the selected points into City EMS.
10. Scheduling: All equipment monitored and controlled by the City ems shall be programmed by the ATC Subcontractor to operate per the schedules noted in the sequence of operations. Additionally, all schedules shall be incorporated into the Wilmington Schedule Management System. This includes:
    a. Global Override System (Snow Days, Holidays, Set Points etc.)
    b. Customized Global Schedule (Schedules established for multiple schools with one function)
    c. Customized Individual Schedules (By building and equipment)
11. Overrides: All points scheduled to have override capability shall be incorporated by the ATC Subcontractor into the Wilmington Override Management System. Features include:
    a. Individual override of schedule
    b. Individual override of setpoint
    c. Global override of schedule
    d. Global override of setpoint
    e. Selected override of schedule in one function
    f. Selected override of setpoint in one function
    g. All overrides shall be selected to be overridden permanently or for a specified period of time. All overrides shall be incorporated into the BPS Pre Scheduled Override system allowing any override(s) to be preprogrammed to occur at a future date.

12. Trending
    a. All points scheduled to be trended shall be incorporated into the City EMS system database. The ATC Subcontractor shall develop standardized reports as requested by the Wilmington Facilities Department personnel. These reports shall be provided in a City's preferred software format and must include requested trending, alarm totalization, runtime totalization, interpolated time series reports of analog values and target vs actual data comparisons.

Y. Manufacturers: The City has elected that the ATC/BMS system shall be a proprietary system as manufactured by:
   1. Trane
   2. Or equal

PART 3 - EXECUTION

3.01 CUTTING AND PATCHING

A. Penetrations through construction as required for the Work of this Section:
   1. Coring: Perform all coring for required work.
   2. Notify Masonry Sub-Contractor of exact locations and sizes for openings required in masonry, to be executed under Section 042000 – Unit Masonry, utilizing lintels furnished per Section 055000 – Metal Fabrications.
   3. Cut openings in new and existing non-masonry construction where required for penetrations. All cutting shall conform to the requirements of Section 017300 – Execution, 024116 – Structure Demolition, and 024119 – Selective Demolition.
   4. Refer to Section 024116 – Structure Demolition and 024119 – Selective Demolition for restrictions on all alterations to structural elements.

B. Patching at penetrations through construction for the Work of this Section:
   1. Notify Masonry Sub-Contractor when plumbing work is complete at penetrations through masonry construction, and ready for patching under Section 042000 – Unit Masonry.
   2. Notify appropriate Sub-Contractors when plumbing work is complete at penetrations through non-masonry construction, and ready for patching under Sections in Division 09 - FINISHES.

3.02 INSTALLATION OF VALVES

A. Examine valve interior through the end ports, for cleanliness, freedom from foreign matter and corrosion. Remove special packing materials, such as blocks used which prevents disc movement during shipping and handling.

B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the position in which it was shipped.

C. Examine threads on both the valve and the mating pipe for form (out-of-round or local indentation) and cleanliness.

D. Examine mating flange faces for conditions which might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size and material, and for freedom from defects and damage.

E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

F. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select valves with the following ends or types of pipe/tube connections:
   1. Copper Tube two inch and smaller (Heating Hot Water): Solder ends.
   2. Steel Pipe Sizes two inch and smaller: Threaded or grooved-end.
   3. Steel Pipes Sizes 2-1/2 inch and larger: Grooved-end or welded.

G. Valve Installation
   1. Locate valves for easy access and provide separate support where necessary.
   2. Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.
   3. Install valves in horizontal piping with the stem at or above the center of the pipe.
   4. Install isolation valves at all branch supply and return piping lines which serve more than two pieces of terminal heating equipment.
   5. Installation of Check Valves: Install for proper direction of flow as follows:
      a. Swing Check Valves: Install in horizontal position with hinge pin level.
      b. Wafer Check Valves: Install between two flanges in horizontal or vertical position.
      c. Lift Check Valves: Install in piping line with stem upright and plumb.

H. Threaded Connections
   1. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
   2. Align threads at point of assembly.
   3. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
   4. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

I. Flanged Connections
   1. Align flanges surfaces parallel.
   2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using a torque wrench.

J. Grooved Connections
   1. Installation shall be in accordance with the latest published instructions from the manufacturer.

K. Field Quality Control
   1. Testing: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks; replace valve if leak persists.

L. Adjusting and Cleaning
   1. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare to receive painting or insulation.

3.03 INSTALLATION OF METERS AND GAGES

A. Installation of Temperature Gages
   1. General: Install temperature gages in vertical upright position, and tilted so as to be easily read by observer standing on floor.
   2. Temperature Gage Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure Cap.

B. Installation of Pressure Gages
   1. General: Install pressure gages in piping tee with pressure gage located on pipe at most readable position.
   2. Pressure Gage Cocks: Install in piping tee with snubber. Install siphon for steam pressure gages.
   3. Pressure Gage Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

C. Installation of Flow Measuring Fittings
   1. General: Install flow measure fittings in piping systems located in accessible locations.

D. Adjusting and Cleaning
   1. Adjusting: Adjust faces of meters and gages to proper angle for best visibility.
   2. Cleaning: Clean windows of meters and gages and factory-finished surfaces. Replace cracked or broken windows; repair any scratched or marred surfaces with manufacturer's touch-up paint.

3.04 INSTALLATION OF HANGERS AND ATTACHMENTS

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.

B. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

C. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors, and other building structural attachments.

D. Prior to installation of hangers, supports, anchors, and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purposes of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified.
E. Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-58. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Where concrete with compressive strength less than 2500 pounds per square inch is indicated, install reinforcing bars through the openings at the tops of inserts.
F. Install hangers, supports, clamps, and attachments to support piping properly from building structure; comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacing complying with MSS SP-58. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.
    1. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.
    2. Prevent electrolysis in support of copper tubing by the use of hangers and supports which are copper plated, or by other recognized industry methods.
    3. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
    4. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
    5. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 Pressure Piping Codes are not exceeded.
    6. Insulated Piping: Comply with the following installation requirements:
        a. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.
        b. Shields: For pipe sizes up to and including four inch provide heavy gage shield at each hanger point.
        c. Saddles: For all pipe sizes over four inch provide saddle at each hanger point. Completely fill void in saddle with loose insulation.
G. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31, and to prevent transfer for lading and stresses to connected equipment.
H. Fabricate and install anchor by welding steel shapes, plates, and bars to piping and to structure. Comply with ANSI B31 and with AWS standards.
I. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
J. Anchor Spacing: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors to accommodate both expansion and contraction of piping.
K. Provide concrete housekeeping bases for all floor-mounted equipment. Size bases to extend minimum of four inch beyond equipment base in any direction; and four inch above finished floor elevation. Construct of reinforced concrete, roughen floor slab beneath base for bond, and provide steel rod anchors between floor and base. Locate anchor bolts using equipment manufacturer's templates. Chamfer top and edge corners.
L. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks mounted on steel stands.
M. Adjusting and Cleaning:
    1. Hanger Adjustment: Adjust hangers so as to distribute loads equally on attachments.

2. Support Adjustment: Provide grout under supports so as to bring piping and equipment to proper level and elevations.
3. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.05 INSTALLATION OF MECHANICAL IDENTIFICATION

A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces; install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

B. General: Install pipe markers of the following type on each system indicated to receive identification, and include arrows to show normal direction of flow:
   1. Plastic pipe markers, with application system. Install on pipe insulation segment where required for pipes.

C. Locate pipe markers and color bands as follows wherever piping is in or above occupied spaces or corridors, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
   1. Near each valve and control device.
   2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
   3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
   4. At access doors, manholes and similar access points which permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced intermediately at maximum spacing of 50 feet along each piping run, except reduce spacing to 25 feet in congested areas of piping and equipment.
   7. On piping above removable acoustical ceilings.

D. Valve Identification:
   1. General: Provide valve tag on every valve, cock, and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
   2. Mount valve schedule frames and schedules in machine rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.

E. Mechanical Equipment Identification:
   1. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of mechanical equipment and each operational device, as specified herein if not otherwise specified for each item or device.
   2. Lettering Size: Minimum 1/4 inch high lettering for name of unit where viewing distance is less than 2 feet - 0 inch, 1/2 inch high for distances up to 6 feet - 0 inch, and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.

F. Adjusting and Cleaning:
   1. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
   2. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.06 INSTALLATION OF MECHANICAL INSULATION

A. Installation of Piping Insulation:
   1. Insulation Omitted: Omit insulation on hot piping within radiation enclosures which serve the zone: hot water passing through the zone must be insulated or unit cabinets; on cold piping within unit cabinets provided piping is located over drain pan. (Couplings in mechanical grooved systems will be insulated.)
   2. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
   3. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance tests.

4. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
5. Clean and dry pipe surfaces prior to insulating. Butt installation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
6. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
7. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated. Do not cover calibrated balance valves until testing adjusting and balancing has been completed.
8. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.
9. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply three inch wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with three inch wide vapor barrier tape or band.

B. Installation of Ductwork Insulation:
1. General: Do not insulate ductwork until ductwork has been sealed successfully, pressure tested, and approved for application of insulation by engineer or commissioning agent. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its indented purpose.
2. Install insulation materials with smooth and even surfaces.
3. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
4. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.
5. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.
6. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.
7. Exterior Ductwork: Install insulation & weather proofing material per manufacturer’s recommendations. Material color/finish by architect.

C. Installation of Equipment Insulation:
1. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.
2. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.
3. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.
4. Do not apply insulation to equipment, breechings, or stacks while hot.
5. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.
6. Coat insulated surfaces with layers of insulating cement, troweled in workmanlike manner, leaving a smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.
7. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least two inch. Apply over vapor barrier where applicable.
8. Do not insulate heat pump manholes, handholes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruption of insulation.
9. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.

D. Protection and Replacement:
1. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

2. Protection; Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

3.07 INSTALLATION OF KITCHEN GREASE DUCT INSULATION

A. EXAMINATION
   1. Do not begin installation until substrates have been properly prepared.
   2. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
   3. Coordinate installation of the Thermal Ceramics FastDoor XL access door between sheet metal and insulation trades.

B. PREPARATION
   1. Remove dirt and dust from surfaces of openings and items penetrating rated floors and rated walls.

C. INSTALLATION
   1. Install FireMaster FastWrap XL or Pyroscat Duct Wrap XL in direct contact with the ductwork in accordance with manufacturer's instructions, applicable laboratory listings and building code reports, and referenced standards. For additional complex duct design installation recommendations, see the Thermal Ceramics' complete installation guide.
   2. Install two layers of FireMaster FastWrap XL or Pyroscat Duct Wrap XL for zero clearance and a one and two hour commercial kitchen grease duct applications per ASTM E 2336.
      a. General Installation Instructions for Double Layer Installations: The inside and outside layers of FireMaster or Pyroscat blankets are cut to a length that will fit around the duct and meet with a tight butt joint. Adjacent blankets on the inside and outside layers are tightly butted against each other. Joints between blankets on the outside layer shall be offset from joints on the inside layer by a minimum six inch (152 mm). Cut edges of the blanket shall be taped with aluminum foil tape. During installation the blankets are temporarily held in place with filament tape until the wrap is mechanically attached with steel bands or steel insulation pins.
   3. Install 1 layer of FireMaster FastWrap XL or Pyroscat Duct Wrap XL for one and two hour air ventilation duct enclosures per ISO 6944-1985.
      a. General Installation Instructions for Single Layer Installations: FireMaster or Pyroscat blankets are cut to a length that will fit around the duct and overlap itself no less than three inch (152 mm). Adjacent blankets overlap each other a minimum of three inch (152 mm), or they can be fitted together with a tight butt joint and covered with a six inch (305 mm) wide collar centered over the butt joint. Cut edges of the blanket are taped with aluminum foil tape. During installation the blankets are temporarily held in place with filament tape until the wrap is mechanically attached with steel bands or steel insulation pins.
   4. Install one layer of Thermal Ceramics PlenumWrap+ on plastic pipe or plastic jacketed electrical cables per Intertek listing reports and testing to NFPA 262 and UL1887.
      a. Cut plenum blanket to a length that will fit around the pipe or cable and overlap itself no less than one inch (25 mm). Adjacent blankets overlap each other a minimum of one inch (25 mm). Plenum blanket is secured using either 1/2 inch (12 mm) steel banding or 16 gauge carbon or stainless steel tie wire on maximum 11-1/2 inch (292 mm) spacing.
   5. Mechanical Fastening of Enclosure Material to Ductwork:
      a. Banding - Carbon steel or stainless steel banding is used to hold the outer layer of the blanket enclosure in place. Banding is minimum 1/2 inch (12.7 mm) wide, and is placed around the entire perimeter of the duct on maximum 10-1/2 inch (267 mm) centers and 1-1/2 inch (38 mm) from each blanket or collar edge.
      b. Pinning - To prevent blanket sag on duct spans wider than 24 inch (610 mm), minimum 12-gauge steel insulation pins are welded to the duct along bottom horizontal and outside vertical runs in columns spaced 12 inch (305 mm) apart, 6 to 12 inch (152 to 305 mm) from each edge, and on 10-1/2 inch (267 mm) centers. Pins are locked in place with 1-1/2 inch (38 mm) diameter or 1-1/2 inch (38 mm) square galvanized steel speed clips or cup head pins. Pins are turned down or the excess cut off to eliminate sharp edges.
   6. Grease Duct Access Door Installation:
      a. Install Thermal Ceramics FastDoor XL per manufacturers' instructions, and applicable building code reports and laboratory design listings.

7. Through-Penetration Firestop System:
    a. When the duct penetrates a concrete or dry wall fire rated floor, ceiling, or wall an approved firestop system shall be employed. FireMaster or Pyroscat insulation shall be installed directly to the duct through the penetration, or terminated on both sides of the penetration depending on the annular space allowance between the duct and the duct opening. When the FireMaster or Pyroscat enclosure system is terminated on both sides of the through penetration, the duct wrap material is mechanically attached to the duct at the termination points using either steel banding or steel pins.
    b. To fire stop the through penetration void area, fill the annular space between the wrapped duct or bare duct and the periphery of the opening with scrap FireMaster or Pyroscat insulation firmly packed into the opening. Compress scrap blanket to percentage stated in the firestop listing for a minimum depth as specified in the firestop listing. Recess packing material below surface on both sides of walls or top side only for floors to the depth stated in the firestop listing. Seal over the packing material using an approved firestop sealant to a depth as stated in the firestop listing, flush with top side of a floor assembly and both sides of a wall assembly.

D. REPAIR PROCEDURES
1. Repair damaged FireMaster FastWrap XL or Pyroscat Duct Wrap XL in accordance with manufacturer's instructions.
2. Remove damaged section by cutting the bands and removing the anchor clips holding it in place. Apply a new section of the same dimension ensuring the same overlap and installation method that existed previously. Cut edges and tears in the foil must be taped with aluminum tape to prevent the insulation from wicking moisture or grease.

E. PROTECTION
1. Protect installed products until completion of project.
2. Touch-up, repair or replace damaged products before Substantial Completion.

3.08 INSTALLATION OF HYDRONIC PIPING AND ACCESSORIES

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.

B. Piping Installations:
1. Locations and Arrangements: Drawings indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design consideration. So far as practical, install piping as indicated.
2. Install piping at a uniform grade of one inch in 40 feet upward in the direction of flow.
3. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.
4. Install branch connections to mains using Tee fittings in main with take-off out the bottom, except for up-freed risers which shall have take-off out the top of the main line.
5. Install unions in pipes two inch and smaller, adjacent to each valve, at final connections of each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.
6. Install flanges on valves, apparatus, and equipment having 2-1/2 inch and larger connections.
7. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated. Install nipple and ball valve in blow down connection of strainers two inch and larger.
8. Anchor piping to ensure proper direction of expansion and contraction. Expansion loops and joints are indicated on the Drawings.
9. Install pipe sleeves at all wall and floor penetrations.
10. Install escutcheons at all exposed pipe wall penetrations.
11. Provide Dielectric couplings at all dissimilar piping/valve connections.

C. Pipe Applications:
1. Copper Tubing: Use Type L, drawn copper tubing with wrought copper fittings and solder joints for two inch and smaller, above ground, within building. Use Type K, annealed temper copper tubing for two inch and smaller without joints, below ground or within slabs. Mechanical fittings (crimp or flair) are not permitted.

2. Steel Pipe: Use steel pipe with threaded joints and fittings for two inch and smaller, and with welded joints for 2-1/2 inch and larger.
3. Steel Pipe: Use mechanical grooved end steel pipe and mechanical couplings and fittings.

D. Grooved Ends:
1. Roll Groove pipe ends in accordance with the latest published instructions from manufacturer of grooved couplings.
2. All grooved piping shall be inspected periodically by the manufacturer representative to insure proper installation is in accordance with manufacturer's guidelines. No insulation work shall proceed until the piping and fittings have been reviewed and accepted by the mfr. rep. a field report indicating manufacturers acceptance shall be submitted for approval to the Architect/Engineer.

E. Inspection
1. A manufacture's factory trained representative shall periodically visit the job site and review the installation for best practices. The installing Contractor shall correct any identified deficiencies.
2. The grooved fittings manufacturer's product that has been examined and has not met the visual inspection criteria for proper installation must be corrected and re-examined by Inspection Services prior to the completion of the project. Any Victaulic product that has not been corrected or was not examined will not be considered as part of the successful completion of Inspection Services.

F. Valve Applications:
1. General Duty Valve Applications: The Drawings indicate valve types to be used. Where specific valve types are not indicated the following requirements apply:
   a. Shut-Off Duty: Use gate, and ball, valves.
   b. Throttling Duty: Use globe, ball, and plug valves.
2. Install drain valves at low points in mains, risers, branch lines, for system drainage.
3. Install pump discharge valves with stem in upward position; allow clearance above stem for check mechanism removal.
4. Install safety relief valve on hot water generators, and elsewhere as required by ASME Boiler and Pressure Vessel Code. Pipe discharge to floor without valves. Comply with ASME Boiler and Pressure Vessel Code Section VIII, Division 1 for installation requirements.
5. Install pressure reducing valves on hot water generators, and elsewhere as required to regulate system pressure.
6. Install isolation valves in all branch supply take-offs from piping mains which serve more than two terminal heating or cooling units. Provide balancing valve with positive shut off in all return branch take-offs which serve more than two terminal heating or cooling units. Provide isolation valves in floor supply main piping lines and balancing valves with positive shut-off in all floor return main piping take-offs.

G. Hydronic Specialties Installation:
1. Install automatic air vents at high points in the system, heat transfer coils, and elsewhere as required for system air venting. Install air vents with cocks such that vents can be removed without draining system.
2. Install combination separator/strainer in pump suction lines. Run piping to compression tank with 1/4 inch per foot (2 percent) upward slope towards tank. Install blowdown piping with gate valve; extend to nearest drain.
3. Install pump suction diffusers on pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and ball valve in blowdown connection.
4. Install shot-type chemical feeders in each hydronic system; in upright position with top of funnel not more than 4eight inch above floor. Install feeder in bypass line, off main using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.
5. Install diaphragm-type compression tanks as indicated. Vent and purge air from hydronic system, charge tank with proper air charge to suit system design requirements.
   a. In the absence of details provide support from the floor or structure above sufficient for the weight of water assuming a full tank of water. Do not overload building components and structural members.

H. Field Quality Control:

1. Preparation for Testing: Prepare hydronic piping in accordance with ASME B 31.9 and as follows:
   a. Leave joints including welds uninsulated and exposed for examination during the test.
   b. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
   c. Flush system with clean water. Clean strainers.
   d. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
   e. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.
2. Testing: Test hydronic piping as follows:
   a. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
   b. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at point for complete removal of the liquid.
   c. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low pressure filling lines are disconnected.
   d. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength, or 1.7 times the "SE" value in Appendix A of ASME B31.9, Code for Pressure Piping, Building Services Piping.
   e. After the hydrostatic test pressure has been applied for at least ten minutes, examine piping, joints, and connection for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.

I. Adjusting and Cleaning:
   1. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
   2. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system installation and initial testing and perform treatment testing 6 months and 12 months after the initial treatment.

3.09 INSTALLATION OF REFRIGERANT PIPING AND ACCESSORIES

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.

B. Piping Installations:
   1. Locations and Arrangements: Drawings indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, and other design consideration.
   2. Install pipe sleeves at all wall and floor penetrations.
   3. Install escutcheons at all exposed pipe wall penetrations.

3.10 INSTALLATION OF AIR SOURCE-TO-WATER SIMULTANEOUS HEATING AND COOLING MODULAR CHILLERS WITH HEAT RECOVERY

A. Examination:
   1. Examine areas to receive chillers for compliance with installation tolerances and other conditions effecting performance and maintenance of chillers.
   2. Examine proposed route of moving chillers into place and verify that it is free of interferences.

3. Verify piping roughing-in locations.
4. Verify branch circuit wiring suitability. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Installation:
1. Install heat pump chillers according to manufacturer's written instructions.
2. Install heat pump chillers plumb and level, and anchor lifting frame to steel/curb. Anchor chiller and vibration isolators to steel/curb.
3. Install vibration isolators according to isolator manufacturer's written instructions. External vibration isolators to be provided by the contractor.
4. Maintain manufacturer's recommended clearances for service and maintenance.
5. Install piping connections maintaining clearances for service and maintenance of chillers.
6. Install differential pressure switches across hot water and chilled-water connections.
7. Install flange connections at chillers.
8. Install flexible pipe connections for chillers mounted on vibration isolators.
9. Install MAIN shutoff valves at chiller inlet and outlet of hot water and chilled-water connections.
10. Install BYPASS MAIN shutoff valves which can short-circuit chiller inlet to outlet of hot water and chilled-water connections.
11. Install water strainers as required for the hot water and chilled water systems.

C. Electrical Connections:
1. Install all necessary electrical wiring devices and services such as fused disconnect switches or circuit breakers to power each module, phase loss monitors. Install all wires and cables routing between each module and the master controller. Install electrical service to the master control panel. All wiring is done in the field and shall be according to local and national electrical codes where applicable.
2. Install and connect remote flow switches and remote chiller control panel.
3. Ground equipment.
4. Tighten electrical connectors and terminals, including grounding connections, according to manufacturers published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
5. Electrical contractor shall supply and install main electrical power line, disconnect switches, circuit breakers, electrical protection devices per local code requirements and indicated necessary by the chiller manufacturer.
6. ATC Contractor shall supply and install electrical wiring and devices required to interface the chiller controls with the building control system.
7. Electrical power shall be supplied to the unit by the Electrical Contractor at the voltage, phase and frequency listed in the equipment schedule.

D. Field Quality Control: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Piping System Flushing Procedure
1. Prior to connecting the Chiller/Heater to the hot water and chilled water loop, the piping loops shall be flushed with a detergent and hot water (1ten-130 deg. F) mixture to remove previously accumulated dirt and other organics. In old piping systems with heavy encrustation of inorganic materials consult a water treatment specialist for proper passivation and/or removal of these contaminants.
2. During the flushing, a 30 mesh (max.) Y-strainers (or acceptable equivalent) shall be in place in the system piping and examined periodically as necessary to remove collected residue. The flushing process shall take no less than six hours or until the strainers examined after each flushing are clean. Old systems with heavy encrustation shall be flushed for a minimum of 24 hours and may take as long as 48 hours before the filters run clean. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturers instructions. After flushing with the detergent and/or dilute acid concentrations the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.
3. Prior to supplying water to the Chiller/Heater the Water Treatment Specification shall be consulted for requirements regarding the water quality during Chiller/Heater operation. The appropriate Chiller/Heater manufacturer’s service literature shall be available to the operator and/or service contractor and consulted for guidelines concerning preventative maintenance and off-season shutdown procedures.

4. Water Treatment Requirements
   a. Supply water for the hot water, chilled water and condenser water circuits shall be analyzed and treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified for the Chiller/Heater's heat exchangers, headers and associated piping. Cycles of concentration shall be controlled such that recirculated water quality for modular Chiller/Heaters using 316 stainless steel brazed plate heat exchangers and carbon steel headers is maintained within the following parameters:
      1. pH — Greater than 7 and less than 9
      2. Total Dissolved Solids (TDS) — Less than ten00 Parts per Minute
      3. Hardness as $CaCO_3$ — 30 to 500 Parts per Minute
      4. Alkalinity as Ca CO_3 — 30 to 500 Parts per Minute
      5. Chlorides — Less than 200 Parts per Minute
      6. Sulfates — Less than 200 Parts per Minute
   b. Refer to Water Treatment Specifications for additional requirements.

F. Cleaning:
   1. Clean finishes to remove dust and dirt.
   2. Touch up scratches in unfinished surfaces to restore corrosion resistance.
   3. Touch up scratches in finished surfaces to restore finish.

G. Commissioning:
   1. Energize chiller and operate controls and safeties.
   2. Verify that motor amperage conforms to manufacturer's data.
   3. Start chiller and verify performance. Demonstrate operation to Owner.

H. Demonstration:
   1. Factory-Authorized Startup Services: Engage a factory-authorized service representative to supervise startup services performed by an independent mechanical contractor provided by the Owner, and to demonstrate and train Owner's maintenance personnel as specified below.
   2. Train the Owner's maintenance personnel on procedures and schedules related to startup, shutdown, troubleshooting, servicing, and preventive maintenance.
   3. Review data in the operation and maintenance manuals.

3.11 INSTALLATION OF HVAC PUMPS

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.

B. General: Install HVAC pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized practices to ensure that HVAC pumps comply with requirements and serve intended purposes.

C. Access: Provide access space around HVAC pumps for service but in no case less than that recommended by manufacturer.

D. Support: Install base-mounted pump assembly on minimum of four inch high concrete base equal or greater than three times total weight of pump and motor. Set and level pump in base and grout with non-shrink grout.

E. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
   1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

F. Adjusting and Cleaning
   1. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, and in presence of manufacturer's service representative.
   2. Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.
   3. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.12 INSTALLATION OF ROOFTOP AIR HANDLING UNITS

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.
B. General: Install rooftop and indoor air handling units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in location indicated, and maintain manufacturer's recommended clearances.
C. Support: Contractor shall coordinate installation with the roofing contractor, and shall install and secure roof curb to roof structure, per details on the drawings and in accordance with National Roofing Contractor's Association (NRCA) installation recommendations and shop drawings. Install and secure rooftop units on curbs and coordinate roof penetrations and flashing.
D. Access: Provide access space around air handling units for service but in no case less than that recommended by manufacturer.
E. Duct Connections: Provide ductwork, accessories, and flexible connections as indicated.
F. Grounding: Provide positive equipment ground for air-handling unit components.
G. Provide two complete extra sets of filters for each air handling unit as part of the project close-out. In addition, install new filters at completion of air handling system work, and after completion of testing, adjusting, and balancing work in accordance with LEED requirements. Obtain receipt from Owner that new filters have been installed.
H. Provide one spare set of belts for each belt-driven air handling unit, obtain receipt from Owner that belts have been received.
I. Electrical Connections: Refer to electrical sections for final connections to equipment and installation of loose shipped electrical components.
J. Start-Up Services:
    1. Provide the services of a factory-authorized service representative to start-up rooftop units, in accordance with manufacturer's written start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment. Provide and submit to engineer field start-up report from factory-authorized service representative.
K. Operating and Maintenance Training:
    1. Provide services of manufacturer's service representative (minimum 8 hrs.) to instruct Owner's personnel in operation and maintenance of rooftop units. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and trouble-shooting procedures plus procedures for obtaining repair parts and technical assistance.
    2. Schedule training with Owner, provide at least 7-day prior notice to the Architect/Engineer. Video record training session and provide copy of media to Owner.

3.13 INSTALLATION OF VARIABLE AIR VOLUME BOXES & CONSTANT AIR VOLUME REGULATORS

A. Vibration Control And Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.
B. General: Install variable air volume boxes and constant air volume regulators as shown on drawings, and in accordance with manufacturer's installation instructions.
C. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.

3.14 INSTALLATION OF TERMINAL COOLING/HEATING UNITS (HYDRONIC)

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.
B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.
C. Installation of Radiant Panels & Radiation

1. Install radiant panel level and plumb. Maintain sufficient clearance for normal services, maintenance, or in accordance with construction drawings.
2. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   a. Verify that controls and control enclosure are accessible.
   b. Verify that control connections are complete to control valves as needed.
   c. Verify that any identification tags are visible.
   d. Verify that controls respond to inputs as specified.
3. Connections
   a. Piping installation requirements are specified in other Division 23 Sections. Drawings indicated general arrangement of piping, fittings, and specialties.
   b. Install piping adjacent to radiant panels to allow for service and maintenance.
   c. In addition to Division 23 Section "Hydronic Piping", connect copper tubing to supply with shut-off valve, strainer, control valve, and union or flange, and return pipe with balancing valve and union or flange.

D. Adjusting and Cleaning:
1. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
2. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
3. Install new filter units for terminals requiring same.

3.15 INSTALLATION OF TERMINAL HEATING UNITS (HYDRONIC)

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.

B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.

C. Installation of Finned Tube Radiation: (Hydronic)
1. General: Install finned tube radiation as indicated, and in accordance with manufacturer's installation instructions.
2. Locate finned tube radiation as indicated, run cover wall-to-wall unless otherwise indicated. Provide butt caps, splice joints, "Z" bends, enclosure end trim pieces and inter-connecting trim pieces and required access doors/panels for a complete installation.
3. Install access panels centered in front of each shutoff valve, balancing cock, steam trap, or temperature control valve.

D. Installation of Convectors: (Hydronic)
1. General: Install convectors as indicated, and in accordance with manufacturer's installation instructions.
2. Locate convectors as indicated, coordinate with other trades to assure correct recess size for recessed convectors.

E. Installation of Horizontal Unit Heaters: (Hydronic)
1. General: Install unit heaters as indicated, and in accordance with manufacturer's installation instructions.
2. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
3. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.
4. Support units with rod-type hangers anchored to building substrate.
5. Install piping as indicated.
6. Protect units with protective covers during balance of construction.

F. Installation of Cabinet Unit Heaters: (Hydronic)
1. General: Install cabinet heaters as indicated, and in accordance with manufacturer's installation instructions.
2. Coordinate with other trades to assure correct recess size for recessed units.
3. Install piping as indicated.
4. Protect units with protective covers during balance of construction.

G. Installation of Radiant Panels & Radiation
   1. Install radiant panel level and plumb. Maintain sufficient clearance for normal services, maintenance, or in accordance with construction drawings.
   2. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
      a. Verify that controls and control enclosure are accessible.
      b. Verify that control connections are complete to control valves as needed.
      c. Verify that any identification tags are visible.
      d. Verify that controls respond to inputs as specified.
   3. Connections
      a. Piping installation requirements are specified in other Division 23 Sections. Drawings indicated general arrangement of piping, fittings, and specialties.
      b. Install piping adjacent to radiant panels to allow for service and maintenance.
      c. In addition to Division 23 Section "Hydronic Piping", connect copper tubing to supply with shut-off valve, strainer, control valve, and union or flange, and return pipe with balancing valve and union or flange.

H. Installation of Coils: (Hydronic)
   1. General: Install coils as indicated, and in accordance with manufacturer's installation instructions.
   2. Pitch coil casings for drainage, not less than 1/8 inch toward return connections, except where drainage feature is included in coil design.

I. Adjusting and Cleaning:
   1. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
   2. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
   3. Install new filter units for terminals requiring same.

3.16 INSTALLATION OF TERMINAL HEATING UNITS (ELECTRIC)

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.

B. Installation of Electric Heating Terminals:
   1. Install electric heating terminal units including components as indicated, in accordance with equipment manufacturer's written instructions, and with recognized industry practices; complying with applicable installation requirements of NEC and NECA's "Standard of Installation".
   2. Coordinate with other electrical work, including wiring/cabling, as necessary to properly interface installation of heating terminal units with other work.
   3. Clean dust and debris from each heating terminal as it is installed to ensure cleanliness.
   4. Comb out damaged fins where bent or crushed before covering elements with enclosures.
   5. Touch-up scratched or marred heating terminal enclosure surfaces to match original finishes.
   6. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminal to comply with tightening torques specified in UL Std. 486A.

C. Grounding:
   1. Provide equipment grounding connections for electric heating terminals as indicated, Tighten connections to comply with tightening torque values specified in UL std. 486A to assure permanent and effective grounding.

D. Electrical Wiring:
   1. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electric Installer.
      a. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

b. Upon completion of installation of electric heating terminals, and after building circuitry has been energized, test heating terminals to demonstrate capability and compliance with requirements. Where possible, field correct malfunctioning units, then retest to demonstrate compliance; otherwise, remove and replace with new units and proceed with retesting.
c. Replace electric heating terminals and accessories which are damaged and remove damaged items from construction site.

E. Adjusting and Cleaning:
1. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
2. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
3. Install new filter units for terminals requiring same.

3.17 INSTALLATION OF POWER AND GRAVITY VENTILATORS

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.
B. General: Except as otherwise indicated or specified, install ventilators in accordance with manufacturer's installation instructions and recognized industry practices to insure that products serve the intended function.
C. Coordinate ventilator work with work of roofing, walls and ceilings, as necessary for proper interfacing.
D. Ductwork: Connect ducts to ventilators in accordance with manufacturer's installation instruction, and details on drawings.
E. Roof Curbs: Furnish roof curbs to roofing Installer for installation.
F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Verify proper rotation direction of fan wheels. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
G. Remove shipping bolts and temporary supports within ventilators. Adjust dampers for free operation.
H. Testing: After installation of ventilators has been completed, test each ventilator to possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.
I. Cleaning: Clean factory-finished surface. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
J. General: Furnish to Owner, with receipt, one spare set of belts for each belt driven power ventilator.

3.18 INSTALLATION OF METAL DUCTWORK

A. Installation of Metal Ductwork:
1. General: Assemble and install ductwork in accordance with SMACNA Standards and Guidelines which will achieve air-tight (leak testing shall be provided for all ductwork and testing shall be performed per SMACNA HVAC Air Duct Leakage Test Manual procedures and in accordance with the leakage class 3 as minimum requirements for all ductwork) and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately with internal surface smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling. Support vertical ducts at every floor.
a. Exposed ductwork shall be supported by air craft cable. Cable shall be sized to match the anticipated weight of the ductwork. Install per manufactures recommendations. Recommend manufacture are Gripple, Rize or approved equal.
2. Sealing: All ductwork joints and seams shall be sealed with flexible duct sealer to assure an airtight installation.

3. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as duct. Overlap opening on four sides by at least 1-1/2 inch Fasten to duct and substrate.
    a. Where ducts pass through fire-rated floors, walls, or partitions, provide firestopping between duct and substrate.
4. Coordination: Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.
5. Installation: Install metal ductwork in accordance with "SMACNA HVAC Duct Construction Standards", SMACNA IAQ During Construction Guidelines, and SMACNA Duct Cleanliness Advanced Levels for New Construction Guidelines.

B. Installation of Duct Liners:
1. General Install duct liners in accordance with SMACNA "HVAC Duct Construction Standards".

C. Installation of Flexible Ducts:
1. Maximum Length: For any duct run using flexible ductwork, do not exceed four feet- zero inch extended length.
2. Installation: Install in accordance with Section II of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible".

D. Field Quality Control:
1. Leakage Tests: After each duct system, test for duct leakage in accordance with SMACNA "HVAC Air Duct Leakage Test Manual". Repair leaks and repeat tests until total leakage is less than leakage class 3 minimum requirements.

E. Equipment Connections:
1. General: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery.

F. Adjusting and Cleaning:
1. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
2. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until final connections are to be completed.
3. Balancing: Refer to Division 23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork. Seal any leaks in ductwork that become apparent in balancing process.
4. HVAC Contractor shall be responsible for internal duct cleaning (Duct cleaning company shall be NADCA certified and HVAC Contractor shall to submit their Duct Cleaning sub-sub-contractor's qualifications) prior to occupancy if Contractor by determination of the Owner/Engineer has failed to adhere to the specification and SMACNA Duct Cleanliness for New Construction Guideline’s requirements for proper ductwork installation and protection during construction.

G. Construction IAQ Management:
1. Follow the SMACNA guidelines for “Duct Cleanliness for New Construction Guidelines” according to advanced levels of cleanliness. Including but not limited to:
    a. Ductwork shall be sealed when transported to the construction site and film shall not be removed until ductwork connections are completed. Seal ends of ductwork and fittings with 15 mil poly film.
    b. Store ductwork in clean, dry conditions and keep sealed while it is stored.
    c. Wipe down internal surfaces of ductwork immediately prior to installation to remove dust.
    d. Seal open ends on completed ductwork and overnight work-in-progress. Do not remove seals until connecting piece of ductwork is ready to be installed.
    e. During installation, protect ductwork waiting to be installed with surface wrapping.
    f. During construction, seal HVAC supply and return openings to protect them from dust infiltration.

3.19 INSTALLATION OF DUCTWORK ACCESSORIES

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.
B. Install turning vanes in square or rectangular 90 degree elbows in supply, return, and exhaust air systems, and elsewhere as indicated.
C. Install volume and/or splitter damper with adjusting rod in each supply branch. Install according to detail on drawings.
D. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.
E. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.
F. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
G. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
H. Furnish extra fusible links to owner, one link for every ten installed of each temperature range; obtain receipt.

3.20 INSTALLATION OF ACOUSTIC DUCT LINING

A. Installation: All portions of duct designed to receive duct liner shall be completely covered. The smooth, black coated surfaces shall face the airstream. All liners shall be cut to assure tight, overlapped corner joints. The top pieces shall be supported by the side pieces. The liner shall be adhered to the sheet metal with full coverage of an approved adhesive that conforms to ASTM C 916, and all exposed leading edges and transverse joints shall be coated with Permacote factory-applied or field-applied edge coating and shall be neatly butted without gaps. Shop or field cuts shall be liberally coated with "Schuller SuperSeal Edge Treatment" or approved adhesive. The liner shall be additionally secured with mechanical fasteners. The pin length should be such as to hold the material firmly in place with minimum compression of the material.

3.21 INSTALLATION OF SOUND ATTENUATORS

A. Vibration Control and Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.
B. General: Install sound attenuators as indicated, and in accordance with manufacturer's installation instructions.
C. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.
D. Upon completion of installation test and demonstrate that sound attenuators, and duct connections to sound attenuators, are leak tight.

3.22 INSTALLATION OF AIR OUTLETS AND INLETS

A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function.
B. Locate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling module.

3.23 INSTALLATION OF DUCTLESS COOLING UNIT SYSTEMS

A. Vibration Control And Seismic Restraint: Refer to section 230548 and drawing VS1.00 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS1.00.
B. General:
    1. Verify all dimensions by field measurements. Verify roof structure, mounting supports, wall structure, and membrane installations are completed to the proper point to allow installation of wall mounted and roof mounted units. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation. Do not proceed until unsatisfactory conditions have been corrected.

2. Install equipment in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

C. Field Quality Control:
1. Provide the services, to include a written report, of a factory authorized service representative to examine the field assembly of the components, installation, and piping and electrical connections.
2. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.

D. Demonstration:
1. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.
2. Start-up service: Place units into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.

E. Training:
1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures.
2. Schedule training with Owner through the Architect/Engineer with at least 7 days prior notice. Measure sound levels in field under full load conditions and included in start-up report.

3.24 INSTALLATION OF CONDENSATE DISCHARGE PUMPS

A. Examine areas and conditions under which pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

B. Installation Of Equipment
1. General: Install equipment in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in drain pans and locations indicated, and maintain manufacturer's recommended clearances.
2. Accessories: Install equipment accessories not installed at factory.
3. Connections: Connect discharge piping as indicated and terminate where indicated on the contract documents.
4. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical installer.
   a. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

C. Field Quality Control
1. General: Start-up equipment, in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

D. Closeout Procedures
1. Training: Instruct Owner's personnel in operation and maintenance of condensate discharge pumps.

3.25 INSTALLATION OF FIRESTOP SYSTEMS

A. General: Install firestop/smoke seal systems at all fire and/or smoke rated construction where penetrated by the Work of this Section.

B. Refer to Section 078413 – Penetration Firestopping, for all installation requirements for maintaining integrity of fire and/or smoke rated construction at penetrations.

3.26 INSTALLATION OF WALL AND CEILING ACCESS DOORS

A. General: Install access doors in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function.

B. All access doors shall be located in a workmanlike manner in closets, storage rooms, and/or other non-public areas, positioned so that the item or part can be easily reached, and the size shall be sufficient for this purpose (minimum size 20 inch by 20 inch). Furnish access doors to permit thorough inspection. When access doors are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect.

3.27 ARCHITECTURAL LOUVERS & VENTS

A. Manufacturers
   1. Acceptable Manufacturers: Greenheck, Ruskin Company, Airolite, Or equal.

B. Wind-Driven Rain Louver
   1. Fabrication: Heavy Gauge extruded aluminum stationary louver style.
      a. Frame: Double frame design.
         1) Frame Depth: Overall combined frame depth is 9.25 inches nominal.
         2) Wall Thickness: 0.081 inch nominal.
         3) Material: Extruded aluminum, Alloy 6063-T6.
      b. Blades:
         1) Style: Sight proof.
         2) Material: Extruded aluminum, Alloy 6063-T6.
         3) Wall Thickness: 0.080 inch (2.1 mm) and 0.062 inch (1.6 mm) nominal.
         4) Blade Depth: Exterior blades are two inches (51 mm) deep, interior blades are six inches (153 mm) deep.
      c. Sill: Sill Flashing: Formed aluminum, 0.081 inch (2.0 mm), upturned sides to prevent water leakage.
      d. Minimum assembly size: 12 inches length by 12 inches high for standard installation.
      e. Maximum assembly size: Standard EHV-90ten shall not exceed 60 inches wide by 120 inches high. Louvers larger than the maximum factory assembly size will require field assembly of smaller sections.
   2. Performance Data:
      a. Performance Ratings: AMCA licensed.
         1) Based on testing 48 inches by 48 inches (1219 mm by 1219 mm) size unit in accordance with AMCA 500.
      b. Free Area: 54 percent, nominal.
      c. AMCA 540 and AMCA 550 Listing with the Air Movement and Control Association Certified Ratings Program, maximum wind-load: plus/minus 130 PSF.
      d. Maximum Pressure Drop (Intake): 0.45 inches w.g. (0.11 KPa).
      e. Louver shall be certified to Miami-Dade standards TAS 201 (Large Missile Impact), TAS 202 (Uniform Static Air Pressure) and TAS 203 (Cyclic Wind Loading).
      f. Wind load Test Performance: Maximum wind load of ±130 PSF (6.22 kPa) design wind loads tested per Miami-Dade County Uniform Wind Pressure Test TAS 202.
      g. Wind-driven Rain Performance:
         1) Effectiveness Ratio: 99.9 percent effective at preventing water penetration through louver when tested at 50 miles per hour (81 km/h) wind with eight inches per hour (203 mm/h) rainfall and 2261 feet per minute (11.5 m/sec) airflow through the free area. Penetration Class ‘A’ in accordance with AMCA 500-L Wind Driven Rain Test.
         2) Effectiveness Ratio: 99.9 percent effective at preventing water penetration through louver when tested at 29 miles per hour (46.4 km/h) wind with three inches per hour (76 mm/h) rainfall and 2247 feet per minute (11.4 m/sec) airflow through the free area. Penetration Class ‘A’ in accordance with AMCA 500-L Wind Driven Rain Test.
   3. Design Windload: +130 PSF (6.2 kPa) and -130 PSF (-6.2 kPa).
   4. Design Windload: Per Code.

C. Accessories
   1. Aluminum Blank-Off Panels: 0.040 inch (1 mm) aluminum sheet, factory installed with removable screws and neoprene gaskets.
   2. Aluminum Insulated Blank-Off Panels: two inches aluminum skin, insulated core, installed by HVAC Contractor with removable screws and neoprene gaskets.
   3. Hinged Frame: Continuous piano hinge attached to angle subframe.
   4. Hinged Frame: Continuous piano hinge attached to channel subframe.
   5. Bird Screen:
      a. Aluminum: Aluminum, 5/8 inch by 0.040 inch (16 mm by 1 mm), expanded, flattened metal.
      b. Frame: Removable, re-wireable.
   6. Insect Screens:
      a. Aluminum: 18-16 mesh, mill finish, .011 inch (0.3 mm) wire.
      b. Frame: Aluminum.

7. Extended Sills:
    a. Formed aluminum, Alloy 3003. Minimum nominal thickness 0.081 inch.
    b. Extruded aluminum, Alloy 6063-T6. Minimum nominal thickness 0.060 inch.
    c. Mullions: Manufacturer's decorative mullions for architectural accent.

D. Finishes
1. Finish: Mill finish.
2. Finish: 70 percent PVDF: Finish shall be applied at 1.2 mil total dry film thickness.
    a. Coating shall conform to AAMA 2605. Apply coating following cleaning and pretreatment. Cleaning: AA-C12C42R1X.
        1) 3-coat metallic.
    b. 20-year finish warranty.
    c. Color: Custom metallic color finish. Color by Architect.
3. Color: Custom. Refer to Drawings.

3.28 INSTALLATION OF AUTOMATIC TEMPERATURE CONTROLS (DDC)

A. Installation Of Automatic Temperature Controls (DDC):
1. Installation of Control Systems:
    a. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.
    b. Control Wiring: Install control wiring, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code.
        1) Install circuits over 25-volt with color-coded No. 12 wire in electric metallic tubing.
        2) Install circuits under 25-volt with color-code No. 18 wire with 0.031 inch high temperature 105 degrees Fahrenheit. (41 degrees Celsius) plastic insulation on each conductor and plastic sheath over all.
        3) Install electronic circuits with color-coded No. 22 wire with 0.023 inch polyethylene insulation on each conductor with plastic-jacketed copper shield over all.
        4) Install low voltage circuits, located in concrete slabs, masonry walls, or in mechanical areas, in electrical conduit. Where exposed in occupied areas install all wiring in wiremold.
        5) Power sources from lighting circuits and wall outlets shall not be used to power DDC controllers.
    c. Controllers and safety devices:
        1) All safety devices such as freezestats, duct mounted heat detectors, and smoke detectors shall be hard wired to shut down the fans independently. Provide audible alarm with silence switch as well as DDC indication.
        2) All supply, return and exhaust fans shall be provided with pressure differential switches. Current sensing devices, starter auxiliary contacts, and relay contacts are unacceptable proof of fan operation.
        3) Primary and standby pumps shall be selectable through the DDC control system. Provide local pilot light to indicate selected pump as well as alarm and silence switch for failed pump. Provide differential pressure switch to prove flow.
2. Adjusting and Cleaning:
    a. Start-Up: Start-up, test, and adjust DDC control systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
    b. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
    c. Final Adjustment: After completion of installation, adjust thermostats, control valves, motor and similar equipment provided as work of this section.
    d. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary temperature control system.
3. Closeout Procedures:
    a. Owner's Instructions: Provide services of manufacturer's technical representative for 40 hours of onsite instruction training on running and basic troubleshooting of DDC control system. Training sessions should be periodically scheduled, per a schedule that is agreeable to the Owner, to occur in multiple sessions over the first year of the two year warranty period.

b. Validation: The automatic temperature control sub-contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequence of operation submitted.
   1) Witnessed validation demonstration shall consist of:
      a) Execute digital and analog commands in English and graphic mode.
      b) Demonstrate all specified diagnostics.
      c) Demonstrate scan, update, and alarm responsiveness.
   2) Comply with SECTION 019113 GENERAL BLDG COMMISSIONING.

4. Training:
   a. All training shall be by the automatic temperature control sub-contractor and shall utilize specified manuals and as-built documentation.
   b. Operator training shall include:
      1) Sequence of Operation review.
      2) Sign on-Sign off.
      3) Modifying warning limits, alarm limits and start-stop times.
      4) System initialization.
      5) Use of Portable Operators Terminal.
      6) Troubleshooting of sensors (determining bad sensors).
      7) Point disable/enable.
      8) Software review of Sequence of Operation programs.
      9) Modification of control programs.
      10) Add/Delete/Modify data points.
      11) Use of diagnostics.
      12) Review of initialization.
   c. Training shall be for Owner-designated personnel at the subject site, and shall consist of multiple sessions that shall be periodically scheduled over the first year of the two year warranty period with the Owner, providing a minimum of two week notice.
   d. All training sessions shall be videotaped by professional videographer, refer to architectural specifications for further requirements.
   e. Seasonal Site Visits:
      1) In addition to the two year warranty period against component or workmanship defects, ATC Contractor shall provide the following: 40 hours of training, 120 hours of extra programming (as it relates to the control system to confirm, verify and modify as required the sequence and/or programming of each piece of equipment to ensure the system is functioning as required and per the sequence of operations), and 64 hours of seasonal testing. The ATC sub-contractor shall provide 16 labor hours per season (four times within a year, total of 64 hours). During each visit they shall, for each piece of equipment confirm operation and functionality, modify and/or repair any control related issues and/or programming and provide training as requested by the owner. This requirement will ensure the equipment/building is operating properly and efficiently as it cycles through each season. These site visits shall begin the following season after substantial completion of the project is issued. Upon substantial completion the ATC Sub-Contractor shall schedule the seasonal site visit dates with the Owner. Attendee Signatures and time logs shall be kept by the ATC contractor and shall be distributed to the CM, Owner and A/E team to record the dates of the seasonal site visits.
         a) Perform Indoor Air Quality Management Building flush out procedures and adhere to IAQ Management Procedures referenced in Section 018119 – INDOOR AIR QUALITY REQUIREMENTS.

B. INSTALLATION OF VARIABLE FREQUENCY DRIVES (VFD)
   1. General: Install variable frequency drives where indicated, in accordance with manufacturer's published installation instructions, complying with recognized practices to ensure that variable frequency drives comply with requirements and serve intended purposes.
   2. Access: Provide access space around control panels for service as indicated, but in no case less than that recommended by manufacturer.
   3. Support: Install drive control panels on walls where indicated on drawings. Provide necessary Unistrut and structural steel to provide adequate support as required by manufacturer. For remote VFDs submit weight of units to Structural Engineering for review.

4. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
   a. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
5. Start-Up:
   a. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.
6. Adjusting and Cleaning:
   a. Alignment: Check compatibility of control panel to motor and where necessary, adjust frequency and provide necessary filters to assure noise free operation of motors. Verify response from control panel to motor to assure turn down ratio specified and that static pressure signals are being received and that drives are controlling as specified and within recommended tolerances by manufacturer. Provide start-up report prepared by manufacturers representative to assure operation is as specified.
7. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's

3.29 TESTING, ADJUSTING, AND BALANCING

A. REQUIREMENTS:

1. Requirements include verification of HVAC system operation, measurement of all system capacity, and establishment of the quantities of the mechanical systems as required to meet specifications, and recording and reporting the results.
2. Commission, test, adjust and balance the following mechanical systems:
   a. Supply air systems.
   b. Return air systems.
   c. Exhaust air systems.
   d. Outside air systems.
   e. Hydronic heating and cooling systems.
   f. Hydronic ground source condenser water system.
   g. Verify temperature control system operation.
3. Do not include:
   a. Installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing. Contact Mechanical Contractor and the Engineer for direction.
4. Comply with Commissioning Test Requirements in Section 01 91 13 MEP Commissioning Specifications.
5. “Pre-Balancing Conference” as specified here within.
6. Comply with Indoor Air Quality Management Building flush out procedures and adhere to IAQ Management Procedures referenced in SECTION 01 81 19 – INDOOR AIR QUALITY REQUIREMENTS.
7. All rooftop units shall operate at the maximum amount of outside air (the design outside airflow rate for maximum occupancy as indicated on the mechanical schedules) during and after the installation of VOC emitting materials for the maximum amount of time feasible, but not less than continuously (i.e. 24 hours) for seven days. During this time, the design temperature and humidity set points shall be maintained. The installation of VOC emitting materials shall be fully coordinated with the Architect.
8. If the project has fallen behind schedule and cannot run the equipment for the required period of time (24 hours for seven days), the flush-out can alternatively be performed while the building is occupied provided all of the following measures to protect building occupants are taken prior to their use of the space: percent
   a. All of the rooms in the school must be inspected for health and thermal comfort by a trained technician or a certified Industrial Hygienist before occupancy. The occupancy evaluation report must be reviewed and approved by a certified Industrial Hygienist (i.e. certified by the American Council of Government and Industrial Hygienists (ACGIH) shall be submitted to LEED showing the following elements have been met at a minimum:

1) Each classroom has been tested to show that the ventilation rate meets minimum code required ventilation rate and receives continuous ventilation during occupancy, per Title 8, Sec 5142.
2) The HVAC filters on all HVAC units are properly in place and meet the MERV rating as specified for the project, the HVAC condensate pans drain correctly and internal HVAC insulation undamaged.
3) Each classroom has been tested to show that particulate matter, PM 10, has measured to be 20 micrograms per cubic meter or less than the outdoor air levels and the PM 2.5 12 micrograms per cubic meter or less than outdoor air levels.
4) Each classroom has been tested to show that the carbon monoxide has been measured and is less that nine parts per million but not greater than two Parts per Minute above outdoor levels. Each classroom has been tested to show that the carbon dioxide has been measured and is less than 200 Parts per Minute above outdoor CO2 levels nearby. The room must be unoccupied during testing, and testing should occur during at least on rush-hour period.
5) Each classroom has been tested to show that the temperature and relative humidity have been measured and are within the criteria in the current ASHRAE Standard 55.
6) Each classroom has been inspected and observed to ensure that there are no health or safety concerns from any chemical, moisture and odor sources in or near the classrooms.
7) Conduct the flush-out for 24 hours a day of continuous ventilation for the total number of days necessary as indicated on LEED flush-out calculator credit documentation which shall be determined by Contractor for all supply fans at their maximum rate and position. Thermal comfort is maintained during occupied hours, per the criteria in the current ASHRAE Standard 55. Internal temperatures are maintained at the most energy efficient level above 60 degrees Fahrenheit ; relative humidity is maintained no higher than 60 percent during non-occupancy hours. Under conditions where the heating can't be met (60 degrees Fahrenheit) at that fan speed, then adjust the fan to meet the 60 degrees Fahrenheit .
8) All air handling unit dampers are at their maximum outdoor air position during the 14 day flush-out
9) Post-occupancy ventilation: When the HVAC Sub-contractor is required to perform touch-up (including furniture after occupancy) work involving products with chemical emissions, provide temporary construction ventilation during application and extend the building flush-out by a minimum of four days after touch-up application, with ten0 percent tempered outside air for 24 hours each day.

b. All unit filters to be replaced upon completion of flush-out

B. REPORT:

1. Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Forms providing test measurements shall indicate piece of equipment, room number, and terminal outlet. In the case of multiple outlets in room, cross-reference on plan as part of TAB submittal. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
   a. General Information and Summary.
   b. Air Systems.
   c. Hydronic condenser (ground source), heating and cooling systems.
   d. Temperature Control Systems.
2. Contents: Provide the following minimum information, forms and data:
   a. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, Contractor, Owner, Architect, Engineer, and Project. Include addresses, and contact names and telephone numbers. Also include a certification sheet containing the seal and name address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentation used for the procedures along with the proof of calibration.

b. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC for each respective item and system.
c. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

C. QUALITY ASSURANCE:
1. An independent testing, adjusting, and balancing agency certified by the AABC or NEBB as a Test and Balance Engineer in those testing and balancing disciplines required for this project.
2. Codes and Standards:
a. AABC: "National Standards For Total System Balance".
b. ASHRAE: ASHRAE Handbook, Current Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.
3. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the Architect/Engineer and Mechanical Contractor. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.
4. System Operation: Systems shall be fully operational prior to beginning procedures. All new automatic temperature controls shall be fully operational. Test, adjust and balance the air systems before refrigerant systems. Test, adjust and balance air conditioning systems during summer season, and heating systems during winter season, including at least a period of operation at outside conditions within 5E F. wet bulb temperature of maximum summer design condition, and within 10E F. dry bulb temperature of minimum winter design condition. Take final temperature reading during seasonal operation.

D. PRELIMINARY PROCEDURES:
1. Air Systems:
a. Obtain drawings and become thoroughly acquainted with the systems.
b. Compare drawings to installed equipment and field installations.
c. Walk the system from the system air handling equipment to terminal units to determine variations in installation.
d. Check filters for cleanliness.
e. Check all dampers (volume and fire) for correct and locked position, and temperature control for completeness of installation before starting fans.
f. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a cross check with required fan volumes.
g. Determine best locations in main and branch ductwork for most accurate duct traverses. Traverses shall be performed in each supply and return duct main and sub-mains for each AHU and return air fan.
h. Place outlet dampers in the full open position.
i. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.
j. Verify lubrication of all motors and bearings.
k. Check fan belt tension.
l. Check fan rotation.
2. Hydronic Systems:
a. Open valves to full open position. Close coil bypass valves.
b. Remove and clean all strainers.
c. Examine hydronic systems and determine if water has been treated and cleaned.
d. Check pump rotation.
e. Check expansion tanks to verify noted air pressure and that the system is completely full of water.
f. Check air vents at high points of system and determine if all are installed and operating freely.
g. Set temperature controls so all coils are calling for full flow.
h. Check operation of automatic bypass valves.
i. Check and set operating temperatures of heat pump chillers to design requirements.
j. Verify lubrication of all motors and bearings.

3. Measurements:
    a. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerance specified in the referenced standards. Instruments shall be properly maintained and protected against damage.
    b. Provide instruments meeting the specifications of the referenced standards.
    c. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.
    d. Apply instrument as recommended by the manufacturer.
    e. Use instruments with minimum scale and maximum subdivisions and with scaled ranges proper for the value being measured.
    f. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than ten percent. When measuring a single point, repeat readings until two consecutive identical values are obtained.
    g. Take all reading with the eye at the level of the indicated value to prevent parallax.
    h. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.
    i. Take measurements in the system where best suited to the task.

E. Performing Testing, Adjusting, and Balancing:
1. Test, adjust and balance all noted systems according to SMACNA standards and as follows:
    a. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.
    b. Cut insulation and ductwork for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
    c. Patch insulation, ductwork, and housings, using materials identical to those removed.
    d. Seal ducts and test for and repair leaks.
    e. Seal insulation to re-establish integrity of the vapor barrier.
    f. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
    g. Retest, adjust and balance system subsequent to significant system modifications, and resubmit test results.
2. System Deficiencies:
    a. The Balancing Contractor shall advise the Mechanical Contractor and the Engineer of all system deficiencies in writing. Report all motors not running, missing dampers, inoperative valves and controls, lack of access.
    b. Upon completion of system deficiencies, Balancing Contractor shall balance and record data.

F. MANUFACTURER'S REPRESENTATIVE AND COMMISSIONING OF SYSTEMS:
1. Each Contractor shall provide, at appropriate time or as directed by the Architect, the onsite services of a competent factory trained Engineer or authorized representative of particular manufacturer of equipment provided under his contract, such as for the rooftop air handling units, automatic temperature controls, building automation system (BAS), Heat Pump Plant Controller, pumps, and chilled water plant provided under this Contract, to instruct the Owner, inspect, adjust and place in proper operating condition any item provided by him, as applicable. The equipment manufacturer will be part of the official equipment startup and the scheduled functional performance test with the commissioning authority. The HVAC Sub-contractor is to carry this allowance in his cost at no additional expense to the Owner.
2. The HVAC Sub-contractor, as applicable, shall commission and set in operating condition all major equipment and systems, such as the hot water system and all air handling systems, in the presence of the applicable equipment manufacturer's representatives, and the Owner and Architect's representatives. In no case will major systems and equipment be commissioned by any of the HVAC Sub-contractor 's forces alone, without the assistance or presence of the equipment manufacturers.
3. A written report shall be issued by the particular equipment manufacturer and the HVAC Sub-contractor summarizing the results of the commissioning and performance of each system for the Architect's record. No additional compensation will be allowed for any Contractor for such services.

4. The HVAC Sub-contractor shall prepare and submit to the Architect for acceptance, a schedule of anticipated system commissioning. No system shall be commissioned without prior acceptance of the schedule by the Architect and Owner. No systems shall be commissioned prior to submittal and acceptance of a formal System Readiness form signed by the appropriate sub contractors.
5. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the installer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.
6. Provide any recommendation for system modification in writing to Owner. Do not make any system modification, including operating parameters and control settings, without prior approval of Owner.

G. Subject to compliance with the above requirements and certifications, provide the services of independent air and water testing and balancing contractor.

3.30 ATTIC STOCK LIST

A. REQUIREMENTS:
1. Provide attic stock of the following quantities and parts for each piece of equipment as follows: Attic stock items shall meet product specifications and be manufactured by the same manufacturer as installed equipment/components.

Equipment/Unit	Parts Description	Quantity
Variable Frequency Drive (VFD)	Indicating Lights	2 of each type
Meters and Gauges	Temperature & Pressure Gauges	2 each
Automatic Temperature Controls	Classroom Space Mounted Temperature Sensors	5
Chemical Treatment	5five gallon Drum of Propylene Glycol (diluted to 20 percent volume)	2
Ductwork Accessories	Fusible Links	5 percent
Exhaust Fans	Complete Set of Belts	1 for each belt driven unit
	Complete Set of Sheaves	1 for each unit
Rooftop and Indoor Air Handling Units (RTU and MAU)	Pre and Final Filters	3 sets of each per unit
	Access Door Gaskets	2 per access door per unit
	Complete Set of Belts	3 of each fan per unit
Condensate Pumps for DCUs / IUs	Condensate Pump	1 per unit
DCU & Hydronic Fan Coil Units	Filters	1 per unit
Unit Heaters	Filters	1 per unit

3.31 INSTALLATION OF FREESTANDING EQUIPMENT SUPPORT SYSTEM

A. Examination:
1. Verify that roofing system is complete and that roof surfaces are smooth, flat, and ready to receive work of this section.
2. Verify that roof surface temperature is at minimum 60 degrees Fahrenheit (15.5 degrees. Celcius) for proper adhesive performance.

B. Preparation:
1. Clean surfaces of roof in areas to receive portable support bases.
   a. Sweep loose gravel from gravel surfaced roofs.
   b. Remove dirt, dust, oils, and other foreign materials.
2. Use care in handling portable support system components during installation, to avoid damage to roofing, flashing, equipment, or related materials.

C. Installation:
1. Equipment Support Systems:

a. Locate bases and support framing as indicated on drawings and as specified herein Provide complete and adequate support of all piping, ducting, and conduit; whether or not all required devices are shown.
b. The use of wood for supporting piping is not permitted.
c. Provide support spacing so deflection of piping does not exceed 1/240 of span.
d. Install framing at spacing indicated, but in no case at greater than ten feet (3 m) on center.
e. Accurately locate and align bases.

2. Manufacturer of existing or new roofing system as to the type of isolation pads required between the roof and base.
   a. Set isolation pads in adhesive, if required by manufacturer's instructions.
   b. Place bases on isolation pads.
   c. Adhere or mechanically attach, if required by code.
   d. Where applicable, replace gravel around bases.
3. Set framing posts into bases and assemble framing structure as indicated.
4. Use galvanized fasteners for galvanized framing and stainless steel fasteners for stainless steel framing.

D. Field Quality Control:
   1. When requested by the Architect, provide a factory-trained representative of the manufacturer to visit the site while the work is in progress to assure that the installation conforms to the manufacturers design and installation requirements.
E. Cleaning and Protection:
   1. Remove all packaging, unused fasteners, adhesive and other installation materials from the project site.
   2. Remove adhesive from exposed surfaces of supports and bases, and leave the work area in clean condition.
   3. Provide protection as required, leaving the work area in undamaged condition at the time of completion of work.

END OF SECTION

SECTION 23 05 48
VIBRATION CONTROL AND SEISMIC RESTRAINT

(Part of Sections 230000 & 260000 Filed Sub-Bid)

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SECTION 23 05 48

VIBRATION CONTROL AND SEISMIC RESTRAINT

(Part of Sections 230000 & 260000 Filed Sub-Bid)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.02 DESCRIPTION

A. General: The work noted within Section 230548 is referenced by Divisions 23 & 26. Provide all necessary labor & material in each division as required herein.

B. Intent:

1. All mechanical, plumbing, fire protection & electrical equipment, piping, conduits and ductwork shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.
2. All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.
3. It is the intent of the seismic portion of this specification to keep all mechanical, plumbing, fire protection and electrical building system components in place during a seismic event.
4. All such systems must be installed in strict accordance with seismic codes, component manufacturer's, and building construction standards. Whenever a conflict occurs between the manufacturer's or construction standards, the most stringent shall apply.
5. Where seismic restraints are required by code, this specification is considered to be minimum requirements for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state or local construction requirements (i.e. California Title 24, California OSHPD, Canadian Building Codes, or other requirements). Refer to Section 1.4 for Code and Standard requirements.
6. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.

C. The work in this section includes, but is not limited to the following:

1. Vibration isolation for piping, conduits, ductwork and equipment.
2. Equipment isolation bases.
3. Flexible piping connections.
4. Seismic restraints for isolated equipment.
5. Seismic restraints for non-isolated equipment.
6. Certification of seismic restraint designs and installation supervision.
7. Certification of seismic attachment of housekeeping pads.
8. All mechanical, plumbing, fire protection and electrical systems. Equipment buried underground is excluded but entry of services through the foundation wall is included. Equipment referred to below is typical. (Equipment not listed is still included in this specification).

AC Units	Heat Exchangers
Air Cooled Condensing Units	Light Fixtures
Air Separators	Piping
Bus Ducts	Pumps (all types)
Cable Trays	Rooftop and Air Handling Units

Heat Pump Chillers	Switchgear
Conduit	Tanks (all types)
Ductwork	Transformers
Electrical Panels	Unit Heaters
Fans (all types)	Variable Frequency Drives
Generators	VAV Boxes

D. Definitions:
   1. Life Safety Systems
      a. All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems.
      b. All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers, and all flowpaths to fire protection and/or emergency lighting systems.
      c. All medical and life support systems.
      d. Fresh air & relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.
   2. Positive Attachment
      a. A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection, electrical conduit, bus duct, or cable trays, etc. are not acceptable as seismic anchor points.
   3. Transverse Bracing
      a. Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.
   4. Longitudinal Bracing
      a. Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

1.03 SUBMITTAL DATA REQUIREMENTS

A. In addition to requirements of Section 01 33 00, Administrative Requirements the manufacturer of vibration isolation and seismic restraints shall provide submittals for products as follows:
   1. Descriptive Data
      a. Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification.
      b. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.
   2. Shop Drawings
      a. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
      b. Provide all details of suspension and support for ceiling hung equipment.
      c. Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.
      d. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

3. Seismic Certification and Analysis
    a. The following certification and analysis shall be provided required by code. Refer to Section 1.4 for Code and Standard requirements.
    b. Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.
    c. All restraining devices shall have a pre-approval number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 450 to the weakest mode.
    d. Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embodiment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces required acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.

1.04 CODE AND STANDARDS REQUIREMENTS

A. Typical Applicable Codes, Standards, and Categories:
    1. International Building Code, latest adopted edition with an effective peak acceleration coefficient of 0.15.
    2. Massachusetts State Building Code, latest adopted edition.
    3. Seismic hazard exposure group of I, II, III and seismic performance category of C, D.

1.05 MANUFACTURER'S RESPONSIBILITY

A. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:
    1. Determine vibration isolation and seismic restraint sizes and locations.
    2. Provide vibration isolation and seismic restraints.
    3. Provide calculations and materials if required for restraint of unisolated equipment.
    4. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

1.06 RELATED WORK

A. Housekeeping Pads:
    1. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embodiment.

B. Supplementary Support Steel:
    1. Contractor shall supply supplementary support steel for all equipment, piping, ductwork, etc. including roof mounted equipment.

C. Attachments:
    1. Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

1.07 DESIGN REQUIREMENTS

A. Design isolators for equipment installed outdoors to provide adequate restraint to withstand the force of a 140 mph wind applied to any exposed surface of the isolated equipment. Isolators for outdoor equipment shall have bolt holes for attachment to equipment and to supports. The vibration isolation Vendor shall submit verifying shear and over turning calculations, for their product and equipment installation arrangement, stamped by a licensed Professional Engineer. The design and supply of miscellaneous support steel above and below isolators will not be the responsibility of the vibration isolation manufacturer.

1.08 QUALITY ASSURANCE

A. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.

C. Supply and install any incidental materials such as mounting brackets, attachments and other accessories as may be needed to meet the requirements stated herein, even if not expressly specified or shown on the drawings, without claim for additional payment.

D. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

E. Should any rotating equipment cause excessive noise or vibration when properly installed on the specified isolators, the Contractor shall be responsible for rebalancing, realignment, or other remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

PART 2 - PRODUCTS

2.01 INTENT

A. All vibration isolators and seismic restraints described in this section shall be the product of a single manufacturer. Mason Industry's products are the basis of these specifications; products of other manufacturers are acceptable provided their systems strictly comply with the specification.

B. For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8 inch and/or horizontal permanent deformation greater that 1/4 inch.

2.02 PRODUCT DESCRIPTIONS

A. Vibration Isolators and Seismic Restraints.

GENERAL:

1. All metal parts installed out-of-doors shall be corrosion resistant after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.
2. Isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.
3. Isolator types are scheduled to establish minimum standards. At the Contractor's option, labor-saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories and seismic restraint features must not degrade the isolation performance of the isolators.
4. Static deflection of isolators shall be as provided in the EXECUTION section and as shown on the drawings. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.

SPECIFICATION:

5. Two layers of ¾ inch thick neoprene pad consisting of two inch square waffle modules separated horizontally by a 16-gauge galvanized shim. Load distribution plates shall be used as required. Pads shall be Type Super "W" as manufactured by Mason Industries, Inc., Novia Corporation, VMC Group or equal.

6. Bridge-bearing neoprene mountings shall have a minimum static deflection of two inch and all directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications. Mountings shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type BR as manufactured by Mason Industries, Inc.
7. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between 2 steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in three degrees planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge bearing quality. Bushing assemblies shall be type PB as manufactured by Mason Industries, Inc.
8. A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact. Neoprene bushings shall be type HG as manufactured by Mason Industries, Inc.
9. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or ¼ inch neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be Type SLF as manufactured by Mason Industries, Inc.
10. Restrained spring mountings shall have an SLF mounting as described in Specification five, within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ inch shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Pre-approval "R" Number from OSHPD in the state of California certifying the maximum certified horizontal and vertical load ratings. Mountings shall be SLR as manufactured by Mason Industries, Inc.
11. Spring mountings as in specification five built into ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of 1/4 inch travel in all directions before contacting the resilient snubbing collars. Mountings shall have an Anchorage Pre-approval "R" number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be SSLFH as manufactured by Mason Industries, Inc.
12. Air Springs shall be manufactured with upper and lower steel sections connected by a replaceable flexible nylon reinforced neoprene element. Air spring configuration shall be multiple bellows to achieve a maximum natural frequency of 3 Hz. Air Springs shall be designed for a burst pressure that is a minimum of three times the published maximum operating pressure. All air spring systems shall be connected to either the building control air or a supplementary air supply and equipped with three leveling valves to maintain leveling within plus or minus 1/8 inch. Submittals shall include natural frequency, load and damping tests performed by an independent lab or acoustician. Air Springs shall be Type MT and leveling valves Type LV as manufactured by Mason Industries, Inc.

13. Restrained air spring mountings shall have an MT air spring as described in Specification 8, within a rigid housing that includes vertical limit stops to prevent air spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ inch shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation. Housing shall be designed to resist all seismic forces. Mountings shall be SLR-MT as manufactured by Mason Industries, Inc.
14. Hangers shall consist of rigid steel frames containing minimum 1 1/ inch thick neoprene elements at the top and a steel spring with general characteristics as in specification five seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability, the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degrees arc from side to side before contacting the rod bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30 degrees capability. Hangers shall be type 30 degrees as manufactured by Mason Industries, Inc.
15. Hangers shall be as described in specifications 10, but they shall be pre-compressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30 degrees capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc.
16. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.
17. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of two and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage pre-approval "R" number from OSHPD in the state of California verifying the maximum certified load ratings. Solid seismic brace assemblies shall be type SSB as manufactured by Mason Industries, Inc.

    Note: Specifications 12 - 14 apply to trapeze as well as clevis hanger locations. At trapeze anchor locations piping must be shackled to the trapeze. Specifications apply to hanging equipment as well.
18. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California. Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.
19. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose performed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California. Clevis cross brace shall be type CCB as manufactured by Mason Industries, Inc.

20. All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4 inch thick. Rated loading shall not exceed 1,000 Pounds per square foot A minimum air gap of 1/8 inch shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated. Snubbers shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Snubber shall be Type Z-1 225 as manufactured by Mason Industries, Inc.
21. All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing specifications. Elastomeric materials shall be replaceable and a minimum of ¾ inch thick. Rated loadings shall not exceed 1,000 Pounds per square foot . Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8 inch nor more that ¼ inch. Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8 inch deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to ½ inch deflection in the x, y and z planes. Snubbers shall have an anchorage pre-approval "R" number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings. Snubbers shall be series Z-101 1 as manufactured by Mason Industries, Inc.
22. Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.0 Evaluation Service, Inc. verifying its allowable loads. Drill-in stud wedge anchors shall be type SAS as manufactured by Mason Industries, Inc.
23. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.0 Evaluation Service, Inc. verifying to its allowable loads. Drill-in female wedge anchors shall be type SAB as manufactured by Mason Industries, Inc.
24. Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case pump shall include supports for suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14 feet provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of one inch. Bases shall be type WF as manufactured by Mason Industries, Inc.
25. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows. Bases shall be a minimum of 1/1 2 of the longest dimension of the base but not less than six inch. The base depth need not exceed 1 2 inch unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of ½ inch bars welded in place on six inch centers running both ways in a layer 1 ½ inch above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a one inch. clearance below the base. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable. Base shall be type BMK or K as manufactured by Mason Industries, Inc.

26. Roof Curb (by HVAC Contractor)
    a. Curb mounted rooftop equipment shall be mounted on structural spring isolation curbs that bear directly on the roof support structure, and are flashed and waterproofed into the roof's membrane waterproofing system. All spring locations shall have removable waterproof covers to allow for spring adjustment and/or removal. Springs shall be Type A.
    b. Unit shall be provided with wood nailer and flashing.
    c. Curbs shall meet all NRCA Standards.
    d. Curbs shall be similar to Novia Associates VibCurb III or equal having a minimum three inch rated static deflection and be 24 inch high.
    e. Vibration control: The spring roof curb shall have the top isolated or floating rail attached in a manner to the fixed lower portion of the curb without short circuiting or bridging between the two. Restraining bolt(s) or threaded rod shall be of sufficient size to withstand the applied wind & or seismic forces at each spring pack location.
    f. An alignment bolt shall be installed before connecting the floating to non-floating parts to guarantee perfect centering of the restraining bolts.
    g. Weather proofing & air seal: The spring curb must keep the weather (air and water) out and any airflow from the RTU in. The weather seal must not have the ability to fail and allow water or air into the building.
    h. The use of exposed exterior neoprene or some other elastomer material to seal the top floating rail from the base of the curb in not acceptable.
    i. Vibration Mountings: Provide a rubber gasket covered by formed galvanized sheet metal top flashing that overhangs the top wood nailer and galvanized bottom flashing. The overlapping shall effectively cover the rubber gasket so it is protected from the elements.
    j. The top flashing / support rail shall be 14 ga. G60–Zc steel formed with 90 bends that extend down to the wood nailer. Provide a counter flashing member with a sponge gasket attached that presses up against the horizontal bend. The seal shall be replaceable, protected from the elements and easy to install.
    k. Curb side material: Provide 12 Ga. G60 galvanized steel for curb side construction. All side and end seam between sheets shall be continuously welded, corner joints to be caulked and bolted.
    l. Structural Capability:
        1) Curbs shall be installed on metal decking/concrete slab. Air handling unit load shall be properly distributed. Coordinate curb construction with pitch of roof. Curbs shall be built to match the roof pitch in accordance with all requirements of this project. Positive attachment of the curb to the structure is imperative. Pitch correction shall be fabricated from 12-gauge galvanized material and be continuous on all sides and ends. Field fabricated and installed tube steel stub-ups are not acceptable. HVAC contractor shall provide detailed information to the curb manufacturer
        2) pitch correction.
        3) Plenum Sections: The side material must be capable of handling the static pressure developed by the fans and not ‘oil can’. Provide spanning bar joists as required to support plenum installation (even when the spring pockets are center span).
        4) Provide a continuous bottom tube steel member or side material of sufficient strength. Mechanical contractor shall coordinate and verify all dimensions, weights, roof penetrations, etc. with the Structural Engineer prior to installation.
        5) Curb Insulation: Provide spring curbs with a space between the floating and non-floating parts for the installation of insulation. Curb manufacturer shall provide factory installed insulation adhered to roof curb. Curbs shall be externally factory insulated with a 1.7 inch thick R-12 foam insulation, FM Class one and UL Class A Ratings, with bonded fiber reinforced facer.
    m. Protection: Curbs shall be completely shrink-wrapped during shipping.

n. Mechanical contractor shall provide all necessary materials to completely weather proof and sound proof the curb installation.

o. Additional features:

1) Sound barrier: Provide a sound barrier package, consisting of G60 galvanized back-to-back angles. Sound barrier package shall be capable of supporting two layers of ½ inch concrete board with a maximum deflection over the width of the curb of L/360. Cement board furnished and installed by the HVAC Contractor. Overlap all joints, caulk all seams and edges. Transmission Loss & STC shall be as shown as follows. Sound Transmission Loss at Frequency (Cycles per second) of (125)=20, (250)=27, (500)=30, (1000)=32, (2000)=30, (4000)=38, (STC)=31.

2) Provide with framed Supply & Return air duct openings. Openings shall match duct sizes and have one inch galvanized steel flanges.

3) Plenum sections: Where indicated on the drawings, provide in the interior of the curb, double wall acoustical floor, walls and plenum divider. All insulation shall be two inch thick fiber glass acoustical duct liner with reinforced coating system. Insulation acoustical performance shall be as follows. Liner shall not support microbial growth and shall be EPA registered and pass ASTM C 1071 & ASTM G21 bacterial tests conducted in accordance with ASTM G22. Floors up to 90 inch curb I.D. width shall be constructed of 22 Ga., 20 Ga. thereafter, solid G60 galvanized bottom panels and 22 Ga. galvanized perforated 22.7percent open area top panel. Floor shall be attached to walls and plenum divider to provide an airtight plenum. Walls shall have 22 Ga. galvanized perforated 22.7% open area inside panels. Plenum divider shall be double wall 22 Ga. perforated galvanized 22.7% open area panel on the supply side with a 14 gauge solid panel opposite. Sound Absorption Coefficient at Frequency (Cycles per second) of (125)=.23, (250)=.64, (500)=.99, (1000)=1.05, (2000)=1.00, (4000)=.98, (NRC)=.90.

27. Flexible spherical expansion joints shall employ peroxide cured EPDM in the covers, liners and Dacron tire cord friction ring. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes two inch and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16 feet to 24 inch may be single sphere. Sizes ¾ inch to 1 ½ inch may have threaded bolted flange assemblies, one sphere and cable retention. 14 inch and smaller connectors shall be rated at 250 Pounds per square foot up to 190 degrees Fahrenheit. with a uniform drop in allowable pressure to 190 Pounds per square foot at 250 degrees Fahrenheit. 16 inch and larger connectors are rated 180 Pounds per square foot at 190 degrees Fahrenheit. and 135 Pounds per square foot at 250 degrees Fahrenheit.. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a five-minute factory test at twice the rated pressure. Concentric reducers to the above specifications may be substituted for equal ended expansion joints.

Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2 inch thick Neoprene washer bushings large enough in area to take the thrust at 1000 Pounds per square foot maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves.

Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc.

28. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes three inch and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

Flanged		Male Nipples	
3 x 14	10 x 26	1/2 x 9	1-1/2 x 13
4 x 15	12 x 28	3/4 x 10	2 x 14
5 x 19	14 x 30	1 x 11	2-1/2 x 18
6 x 20	16 x 32	1-1/4 x 12	
8 x 22			

Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be type BSS as manufactured by Mason Industries, Inc.

29. All-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum 1/2 inch thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 Pounds per square foot and the design shall be balanced for equal resistance in any direction. All-directional anchors shall be type ADA as manufactured by Mason Industries, Inc.
30. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2 inch thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of + 1 5/8 inch motion, or to meet location requirements. Pipe guides shall be type VSG as manufactured by Mason Industries, Inc.
31. Split Wall Seals consist of two bolted pipe halves with minimum 3/4 inch thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of one inch. past either face of the wall. Where temperatures exceed 240 degrees Fahrenheit, 10 number density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.
32. The horizontal thrust restraint shall consist of a spring element in series with a neoprene molded cup as described in specification five with the same deflection as specified for the mountings or hangers. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of ¼ inch movement at start and stop. The assembly shall be furnished with one rod and angle brackets for attachment to both the equipment and the duct work or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Horizontal thrust restraints shall be type WBI/WBD as manufactured by Mason Industries, Inc.

PART 3 - EXECUTION

3.01 GENERAL

A. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data. At the completion of all construction work the vibration and seismic device supplier shall inspect all installations and provided a written report of installation compliance to the engineer of record. A copy of this written certification shall also be provided in the operations manual provided to the owner.

B. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.

C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

E. Coordinate work with other trades to avoid rigid contact with the building.

F. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineer's attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.

G. Bring to the architects/engineer's attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractor's expense.

H. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractor's expense.

I. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:

1. Flanges of structural beams.
2. Upper truss cords in bar joist construction.
3. Cast in place inserts or wedge type drill-in concrete anchors.

J. Specification 12 cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.

K. Specification 12 cable assemblies are installed taut on non-isolated systems. Specification 13 seismic solid braces may be used in place of cables on rigidly attached systems only.

L. At locations where specification 12 or 13 restraints are located, the support rods must be braced when necessary to accept compressive loads with specification 14 braces.

M. At all locations where specification 12 or 13 restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with specification type 15 braces.

N. Drill-in concrete anchors for ceiling and wall installation shall be specification type 18, and specification type 19 female wedge type for floor mounted equipment.

O. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted on this project.

P. Hand built elastomeric expansion joints may be used when pipe sizes exceed 24 inch or specified movements exceed specification 23 capabilities.

Q. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide specification 27 wall seals.

R. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraint shall be specification type 28.

S. Locate isolation hangers as near to the overhead support structure as possible.

3.02 VIBRATION ISOLATION AND SEISMIC RESTRAINT OF PIPING, DUCTWORK, AND CONDUIT

A. Where piping connects to rotating or vibrating mechanical equipment install specification 23 expansion joints or specification 24 stainless hoses if 23 is not suitable for the service.

B. Seismic Restraint of Piping:

1. Seismically restrain all piping listed as a, b or c below. Use specification 12 cables.
    a. Fuel oil piping and compressed air piping.
    b. Piping located in boiler rooms, mechanical equipment rooms, and refrigeration equipment rooms that is 1-1/4 inch I.D. and larger.
    c. All other piping 2-1/2 inch diameter and larger.

2. Transverse piping restraints shall be at 40 feet maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
3. Longitudinal restraints shall be at 80 feet maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
4. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
5. For fuel oil piping transverse restraints must be at 20 feet maximum and longitudinal restraints at 40 feet maximum spacing.
6. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24 inch of the elbow or TEE or combined stresses are within allowable limits at longer distances.
7. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.
8. Branch lines may not be used to restrain main lines.

C. Pipe Isolation
1. All chilled water, condenser water, hot water, steam, refrigerant, drain and engine exhaust piping that is connected to vibration-isolated equipment shall be isolated from the building structure within the following limits:

   Within mechanical rooms;

   Within 50 feet total pipe length of connected vibration-isolated equipment (chillers, pumps, air handling units, pressure reducing stations, etc.);

   At every support point for piping that is greater than four inches in diameter.
2. Piping shall be isolated from the building structure by means of vibration isolators, resilient lateral supports, and resilient penetration sleeve/seals.
3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than ½ inch, Type FSN or HSN isolators shall be used. When the required static deflection is less than or equal to ½ inch, Type FN or HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or HN achieving at least ¼ inch static deflection.
4. Where lateral support of pipes is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
6. Provide flexible pipe connections as called for under Major Equipment above and wherever shown on the drawings.

D. Seismic restraint of ductwork:
1. Seismically restrain all duct work with specification 12 or 13 restraints as listed below:
   a. Restrain rectangular ducts with cross sectional area of six square feet. or larger.
   b. Restrain round ducts with diameters of 28 inch or larger.
   c. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.
      1) Transverse restraints shall occur at 30 feet intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.
      2) Longitudinal restraints shall occur at 60 feet intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within four feet of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.

3) The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.
4) A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
5) Walls, including gypsum board nonbearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

E. Duct Isolation:
1. All sheet metal ducts and air plenums that are within mechanical rooms or within a distance of 50 feet total duct length of connected vibration-isolated equipment (whichever is longer) shall be isolated from the building structure by Type FN, PCF or HN isolators. All isolators shall achieve once inch minimum static deflection.
2. Ducts within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
3. Flexible duct connections shall be provided as called for above under Major Equipment and wherever shown on the drawings.

F. Seismic Restraint of Electrical Services:
1. All electrical conduit 2-1/2 inch in diameter and larger shall be restrained with specification type 12 seismic cable restraints or specification type 13 for seismic solid brace restraints.
2. All electrical bus ducts, cable trays and ladder trays shall be restrained with specification type 12, seismic cable restraints or specification 13 seismic solid brace restraints.
3. Transverse restraints shall occur at 30 feet intervals or both ends if the electrical run is less than the specified interval. Transverse restraints shall be installed at each electrical services turn and at each end of the electric run.
4. Longitudinal restraints shall occur at 60 feet intervals with at least one restraint per electric run. Transverse restraints for one electric section may also act as a longitudinal restraint for a duct for an electric section connected perpendicular to it if the restraints are installed within four feet of the intersection of the electric run and if the restraints are sized for the larger electric run.
5. All rigid floor mounted equipment must have a resilient media between the equipment mounting hole and the anchor bolt. Neoprene bushings shall be specification type four and anchor bolts shall be specification type 18 or 19.
6. Wall mounted panels shall be mounted with specification type three bushings. Floor mounted panels shall be mounted on specification type four bushings. Anchor bolts shall be specification type 18 or 19.

G. All fire protection piping shall be braced in accordance with NFPA 13 and 14.

H. All mechanical equipment shall be vibration isolated and seismically restrained.
1. All fire protection equipment is considered life safety equipment and shall be seismically restrained.

3.03 SEISMIC RESTRAINT EXCLUSIONS

A. General:
1. Fire Protection, Plumbing, Mechanical and Electrical Components to be installed within seismic design category “B” shall be exempt from the seismic requirements within this specification in accordance with ASCE-7 (2010). Refer to the Structural Drawings and Specifications for Project Design Category.

B. Piping:
1. All piping less than 2 1/2 inch except for fire protection piping.
2. All piping in boiler and mechanical equipment rooms less than 1 1/4 inch I.D.

3. All clevis or trapeze supported piping suspended from hanger rods where the point of attachment is less than the 12 inch in length from the structure to the structural connection of the clevis or trapeze.
    a. All PVC and fiberglass suspended waste or vent pipe six inch in diameter and smaller.

C. Ductwork:
1. Rectangular, square or oval ducts less than six square feet in cross sectional area.
2. Round duct less than 28 inch in diameter.
3. Duct supported by hanger rods where the point of attachment is less than 12 inch in length from the structure to the structural connection of the duct work.

D. Electrical:
1. All conduit less than 2 1/2 inch diameter suspended by individual hanger rods.
2. All clevis or trapeze supported conduits suspended by hanger rods where the point of attachment is less than 1 2 inch in length from the structure to the structural connection of the clevis or trapeze.

3.04 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General
1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolators
1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
2. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft unless this is not possible because of physical constraints.
3. Locate isolators to provide stable support for equipment, without excess rocking.
4. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein.
5. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
6. Hanger rods for vibration-isolated support shall be connected to major structural
7. members, not the floor slab between major structural members. Provide suitable intermediate support members as necessary.
8. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the anger housing may rotate a full 360 degrees. about the rod axis without contacting any object.
9. Parallel running pipes may be hung together on a trapeze that is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and unisolated pipes on the same trapeze.
    a. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
    b. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.

c. The installed and operating heights of equipment supported by Type FSNTL isolators or with Type RC-2 isolation bases shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide ¼ inch clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.

d. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases

1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements and is not specifically called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.
2. Unless otherwise indicated, there is to be a minimum operating clearance of one inch between steel rails, steel frame bases or inertia bases and the floor beneath the equipment. The isolator mounting brackets shall be positioned and the isolators adjusted so that the required clearance is maintained. The clearance space shall be checked by the Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.
3. Isolation bases shall be installed in strict accordance with the manufacturer’s instructions.

D. Flexible Duct Connections:

1. Prior to installation of the flexible connection, sheet metal ducts and plenum openings shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section, and the gap between connected parts shall be uniform. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

E. Flexible Pipe Connections:

1. Install flexible pipe connections in strict accordance with the manufacturer's instructions.

F. Thrust Restraints:

1. Thrust restraints shall be attached on each side of the fan parallel to the thrust force. This may require custom brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

G. Grommets:

1. Where grommets are required at hold down bolts of isolators, bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers shall be galvanized.

H. Resilient Penetration Sleeve/Seals:

1. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

END OF SECTION

SECTION 26 00 01
ELECTRICAL TRADE BID SUMMARY

PART 1 GENERAL

1.01 FILING OF TRADE BIDS

A. Trade Bids are required for work under this section in accordance with the provisions of the General Laws of the State of Massachusetts, Chapter 149A, Sections 1-8, 10, and 11, as most recently amended.

B. Trade Bids shall be submitted to the Awarding Authority as set forth in the Invitation to Bids and the Instructions to Bidders, accompanied by the bid deposit specified therein.

C. Every Trade Bid for work under this section shall be on the form in this Project Manual furnished by the Awarding Authority.

1.02 GENERAL REQUIREMENTS

A. The General and Supplementary Conditions of the Contract, Construction Manager's Scoping Documents, and General Requirements of the Project Manual, including without exception all sections in Divisions 00 and 01, apply to the Electrical Trade Contractor, material suppliers, and all other persons furnishing labor and materials under this section.

B. Examine all project specifications and drawings for requirements that affect work of this section whether or not such work is specifically mentioned in this section.

C. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.

D. The following definitions apply to the drawings and specifications:

1. Furnish: The term "furnish" is used to mean "supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations".
2. Install: The term "install" is used to describe operations at the project site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
3. Provide: The term "provide" is used to mean "furnish and install, complete and ready for the intended use".
4. Installer: An "installer" is the subcontractor or an entity engaged by the subcontractor, either as an employee or sub-subcontractor for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.

E. When open-flame or spark-producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the Construction Manager shall be notified not less than 24 hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant dedicated fire watch who is not otherwise employed as installation labor, where work is being performed until it is completed.

1.03 DESCRIPTION

A. The work of this Trade Bid section shall include all furnishing and installation of complete electrical, communications, and building security systems for the project, as shown on drawings, as described in the specifications, or as reasonably inferred from either, in the judgment of the Architect.

B. The work of this Trade Bid section may be (but is not exclusively) shown on the drawings by the section number 26 00 01 or the abbreviation "SC-ELECT".

C. The work of this Trade Bid section shall include the scope of each of the following sections in their entirety:
   1. Section 26 00 10 - Electrical.
   2. Section 27 00 00 - Communications Systems.
   3. Section 27 10 00 - Structured Cabling.
   4. Section 27 41 00 - Audio Visual Systems.
   5. Section 27 51 20 - Speech Reinforcement System.
   6. Section 28 00 00 - Electronic Security Systems.

D. The work of this Trade Bid section shall include part of the scope of each of the following sections:
   1. Section 01 51 00 - Temporary Utilities: for provision of temporary power and lighting systems and components.
   2. Section 07 84 00 - Firestopping: for material and installation requirements related to firestopping by this subcontractor at penetrations of fire rated assemblies (floors, walls, and ceilings) by the work by this section.
   3. Section 08 31 00 - Access Doors and Panels: for material and installation requirements related to access doors and frames required to access concealed components of this Section, to be furnished by this subcontractor to Section 06 20 00 - Finish Carpentry for installation..
   4. Section 08 71 00 - Door Hardware: coordination with security hardware requirements including access control, electrically-operated locks and exit devices, power transfers, door openers, fire alarm system, related power supplies, associated door hardware power requirements, and _____. This subcontractor shall perform the following work:
      a. At removable electrified mullions, field-modify the wiring harness to relocate the quick disconnect coupler to within 6 inches of the top of the mullion to permit easier removal of the mullion by the end users.
   5. Section 10 14 23 - General Signage: for provision of power and final connection to lighted panel signage.
   6. Section 10 43 00 - Emergency Aid Specialties: for provision of power and communication to AED units.
   7. Section 10 44 00 - Fire Protection Specialties: for provision of power and alarm cabling to cabinets.
   8. Section _____: for connection, by this Trade Contractor, of hoods, dishwasher vents, and other components provided and installed by the Construction Manager, including external wiring, the mounting and wiring of motor starters, solenoid valves, switches and receptacles not integral with the equipment.
   9. Section 11 52 13 - Projection Screens: for electrical supply conduit and wiring to projection screens.
   10. Section 11 61 43 - Stage Curtains: for provision of power and final connection to powered rigging equipment.
   11. Section 11 66 23 - Gymnasium Equipment: for electrical supply conduit and wiring to gymnasium equipment.
   12. Section 11 95 13 - Kilns: for electrical supply conduit and wiring to kilns and downdraft systems.
   13. Section 12 24 00 - Window Shades: for provision of power, electric motors and controls, and final connections to powered window shades.
   14. Section 12 32 00 - Manufactured Wood Casework: for furnishing and installation of electrical wiring, conduit and devices mounted in wood casework.

15. Section 12 66 13 - Telescoping Bleachers: for provision of power, electric motors and controls, and final connection to motor operated bleachers.
16. Section 14 24 00 - Hydraulic Elevators: for electrical service to elevator equipment and wiring between components not provided by the elevator installer by Division 26 and voice communication between machine room and cab by Division 27.
17. Section 23 04 58.10 - Vibration Control and Seismic Restraint: For requirements related to seismic bracing of components to be provided by this subcontractor.

E. This subcontractor shall fully coordinate the execution of the work of this section with, and anticipate the requirements of the following sections:
1. Division 01 91 13 - MEP Commissioning Requirements: list of equipment to be commissioned and requirements for cooperation with the Commissioning Agent.
2. Section 04 20 00 - Unit Masonry: coordination of sleeves and conduit.
3. Section 08 36 13 - Sectional Doors: For provision of power to overhead door operators, sensors, and other electrically-operated devices.
4. Section 09 21 16 - Gypsum Board Assemblies: coordination of sleeves and penetrations.
5. Section 09 30 00 - Tiling: junction boxes and devices in tiled surfaces.
6. Section 09 91 13 - Exterior Painting: preparation of exposed exterior piping to be painted.
7. Section 09 91 23 - Interior Painting: preparation of exposed interior piping to be painted.
8. Section 10 26 41 - Ballistics Resistant Panels: bullet resistant protection at junction boxes and penetrations of bullet resistant walls.
9. Section 22 00 10 - Plumbing: For provision of power to electrically-operated pumps and other devices.

F. Sub-Sub Bid Requirements:
1. Each Trade Bidder shall list in Paragraph E of 00 41 01 - Form for Trade Contractor Bid the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the section of the specifications for that sub-trade requires such listing; provided that, in the absence of a contrary provision in the specifications, any sub-bidder may, without listing any bid price, list their own name in said Paragraph E for any such class of work or part thereof and perform that work with persons on sub-bidder's own payroll, if such sub-bidder, after sub-bid openings, establishes to the acceptance of the Awarding Authority that sub-bidder does customarily perform such class or part thereof with persons on sub-bidder's own payroll and is qualified to do so. This section requires that the following class(es) of work shall be listed in Paragraph E under the conditions indicated herein.
    a. Lightning Protection as described in Paragraph _____ and related installation requirements in Paragraph ____ of Part 3 of Section 26 00 10.
    b. Building Fire Alarm and Detection System as described in Paragraph _____ and applicable installation requirement in Paragraph ____ of Part 3 of Section 26 00 10.
    c. Communications systems, as described in Division 27 - Communications sections.
    d. Electronic Safety and Security, as described in Division 28 - Electronic Safety and Security sections.
2. See Section 00 21 13 - Instructions to Bidders FILED SUB-BIDS Paragraph, and Section 00 41 02 - Form for Filed Sub-Bid for additional instructions regarding "Paragraph E" Sub-Sub Bids.

G. Primary Drawings listed are those intended to indicate the scope of work for this Trade Contract.
1. List of Primary Drawings: To be provided prior to the release of Bid Set.
2. This subcontractor shall review all remaining drawings that may show additional information relating to specific installation conditions and information that may be required to calculate

exact quantities, determine specific installation requirements, or generally coordinate the work with other trades.

3. Additionally, this subcontractor must include in the List of Primary Drawings: _____, Code Plans, Phasing Plans, Demolition Plans, and all project detail sheets for general and code-related information, installation or other conditions and instructions that directly affect their work.

H. Staging and Scaffolding: The work of this Trade Bid section shall include the provision of staging and scaffolding (including design, engineering, erection, maintenance, and removal) where required to complete the work of this Trade Bid category.
   1. See Section 01 50 00 - Temporary Facilities and Controls for additional information.

I. Temporary Hoisting Equipment, Lifts, and Machinery: The work of this Trade Bid section shall include all temporary hoisting equipment, lifts, and machinery required to complete the work of this Trade Bid category. All hoisting equipment, lifts, and machinery and operation shall comply in all respects to the governing laws and codes.
   1. See Section 01 50 00 - Temporary Facilities and Controls for additional information.

J. Cutting and Patching:
   1. This Trade Contractor shall perform all cutting and coring required to complete the work of this Trade Bid category, except as specifically indicated in the respective Trade Contract sections. Where any of the sections listed as part of this Trade Bid indicate that cutting and coring shall be performed by others, the cost of such cutting and coring necessary for the work of this section shall be borne by this Trade Contractor.
   2. All patching required to complete the work of this Trade Bid shall be performed by the appropriate trade, and the cost of such patching necessary for the work of this section shall be borne by this Trade Contractor.
   3. All cutting, coring, and patching shall be coordinated through and by the Construction Manager.
   4. Any and all cutting of structural members, including floor slabs, shall require approval of the Structural Engineer of Record; see Structural Drawings for typical penetrations and openings in structural members, including floor slabs. For any openings outside the parameters of those shown on Structural Drawings, obtain approval from Structural Engineer of Record.

1.04 REFERENCE STANDARDS

A. See each individual technical specification section listed above for Reference Standards.

1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. See each individual technical specification section listed above for required product information, samples, shop drawings, and other submittals required.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: Independent firm specializing in performing testing and inspections of the type specified in this section.

B. See each individual technical specification section listed above for additional requirements.

C. See Section 01 40 00 - Quality Requirements for additional requirements.

1.07 LEED REQUIREMENTS

A. This project is intended to be certified as a LEED for Schools v4/v4.1 building, with a rating of LEED "Silver". See Section 01 81 14 - LEED for Schools v4/v4.1 Project Scorecard for projected LEED credits. Some product and material selections, and some performance requirements of this section are required to achieve the credits listed.

B. Prior to any product submittals, the Electrical Trade Contractor shall assist the Construction Manager in the creation of a LEED action plan identifying products that will contribute toward

LEED credits. The LEED Action Plan shall be submitted prior to any product submittals to assist the Architect in evaluating product submittals that must meet LEED criteria.

C. The Electrical Trade Contractor shall provide all documentation indicating applicability of all products of this section to potential LEED credits to the project LEED Administrator for submission to www.leedonline.com. See Section 01 81 13 - Sustainable Design Requirements for additional requirements.

1.08 WARRANTY

A. See Sections 01 70 00 - Execution and Closeout Requirements and 01 78 00 - Closeout Submittals , for additional warranty requirements.

B. See each individual technical specification section listed above for specific warranties required.

PART 2 PRODUCTS (SEE EACH INDIVIDUAL SPECIFICATION SECTION LISTED ABOVE FOR PRODUCT REQUIREMENTS)

PART 3 EXECUTION (SEE EACH INDIVIDUAL SPECIFICATION SECTION LISTED ABOVE FOR ADDITIONAL EXECUTION REQUIREMENTS)

3.01 CLEANING

A. Electrical Trade Contractor shall be responsible for cleaning up Electrical Trade Contractor's own work at the end of each day, and depositing waste and debris created by Electrical Trade Contractor's work in the appropriate dumpsters, separating eligible products for recycling, and depositing recycling in designated recycling containers. Dumpsters shall be provided and maintained (including payment of costs for legal disposal off-site) by the Construction Manager.

1. See Section 01 50 00 - Temporary Facilities and Controls.
2. See Section 01 74 19 - Construction Waste Management and Disposal.

END OF SECTION

SECTION 26 00 10
ELECTRICAL

(Filed Sub-Bid Required)

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SECTION 26 00 10
ELECTRICAL

(Filed Sub-Bid Required)

PART 1 GENERAL

1.01 FILED SUB-BID REQUIRED

A. The work of this section shall be included in the Electrical Subcontractor Sub Bid. Refer to Section 26 00 01 ELECTRICAL FILED SUB-BID SUMMARY for additional requirements.

1.02 DESCRIPTION OF WORK

A. Work described herein shall be interpreted as work to be done by the Electrical Subcontractor. Work to be performed by other trades will be referenced to a particular Sub-Contractor or subcontractor.

B. This Contractor shall also examine all other Drawings and all other Sections of the Specifications for requirements therein affecting the Work of this Section, not just those pertaining to this Sub-trade. Where The drawings for this contractors work reference another trades drawing for information, that referenced scope shall be provided in this contractors bid.

C. Where the Contract drawings conflict with themselves or the specifications, Electrical Sub-contractor shall carry the higher quantity or quality.

D. Provide all labor, materials, tools, and equipment, to complete the installation of the electrical system. Install, equip, adjust, and put into operation the respective portions of the installation specified, and so interconnect various items or sections of work in order to form a complete and operating whole. Systems may be referenced in singular or plural terms, also refer to drawings to confirm quantities. The work shall consist of, but shall not necessarily be limited to, the following:

1. Primary, secondary and low tension ductbanks, manholes, handholes, pre-cast bases, specified herein and as indicated on drawings.
2. Secondary distribution equipment, including secondary switchboard, metering, motor controls, variable frequency drives, dry-type transformers, distribution panels, and panelboards, including feeders and subfeeders.
3. Sub-metering equipment, wiring and bacnet interface with BMS system.
4. Fire alarm system, voice evacuation with integrated mass notification system.
5. Emergency power distribution system including diesel generator, automatic transfer switches, manual transfer switches, MI cable, by-pass relays, emergency lighting, exit signs, and all other equipment and fixtures associated with emergency systems.
6. Lighting systems exterior and interior fixtures, and a complete automated addressable lighting control system with all sensors occupancy, daylight, photosensors, switches and Bacnet BMS integration.
7. All raceway systems, including boxes, couplings, and fittings.
8. All branch circuit wiring systems, including wiring devices, and plates.
9. Excavation and backfill within building foundation walls for any/all underground raceways
10. Connections for all building equipment, including mechanical, plumbing, fire protection, elevator, owner furnished equipment, and the like.
11. Core drilling for electrical conduit systems, and equipment in accordance with Section 01 70 00 – Execution and Closeout Requirements.
12. Cutting through non-masonry construction shall be in accordance with Section 01 70 00 – Execution and Closeout Requirements.
13. Systems Identification.
14. Scaffolding, Rigging, and Staging required for all Electrical Work in accordance with Section 01 50 00 – Temporary Facilities and Controls.
15. Electrical vehicle charging equipment provisions.
16. Provisions forroof mounted Photovoltaic Sytsem.

17. Hoisting Equipment and Machinery: Unless otherwise specified, all hoisting equipment and machinery required for the proper and expeditious prosecution and progress of the work shall be furnished, installed, operated and maintained in safe condition by the individual Non Filed Sub-Contractor and Filed Sub-Contractors and is so stated in each appropriately related Section of the Specifications. All costs for hoisting operating services shall be borne by the Non Filed Sub-Contractor and Filed Sub-Contractors unless specifically excepted in the Contract Documents.
    a. A licensed equipment manufacturer's representative will be present at all times, to witness the erection and dismantling of all hoisting equipment and machinery, whenever such equipment is being erected or dismantled. No such work will be performed without the presence of such representative.
    b. Hoisting equipment and machinery erection and dismantling shall be performed only by trained, certified, and experienced riggers qualified to perform such work.
18. Provide Seismic Restraints for all Electrical Systems conforming to the requirements of Section 23 05 48 which section is herein incorporated by reference.
19. Coordination Drawings in accordance with Section 01 31 14 COORDINATION.
20. Communications system provisions including cable tray, 120 volt sources, outlet boxes and raceway system, grounding and firestopping for voice, data, cable TV, paging, intercom, local sound systems and clock system as indicated on electrical and technology drawings and as specified in Division 27 COMMUNICATIONS.
21. Integrated Electronic Security System and Audio/Visual System provisions including outlet boxes and raceway system, cable tray, 120 volt sources, grounding, and firestopping as indicated on Electrical and Security/Audio/Visual drawings and specified in Division 28, Electronic Safety and Security.
22. Meet LEED v4 requirements, refer to Section 01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS.
23. Temporary Power and Lighting, Section 01 51 00. Refer to Section 01 51 00 for temporary power and lighting requirements.
24. Lightning protection system.
25. Furnish access doors and frames in accordance with Section 08 31 00 – Access Doors and Panels.
26. Firestopping of penetrations through fire rated walls, slabs, and partitions in accordance with Section 07 84 00 – Firestopping.
27. Sealing of all penetrations through walls, slabs, partitions, which are not fire rated.
28. Platform dimming and performance lighting system.
29. Electronic Scoreboards
30. Two-Way Communications Call Box System
31. Pedestal mounted electric vehicle charging equipment (EVSE) System
32. Emergency responder radio amplification system (BDA) provisions per Section 27 53 19 inclding outlet boxes and all conduit provisions and interface with fire alarm system.
33. Commissioning requirements per Section 01 91 13 – MEP COMMISSIONING SPECIFICATIONS REQUIREMENTS and 26 08 00 ELECTRICAL SYSTEMS COMMISSIONING.
34. Variable Frequency Drives.
35. Coordination with ATC, Section 23 00 10 HVAC, for all lighting controls and infrastructure.
36. Testing of all equipment installed.
37. Any other item of work hereinafter specified or indicated on the electrical drawings.
38. Sustainable Design Intent: Comply with Project requirements intended to achieve a Certification, measured and documented according to the LEED v4.

1.03 DEFINITIONS

A. Most terms used within the documents are industry standard. Certain words or phrases shall be understood to have specific meanings as follows:
   1. Provide: Furnish and install completely connected up and in operable condition.
   2. Furnish: Purchase and deliver to a specific location within the building or site.
   3. Install: With respect to equipment furnished to this contractor, install means to receive, unpack, move into position, mount and connect, including removal of packaging materials.
   4. Conduit: Raceways of the metallic type which are not flexible. Specific types as specified.
   5. Connect: To wire up, including all branch circuitry, control and disconnection devices so item is complete and ready for operation.
   6. Subject to Mechanical Damage: Equipment and raceways installed exposed and less than eight feet. above finished floor in mechanical rooms or other areas where heavy equipment may be in use or moved.

1.04 ITEMS TO BE FURNISHED ONLY

A. Furnish the following items for installation under designated sections.
   1. Duct smoke detectors and carbon monoxide duct detectors with sampling tube: Section 23 00 10 - HVAC.
   2. Access Panels: Section 08 31 00 – ACCESS DOORS AND PANELS.
   3. Pre-cast pole bases to be installed by Site Sub-Contractor.
   4. Manholes and handholes – installed by Site Sub-Contractor.

1.05 ITEMS TO BE INSTALLED ONLY

A. Install the following items furnished under designated sections.
   1. Specialty Backboxes for Communications, Security, and Audio/Visual, i.e; Speakers.: Division 27 and Division 28.
   2. Power operated window shades – Section 12 24 00 WINDOW SHADES.
   3. Gym equipment motorized winch control system – Section 11 66 23 GYMANSIUM EQUIPMENT

1.06 RELATED REQUIREMENTS

A. The Conditions of the Contract documents and the General Requirements of the Project Manual apply to this subcontractor, material suppliers, and all other persons furnishing labor and materials under this Section. The General Conditions, Supplemental conditions, and applicable parts of Division 00 and 01 are included as part of this Section.

B. Work described in other Sections which contain requirements applicable to the work of this Section, or with which this subcontractor shall coordinate the work of this section include the following:
   1. Section 01 50 00 – Temporary Facilities and Controls: Temporary Controls
   2. Section 01 51 00 - Temporary Utilites: Temporary light and power.
   3. Section 01 91 13 – MEP Commissioning Specifications and 26 08 00 Commissioning of Eletrical Systems: Commissioning of systems and requirements.
   4. Section 03 30 00 – Cast-In-Place Concrete: Switchboard pad.
   5. Section 03 30 00.13 – Cast-In-Place Concrete (Site): Concrete Pads and Duct Envelopes.
   6. Section 07 21 00 – Thermal Insulation: Insulation.
   7. Section 07 84 00 – Firestopping: product and installation requirements for firestopping to be furnished and installed by Electrical Sub-Sub-Contractor.
   8. Section 08 33 26 overhead coiling grilles, 08 36 13-Sectional Doors
   9. Section 10 22 39-Folding Panel Partitions
   10. Section 11 61 43-Stage Curtains
   11. Section 12 66 13-Telescoping Bleachers
   12. Section 08 71 00 – Door Hardware.
   13. Section 08 31 00 – Access Doors and Panels: Installation of access doors and frames.

14. Section 09 91 13 – Exterior Painting.
15. Section 09 91 23 – Interior Painting.
16. Section 11 30 13 - Appliances – powered appliances.
17. Section 11 52 13 - Projection screens – power to projection screens
18. Section 11 66 23 - Gymnasium Equipment - power to Athletic equipment.
19. Section 11 95 13 – Kilns – power to equipment.
20. Section 14 24 00 – Hydraulic Elevators
21. Section 12 24 00 – installation and Power to motorized window shades
22. Section 23 00 10 – HVAC: Power to mechanical equipment
23. Section 23 00 10 – HVAC: Automatic temperature controls
24. Section 27 53 19 - BDA system
25. Division 27 – Communications: Communications System Wiring and Equipment.
26. Division 28 – Electronic and Safety Security: Integrated Security System Wiring and Equipment
27. Division 31 – Earthwork: Excavation and Backfill, except within building foundation.
28. Division 32 – Exterior Improvements: Site features and furnishings requiring electrical service.
29. Electrical Sub-Contractor shall review and coordinate with the structural drawings, details and specifications for building attachment method and requirements. This applies to all equipment and conduits that are to be hung/supported from the building structure. The Electrical Sub-Contractor shall provide all the necessary supplemental steel, supports, fasteners in accordance with the structural drawings, details and specifications to hang/support all electrical equipment.
30. Cutting and patching in masonry construction, and associated lintels
31. Patching of non-masonry construction.
32. Hoisting Equipment and Machinery: All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Filed Sub-Contractor shall be furnished, installed, operated and maintained in safe conditions by this Filed Sub-Contractor, as referenced under Section 01 50 00 - Temporary Facilities and Controls.

1.07 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 01 91 13 – MEP COMMISSIONING and 260800 ELECTRICAL SYSTEMS COMMISSIONING
B. Complete installation and startup checks and functional tests according to Section 01 91 13 – MEP COMMISIONING SPECIFICATIONS and 260800 ELECTRICAL SYSTEMS COMMISSIONING
C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start-up procedure.
D. Verify that equipment is installed and commissioned as per requirements of Section 01 91 13 - MEP COMMISIONING SPECIFICATIONS and 260800 ELECTRICAL SYSTEMS COMMISSIONING manufacturers written instructions/requirements.
E. Inform Commissioning Agent at least one week prior to startup and/or programming of lighting control system.

1.08 ENVIRONMENTAL REQUIREMENTS

A. The work of this section shall comply with requirements of the following:
    1. SECTION 01 30 00 – Administrative Requirments
    2. SECTION 01 81 13 Sustainable Design Requirements.
    3. SECTION 01 81 13.10– LEED v4 BD+C
    4. SECTION 01 81 13.20 – LEED Product Data Submittal – Sustainable Attributes Reorting Form.
    5. SECTION 01 81 13.40 – LEED Materials Tracking Matrix

6. SECTION 01 81 19 - Indoor Air Quality Requirements

1.09 CONTRACT COST BREAKDOWN

A. Submit a breakdown of contract price to aid Architect in determining value of work installed as job progresses. The submission shall be broken out by sitework, and per building. Each should then be further broken out by materials, rough-in and finish work.

1.10 INSPECTION OF SITE

A. Electrical bidders will be permitted to inspect site. Failure to inspect existing conditions or to fully understand work which is required shall not excuse Electrical Subcontractor from its obligations to supply and install work in accordance with specifications and the drawings and under all site conditions as they exist.

1.11 SUB-CONTRACTOR'S REPRESENTATIVE

A. Retain a competent representative on the project. Do not substitute representative without prior approval from Owner.

1.12 COOPERATION

A. Work shall be carried on under usual construction conditions, in conjunction with other contractors work. Cooperate with other contractors, coordinate work and proceed in a manner as not to delay progress.

B. Before proceeding, examine all construction drawings and consult other contractors to coordinate installation and avoid interference.

C. In case of dispute, the Architect will render a decision in accordance with General and Supplementary General Conditions.

1.13 CODES, ORDINANCES, AND PERMITS

A. Codes and Ordinances:

1. All material and work provided shall be in accordance with the following codes and standards as most recently amended.

   Commonwealth of Massachusetts Building Code
   Massachusetts Electric Code, 2026 Edition
   State Department of Public Safety
   NFPA 101 "Life Safety Code"
   NFPA Standards
   NEMA TCB 2-2017
   Standards of the Underwriters Laboratories (UL)
   Occupational Safety and Health Act (OSHA)
   Americans with Disabilities Act (ADA)
   Energy Conservation Code
   Town of Wilmington

2. Where contract documents indicate more stringent requirements than codes, the contract documents shall take precedence.

B. Permits: Be responsible for filing documents, and securing of inspection and approvals. Pay all permit and inspection fees.

C. Utility Company backcharges for permanent service will be paid directly by the Owner. Costs related to temporary service, refer to Section 01 51 00 – Temporary Utilites. Refer to Instructions to Bidders and General Conditions.

1.14 ELECTRICAL ROOMS OR SPACES

A. Be responsible for ensuring that the dedicated space and clearances required in the NEC, Section 110-26 are maintained for all electrical equipment.

B. Call other contractors' attention to the requirements contained in the above mentioned code sections, prior to the installation of equipment by other contractors, in order to ensure no violations.

1.15 SUBMITTALS

A. Refer to sections 01 30 00, Administrative Requirements, for information relative to submission of shop drawings. Provide submittals for all products and systems specified herein or specified under other sections but furnished under this section, i.e. access panels.

B. Submit the following samples:
   1. Lighting fixtures as may be requested.
   2. Color samples of all finished equipment to be sent to the architect for final selection.
   3. Other items as may be requested.

1.16 GUARANTEE

A. All parts of the work shall be guaranteed for a period of one year from the date of acceptance of the job by Owner. If during that period of general guaranty, any part of the work fails, becomes unsatisfactory, or does not function properly due to any fault in material or workmanship whether or not manufactured or job built, the Owner will upon notice from owner promptly proceed to repair or replace such faulty material or workmanship without expense to owner, including cutting, patching, and painting, or other work involved, and including repair or restoration of any damaged sections of the premises resulting from such faults.

B. In the event that a repetition of any one defect occurs indicating the probability of further failure and which can be traced to faulty design, material, or workmanship, then repair or replacement shall not continue to be made but the fault shall be remedied by a complete replacement of the entire defective unit.

C. Refer to Section 01 78 00 – Closeout Submittals for additional requirements.

D. In addition to the general guaranty, obtain and transmit to owner any guaranties or warranties from manufacturers of specialties, but only as supplementary to the general guaranty which will not be invalidated by same.

1.17 ELECTRICAL CHARACTERISTICS

A. In general, and unless specifically indicated otherwise, all building service, heating, ventilating, air conditioning, and plumbing equipment shall be of the following characteristics:
   1. Motors up to and including 1/3 HP shall be suitable for 120 volts, one phase operation.
   2. Motors larger than 1/3 HP shall be suitable for 480 volts, three phase operation.
   3. Electric heating equipment 4 KW and less shall be suitable for 277 volt single phase operation. Over 4 KW shall be 480 volt three phase.

B. Power Factor: All equipment provided rated greater than 1,000 watts and lighting equipment greater than 15 watts with an inductive reactance load component shall have a power factor of not less than 90 percent under rated load conditions.

1.18 TEMPORARY LIGHT AND POWER

A. Refer to Section 01 50 00 – Temporary Facilities and Controls and Section 01 51 00 - Temporary Utilities.

1.19 INSPECTIONS AND TESTS

A. Inspection: If inspection of materials installed shows defects, such defective work, materials, and/or equipment shall be replaced and inspection and tests repeated.

B. Tests: Make reasonable tests and prove integrity of work and leave electrical installation in correct adjustment and ready to operate. All panels and switchboards shall have phases balanced as near as practical. A consistent phase orientation shall be adhered to at all terminations.

1.20 ENERGY REBATE PROGRAM

A. This project has been designed to incorporate equipment approved for energy rebate such as fixtures, performance lighting, building lighting controls, and VFDs. Meet with Utility Company prior to lighting shop drawing submittal to ascertain that submittal meets program guidelines. Fixtures shall be DLC listed or equivalent. Assist Owner and Engineer in effort to obtain utility rebates the Owner is eligible for. Equivalent lighting fixtures which meet DLC shall require lighting vendor to submit shop drawings to utility company for approval. Assist the Owner in filling out Utility Company rebate applications. Provide fixture shop drawings and control cut sheets along with required drawings and information required to complete the Utility Company rebate

1.21 COMMUNICATIONS, AUDIO/VISUAL, AND INTEGRATED ELECTRONIC SECURITY SYSTEMS PROVISIONS

A. Electrical sub-Sub-Contractor shall work closely with the Communications, Audio/Visual and Integrated Security System Sub-Contractors to assure a first class installation. Coordinate all back boxes and conduits required prior to installations. In general, the electrical Sub-Contractor shall provide outlet boxes and conduits to accessible ceiling space of same floor.

B. Responsibilities of the Electrical Sub-Sub-Contractor: The Electrical Sub-Sub-Contractor shall be responsible for furnishing and installing all related system provisions including, but not limited to: 120 volt power, cable trays, conduits with bushings, conduit stubs with bushings, sleeves with bushings (all conduits, stubs, and sleeves, shall be brought to an accessible ceiling of the same floor), backboxes, plaster rings, pull strings, bonding, grounding, for a completely operational system, as specified. Specialty backboxes shall be furnished by Division 27 and 28 and installed under this section.

C. Responsibilities of the Communications, Audio/Visual and Integrated Security System Sub-Contractors (Division 27 and 28): These Sub-Contractors shall be responsible for furnishing, installing, wiring, programming, troubleshooting, training and warranty service of all cabling, outlets and equipment, for complete operational systems.

1.22 COORDINATION DRAWINGS

A. Before materials are purchased or work is begun, prepare and submit to the Architect, Coordination Drawings showing the size and location of all equipment and piping lines, and pull boxes, relevant to the complete system. Ensure that these Drawings are compatible and correctly annotated and cross-referenced at their interfaces. Refer to Section 01 31 14 – Coordination for general requirements for the preparation and submittal for coordination drawings.

1.23 RECORD DRAWINGS

A. Provide two sets of black or blue line on white drawings to maintain and submit record drawings, one set shall be maintained at site and which shall be accurate, clear, and complete showing actual location of all equipment as installed. Record drawings shall be updated at least monthly. Record drawings shall show outlet from which homeruns are taken, and location of all junction boxes and access panels. These drawings shall be available to Architect/Engineer field representative. In addition to drawings, a PDF and AutoCAD set of drawings shall also be maintained on site.

B. Any addenda sketches and supplementary drawings issued during course of construction shall be attached to drawings.

C. Refer to Section 01 70 00 – Execution and Closeout Requirements for general requirements for maintenance as-built drawings and submitting final reproducible record documents.

1.24 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

A. General: Refer to Section 01 78 00 – Closeout Submittals for general requirements for submittal of operations and maintenance manuals, training of personnel and related closeout procedures.

B. Operating Instructions: Furnish operating instructions to Owner's designated representative with respect to operations, functions and maintenance procedures for equipment and systems installed. Cost of such instruction up to a full three days of Electrical Subcontractor's time shall be included in contract. Cost of providing a manufacturer's representative at site for instructional purposes shall also be included.

C. Maintenance Manuals:
   1. At completion of the project, provide four copies of complete manuals containing the following:
      a. Complete shop drawings of equipment.
      b. Operation description of systems.
      c. Names, addresses, and telephone numbers of suppliers of systems.
      d. Vendors' P.O. numbers for equipment installed.
      e. Preventive maintenance instructions for systems.
      f. Spare parts list of system components.
   2. All information shall be in one binder.

1.25 RETURN AIR PLENUM

A. All wiring systems in areas above hung ceiling shall either be in conduit or shall be “UL Listed” Plenum rated cable.

1.26 QUALITY ASSURANCE

A. Sustainable Goals: The Architect has designed the project to meet the Owner’s sustainable goals. Products and systems have been specified which meet certain third-party evaluations or have particular VOC and source requirements. Evaluation of products proposed for substitution will be evaluated based on the Owner’s sustainable goals and other criteria included in Division 01. The Sub-Contractor is encouraged to use sustainable construction practices, means and methods. Unless specifically stated in a specification section, no sustainable design documentation is required of this Sub-Contractor.

1.27 SUSTAINABLE DESIGN INTENT

A. The proposed project is intended to be certified as a LEED “v4 BD+C” building per the LEED Version 4: Schools rating system. As a result, the documentation requirements for each credit, as described in Section 01 81 13.10 - LEED v4 BD+C: SCHOOLS (LEEDv4) PROJECT SCORECARD, Section 01 81 13.20 - LEED V4 PRODUCT DATA – SUSTAINABLE ATTRIBUTES REPORTING FORM and Section 01 81 13.30 - LEED MATERIALS TRACKING MATRIX, pertain to this specification section

B. This subcontractor shall provide all documentation indicating applicability of all products of this section to any potential LEED credits to the Project LEED Manager for submission to GBCI LEED Online. See Section 01 81 13.10 - LEED v4 BD+C: SCHOOLS (LEEDv4) PROJECT SCORECARD, Section 01 81 13.20 - LEED V4 PRODUCT DATA – SUSTAINABLE ATTRIBUTES REPORTING FORM and Section 01 81 13.30 - LEED MATERIALS TRACKING MATRIX.

1.28 PHASING, DEMOLITION AND MAINTAINING EXISTING SERVICES

A. Disconnect and remove all existing services and systems in phases to accommodate Owner’s phasing plans. Refer to Section 02 41 00 DEMOLITION.
   1. Electrical Contractor shall issue a work orders to the local utility company for removal of existing electrical services. Utility work back charges will be paid by the Owner.
   2. Electrical Contractor shall cut, cap and make safe the existing fire station portion for demolition by the General Contractor. Identify existing service equipment and disconnect.
   3. Coordinate all demolition work with General Contractor prior to performing work.
   4. Electrical Contractor shall provide a Cut over plan that includes; dates, timeframes, and required temporary connections to maintain existing occupied areas. The cut-over plan shall be reviewed by the Owner, G.C. and Design team for approval prior to performing the work.

B. The existing elementary school building will remain occupied during construction.
   1. During the execution of the work, required relocation, and rerouting of existing equipment and systems in the existing building areas where new work is to be installed or new connections are scheduled to be made, shall be performed by the Electrical Subcontractor, per job conditions and as determined by the Architect in the field, to facilitate the installation of the new system, while demolition, relocation work or new tie-ins will be performed. Outages required for construction purposes shall be scheduled for the shortest practical periods of time, in coordination with the Owner's designated representative, for specified, mutually agreeable periods of time, after each of which the interruption shall cease and the service shall be restored. This procedure shall be repeated to suit the Owner's working schedule, until all work is complete. Any outages of service shall be approved by the Owner, prior to commencing the work. No outages or shutdowns of service shall occur without the written authorization of the Owner prior to commencing the work. Give notice of any scheduled shutdowns, a minimum of two weeks in advance. Owner will make their best effort to meet this request without adversely affecting the electric service to the existing building.
   2. Electrical Trade contractor is responsible to disconnect and make safe all Electrical equipment/systems/ appurtenances scheduled for demolition in each phase which is the responsibility of the GC to coordinate. The demolition contractor shall drop all suspended equipment / systems / piping / appurtenances to the floor, demolish and dispose from the site. Trade contractors are advised that the demolition drawings are not as-builts and the Architect does not warrant their accuracy for total quantities. All contractors are advised to take the opportunity to attend the pre-bid meeting and review the existing conditions. No change order will be approved for additional quantities of equipment/systems/piping/appurtenances required to be made safe.
   3. Prior to any deactivation and relocation or demolition work, consult the drawings and arrange a conference with the Architect and the Owner's representative in the field to inspect each of the items to be deactivated, removed or relocated. Care shall be taken to protect all equipment designated to be relocated and reused or to remain in operation and be integrated with the new systems.
   4. All deactivation, relocation and temporary tie-ins of electrical systems and equipment shall be provided by the Electrical Subcontractor. All demolition and removal of electrical systems and equipment designated to be demolished shall be by the Electrical Subcontractor and removed by the General Contractor. Stack all demolished electrical materials except hazardous materials (lighting ballasts, fluorescent lamps) nearby for removal by the General Contractor. All hazardous electrical materials shall be legally disposed by the Hazmat Contractor. The Hazmat Contractor shall remove lamps and ballasts from light fixtures.
   5. The Owner reserves the right to inspect the material scheduled for removal and salvage any items he deems usable as spare parts.

1.29 TRADE RESPONSIBILITY FOR INTERCONNECTIONS MATRIX

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke Detectors (Area type)	26 00 10	26 00 10	26 00 10	N/A	26 00 10	
Smoke Detectors (Duct mounted)	26 00 10	23 00 10	26 00 10	23 00 10 (ATC)	26 00 10	
Carbon monoxide Detectors (Duct mounted)	26 00 10	23 00 10	26 00 10	23 00 10 (ATC)	26 00 10	

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke and Fire/Smoke Dampers	23 00 10	23 00 10	N/A	N/A	N/A	
Smoke and Fire/Smoke Damper Actuators	23 00 10	23 00 10	26 00 10	23 00 10 (ATC)	26 00 10	
Fire Dampers	23 00 10	23 00 10	N/A	N/A	N/A	
VAV Boxes	23 00 10	23 00 10	26 00 10 and 23 00 10 (ATC)	23 00 10 (ATC)	N/A	2
VAV Box Damper Actuator	23 00 10 (ATC)	Box Mfr	23 00 10 (ATC)	23 00 10 (ATC)	N/A	2
Hydronic Control Valves	23 00 10 (ATC)	23 00 10	N/A	N/A	N/A	1
Hydronic Control Valve Actuator	23 00 10 (ATC)	23 00 10 (ATC)	23 00 10 (ATC)	23 00 10 (ATC)	N/A	1
Sheet Metal Damper	23 00 10	23 00 10	N/A	N/A	N/A	1
Sheet Metal Damper Actuators	23 00 10 (ATC)	23 00 10 (ATC)	23 00 10 (ATC)	23 00 10 (ATC)	N/A	1
Natural Gas Energy Sub-Meters	23 00 10 (ATC)	22 00 10	26 00 10 and 23 00 10 (ATC)	23 00 10 (ATC)	N/A	3
Electrical Energy Meters	26 00 10	26 00 10	26 00 10	26 00 10	N/A	
Domestic Water Sub-Meters	23 00 10 (ATC)	22 00 10	26 00 10 and 23 00 10 (ATC)	23 00 10 (ATC)	N/A	3
HVAC Hydronic Energy Meters	23 00 10	23 00 10 (ATC)	26 00 10 and 23 00 10 (ATC)	23 00 10 (ATC)	N/A	3
Airflow Measuring Stations	23 00 10	23 00 10 (ATC)	N/A	23 00 10 (ATC)	N/A	
DDC Panels	23 00 10 (ATC)	23 00 10 (ATC)	26 00 10 and 23 00 10 (ATC)	23 00 10 (ATC)	N/A	4
VFDs at RTU, MAU, AHU, HV and ERV	23 00 10	23 00 10	26 00 10 and 23 00 10	23 00 10 (ATC)	N/A	5
VFDs at EFs and Pumps	26 00 10	26 00 10	26 00 10	23 00 10 (ATC)	N/A	6
VFDs at Kitchen Exhaust Fans	11 40 00	26 00 10	26 00 10	11 40 00	N/A	6
Elevator Hoistway Vent Damper	23 00 10	23 00 10	N/A	N/A	N/A	

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Elevator Hoistway Vent Damper Actuator	23 00 10 (ATC)	23 00 10 (ATC)	23 00 10 (ATC)	23 00 10 (ATC)	26 00 10	
Boiler/DHW/Breeching	22 00 10	22 00 10	N/A	N/A	N/A	
Kitchen Emergency Gas Valve	22 00 10	22 00 10	26 00 10	26 00 10	26 00 10	
Emergency Shower/Eye Wash	22 00 10	22 00 10	26 00 10	23 00 10 (ATC)	N/A	
Generator Breeching	22 00 10 or 23 00 10	22 00 10 or 23 00 10	N/A	N/A	N/A	7

Notes:

1. Section 23 00 10 and Section 23 00 10 (ATC) Contractors shall fully coordinate all airflow damper and hydronic valves sizes and quantities.
2. VAV Box power wiring shall be provided by Section 26 00 10 to junction box locations shown on electrical drawings; Section 23 00 10 (ATC) Sub-Sub-Contractor shall provide final power wiring from junction box to end device location.
3. Section 26 00 10 Sub-Sub-Contractor shall provide all line-voltage power wiring required for meters; Section 23 00 10 (ATC) Sub-Sub-Contractor shall provide all low-voltage power wiring required for meters.
4. Section 26 00 10 shall provide power at main DDC Panel. Section 23 00 10 (ATC) shall provide power to all other DDC Panels. Power source shall be from optional stand-by power system.
5. Power wiring for RTU, HV, MAU, AHU and ERV shall be a single point connector made by the Electrical Sub-Sub-Contractor (26 00 10). Integral wiring and connections shall be provided by Section 23 00 10.
6. Section 26 00 10 shall provide VFDs for all EFs and pumps with exception to EFs and/or pumps provided with ECM motors. ECM motors are specified in Section 23 00 10 and provided by Section 23 00 10 coordinate with mechanical schedules and specifications. VFD at Kitchen Exhaust Fan provided by Section 23 10 00 and installed by Section 26 00 10.
7. Generator breeching for diesel fired generators is provided by 23 00 10. Generator breeching for natural gas fired generators is provided by Section 22 00 10.

PART 2 PRODUCTS

2.01 GENERAL

A. Product specifications are written in such a manner so as to specify what materials may be used in a particular location or application and therefore do not indicate what is not acceptable or suitable for a particular location or application. As an example: non-metallic sheathed cable is not specified; therefore, it is not acceptable.

B. For purpose of establishing a standard of quality and not for purpose of limiting competition, the basis of this Specification is upon specified models and types of equipment and materials, as manufactured by specified manufacturers.

C. In all cases, standard cataloged materials and systems have been selected. Materials such as lighting fixtures specially manufactured for this particular project and not part of a manufacturers' standard product line will not be acceptable. In the case of systems, the system components shall be from a single source regularly engaged in supplying such systems. A proposed system made up of a collection of various manufacturers' products will be unacceptable.

D. Where Specifications list manufacturers' names and/or "as approved" or "Equal approved by Architect", other manufacturers' equipment will be considered if equipment meets Specification requirements and has all features of the specified items as are considered essential by Architect.
E. All material shall be new and shall be UL listed.

2.02 RACEWAYS AND FITTINGS

A. Raceways - General:
   1. No raceway shall be used smaller than 3/4 inch diameter and shall have no more than four 90 degree bends in any one run, and where necessary, pull boxes shall be provided. Only rigid metal conduit or intermediate metal conduit is allowed for slab work. Cable systems, if allowed to be used by other sections of this specification, shall not be used exposed or in slabs, whether listed by "UL" for such use or not.
   2. Rigid metal conduit conforming to, and installed in accordance with, Article 344 shall be heavy wall zinc coated steel conforming to American Standard Specification C80-1 and may be used for service work, exterior work, slab work, and below grade level slab, wet locations, and in mechanical rooms for drops down to equipment from elevations below eight feet. and also where raceway may be subject to mechanical damage.
   3. Intermediate metal conduit conforming to, and installed in accordance with, Article 342, may be used for all applications where rigid metal conduit is allowed by these specifications.
   4. Electrical Metallic Tubing (EMT), conforming to, and installed in accordance with, Article 358 shall be zinc coated steel, conforming to industry standards, may be used in masonry block walls, stud partitions, above furred ceilings, where exposed but not subject to mechanical damage, and may be used for fire alarm work.
   5. Surface metal raceways conforming to, and installed in accordance with, Article 386 may be used only where raceways cannot be run concealed, and then, if only specifically approved.
   6. Flexible metal conduit shall be used for final connections to recessed lighting fixtures from above ceiling junction boxes and for final flexible connections to motors and other rotating or vibrating equipment. Liquid tight flexible metal conduit shall be used for the above connections which are located in moist locations. All flexible connections shall include an insulated grounding conductor.
   7. Rigid non-metallic conduit may be used for underground electric and telephone services outside the foundation wall and also below slab and shall be polyvinyl chloride (PVC) schedule 40, 90 degrees C. Rigid metal conduits shall be used thru-foundation walls and thru-slab. Below slab conduits do not require concrete encasement.
   8. PVC Schedule 40 may be used for below slab for feeders and circuits within building confines. Below slab rigid non-metallic conduits do not require concrete encasement. Rigid non-metallic conduits may be used for below slab feeders and branch circuits, but shall not be used in slabs, nor for elbows which penetrate slabs. Raceways and fittings shall be produced by same manufacturer.
   9. PVC schedule 40 may be used for underground branch circuits and feeders outside the foundation wall.
   10. Acceptable manufacturers:
      a. Pittsburgh Standard Conduit Company
      b. Republic Steel and Tube
      c. Youngstown Sheet and Tube Company
      d. Carlon
      e. Or equal

11. Fittings:
    a. Provide insulated bushings on all raceways 1 inch diameter or larger.
    b. Manufacturer's standard fittings shall be used for raceway supports.
    c. Expansion Fittings: Expansion fittings shall be used where structural and concrete expansion joints occur and shall include a ground strap. Bond separate buildings in accordance with code.
    d. Couplings for rigid metal and intermediate metal conduit shall be threaded type.
    e. Threadless fittings for EMT shall be watertight compression type or set-screw type (dry-locations). All fittings shall be concrete tight. No diecast fittings allowed except for raceways larger than 1 inch diameter.
    f. Cable supports in vertical raceways shall be of the split wedge type. Armored cable supports for vertical runs to be of wire mesh basket design.
    g. Wall entrance seals shall be equal to O.Z. Gedney type "WSK".
    h. Couplings, elbows and other fittings used with rigid nonmetallic conduit shall be of the solvent cemented type to secure a waterproof installation.
    i. Acceptable manufacturers:
        1) O.Z.
        2) Crouse Hinds
        3) Appleton
        4) EFCOR
        5) Steel City
        6) Or equal

B. Outlets, Pull and Junction Boxes:
1. Outlets:
    a. Each outlet in wiring or raceway systems shall be provided with an outlet box to suit conditions encountered. Boxes installed in normally wet locations or surface mounted shall be of the cast-metal type having hubs. Concealed boxes shall be cadmium plated or zinc coated sheet metal type. Old work boxes with Madison clamps not allowed in new construction. Thru the wall boxes are not permitted.
    b. Each box shall have sufficient volume to accommodate number of conductors in accordance with requirements of Code. Boxes shall not be less than 1-1/2 inch deep unless shallower boxes are required by structural conditions and are specifically approved by Architect. Ceiling and bracket outlet boxes shall not be less than 4 inch octagonal except that smaller boxes may be used where required by particular fixture to be installed. Flush or recessed fixtures shall be provided with separate junction boxes when required by fixture terminal temperature requirements. Switch and receptacle boxes shall be 4 inch square or of comparable volume.
    c. Far side box supports shall be Caddy J-1A.
    d. Acceptable manufacturers:
        1) Appleton
        2) Crouse Hinds
        3) Steel City
        4) RACO
        5) Or equal

2. Pull and Junction Boxes: Where indicated on plans, and where necessary to terminate, tap off, or redirect multiple raceway runs or to facilitate conductor installation, furnish, and install appropriately designed boxes. Boxes shall be fabricated from code gauge steel assembled with corrosion resistant machine screws. Box size shall be per Code.

   Boxes in moist or wet areas shall be galvanized type. Boxes larger than 4-11/16 inch square shall have hinged covers. Boxes larger than 12 inch in one dimension will be allowed to have screw fastened covers, if a hinged cover would not be capable of being opened a full 90 degrees due to installation location.

   a. Acceptable Manufacturers:
      1) Brasch
      2) Hoffman
      3) Keystone
      4) Lee Products Co.
      5) McKinstry Inc.
      6) Eldon Inc.
      7) Or equal

2.03 CONDUCTORS

A. All conductors shall be a minimum size of #12 AWG except for control wiring and fire alarm wiring where #14 AWG may be used. For all exit sign circuits, normal/emergency and/or emergency only circuits, exterior lighting circuits, and also where distance from panelboard to first outlet exceeds 100 feet. at 120 volts and 150 feet. at 277 volts, #10 AWG shall be minimum size wire allowed. Where circuits are greater than 250 feet. at 120 volts #8 AWG shall be mimimum size wire allowed, provide #10 AWG pigtail for all 120 volt circuits over 250 feet. All feeder and branch circuit conductor shall be color coded as follows:

1.	208Y/120V	Phase A	Black
2.	208Y/120V	Phase B	Red
3.	208Y/120V	Phase C	Blue
4.	480Y/277V	Phase A	Brown
5.	480Y/277V	Phase B	Orange
6.	480Y/277V	Phase C	Yellow
7.	Grounded Conductor		
		120/208	White
		277/480	Grey
8.	Equipment Ground		
		120/208	Green
		277/480	Green with Yellow Trace
9.	Isolated Ground	120/208	Green with Orange Trace

B. All conductors not installed in accordance with color scheme shall be replaced. All conductors larger than #6 AWG must be identified with colored tape.

C. Comply with CMR 527, Massachusetts Electrical Code.

D. Comply with Underwriter's Laboratories (UL) standards:
   1. UL 4: Armored Cable.
   2. UL 62: Flexible Cord and Fixture Wire.
   3. UL 83: Thermoplastic-Insulated Wires and Cables.
   4. UL 486A: Wire Connectors and Soldering Lugs for Use with Copper Conductors.
   5. UL1569: Metal -Clad Cables.

E. Comply with NEMA WC-5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

F. Connections throughout the entire job shall be made with solderless type devices.
   1. For #10 AWG shall smaller: spring type.

2. For #8 AWG and larger: circumferential compression type.
3. Acceptable manufacturers:
   a. 3M "Scotchlock"
   b. IDEAL "Wingnut"
   c. BURNDY
   d. MAC
   e. Or equal
4. Any splices made up in ground mounted pull boxes shall be resin cast waterproof type or waterproof pressure type.

G. Conductors up to 90Amperes: Copper wire, soft drawn, annealed, 98 percent conductivity, rated at 600 volts, and complying with reference Electrical Code. Minimum size # 12 AWG for the power circuits. Conductors shall be insulated for 600 volts and be of following types:
   1. All conductors shall have heat/moisture resistant thermoplastic insulation type THHN/THWN (75 degrees C) except as follows:
      a. In sizes #1 AWG and larger: Crosslinked polyethylene insulation type XHHW (75 degrees C – 90 degrees C) may be used.
      b. Fire alarm system conductors shall be #14 AWG, type THHN, solid. Color coding of fire alarm conductors shall be in accordance with fire codes.
      c. Fixture whips #16AWG type "SF".

H. Conductors 100Amperes and higher may be Aluminum, unless specifically noted otherwise on the drawings. Secondary service conductors shall be copper no exceptions. All conductor and conduit sizing shown on the drawings is done using copper conductors, where the electrical contractor utilizes Aluminum conductors for feeders 100Amperes or higher it is the responsibility of the electrical contractor to convert the feeder size and conduit size to comply with NEC aluminum conductor ampacity based on NEC 310.15(B)(16). Utilize conduit fill tables in the NEC to size conduit for aluminum conductors.

I. Where stranded Aluminum conductors are utilized terminate cable using a compression connector system that is compatible with aluminum conductors for a high quality connection, Utilize Thomas and betts compression connector system or equal. Compression type pigtail adapters are also acceptable.

J. Secondary Service conductors shall be Copper as indicated on the contract documents.

K. Stranded conductors for all wiring systems except fire alarm will be allowed if installed and terminated as specified under Execution Section.

L. Mineral-Insulated Metal-Sheathed Fire-Resistive Cables (Type MI) - Cables shall consist of a factory assembly of one or more solid copper conductors insulated with highly-compressed magnesium oxide and enclosed in a seamless, liquid-and-gas-tight continuous copper sheath. Cables shall be rated for 600 volts and less. Cables shall comply with Article 332 of the National Electrical Code. Cables shall be classified by Underwriters Laboratories, Inc. as having a 2-hour fire resistive rating. Cable terminations shall be made with UL listed mineral-insulated cable fittings. Approved Manufacturer - Pyrotenax USA, Inc. or equal.

M. Type MC Cable may also be used for concealed branch circuits in hollow spaces where allowed by code if installed and terminated as specified under Execution Section. Armor to be galvanized steel and shall be UL listed for 2 hour fire wall penetration. Light steel armor is acceptable.

N. Type MC Cable may be used for fire alarm where concealed and allowed by Code, armor shall be red.

O. Acceptable manufacturers:
   1. AFC Cable Systems
   2. American Wire and Cable
   3. Cerro
   4. Cornish
   5. Cresent

6. General Cable
7. Okonite
8. Or equal

P. Installation of conductors and cables
   1. Install all power and 120 volt control wire and cable in approved raceways. When low tension wiring is run exposed, install it in conduit. Plenum rated low tension cable may be used for installation above suspended ceilings where it is allowed by the Code and is allowed in the specification for the specific system.
      a. Wire Size:
         1) Install minimum No. 12 AWG for power and lighting circuits.
         2) Install minimum No. 10 AWG for 120 volt 20 ampere branch circuits of 75 feet. to 150 feet. length, and minimum No. 8 AWG for the circuits of 150 feet. to 250 feet. unless otherwise shown on the drawings or required by the equipment shop drawings.
         3) Install minimum No. 10 AWG for 277 volt 20 ampere branch circuits of more than 150 feet. unless otherwise shown on the drawings.
   2. Metal clad cable type MC may be used for branch circuit wiring above suspended ceilings and for device wiring in the metal stud partitions. MC cable shall not be used for a termination at the panels (homeruns) and where they run exposed. Any wiring associated with Smoke control systems shall not be installed in MC cable as it does not meet 780 CMR Section 909.12.1.
   3. Bundle conductors #10 and smaller in branch circuit panelboards, signal cabinets, signal control boards in switchboards and motor control centers.
   4. Homerun Circuits:
      a. Follow homerun circuit numbers shown on the drawings to connect circuits to the panelboards. Where homerun circuit numbers are not shown on the drawings, divide similar types of connected loads among phase busses so that currents in each phase are within 10 percent of each other during normal usage.
      b. Wire multi-wire branch circuit homerun with two or three single phase and one common neutral conductor to a panel in a such manner that each phase circuit is fed from the adjacent circuit breakers. Do not combine circuits so that any homerun has more than three circuits (total of five wires) installed in one conduit, unless the circuit conductors are de-rated in strict accordance with the referenced Electrical Code.
      c. Branch circuit wiring in the classrooms, laboratories and offices shall be provided with a dedicated neutral conductor for each phase conductor.
   5. Properly group feeders, branch circuit and auxiliary system wiring passing through pull boxes and/or being made up in panelboards; neatly bind each group of wires together with plastic cable ties, and trim loose ends of the ties.
   6. Peel branch circuits and auxiliary system wiring out of the wiring gutters at the terminal cabinet and panels at 90 degrees to circuit breakers and terminal lugs before making connections.
   7. Color code conductors No. 6 AWG and larger by applying colored plastic tape at ends and where connections and splices are made. Wrap tape around the conductor three complete turns.
   8. Splices and Terminations:
      a. Make splices and joints by means of UL-listed, solderless connectors rated 600 volt, of sizes and types required by manufacturer's recommendations, with temperature ratings equal to that of wire.
      b. Attach copper wire to panelboards, switchboards, disconnect switches and other electrical equipment by means of bolt-on lugs with hex screws. Properly size lugs; do not cut strands from a conductor in order to fit conductor into a lug.
      c. Connectors for cables 250 MCM and larger shall have two clamping elements and terminals for bus connections shall have two bolt holes.

9. Identification: Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems." Label feeder and branch circuits in pull and junction boxes, handholes and at cable terminations in the panelboards, motor control centers, and switchboards. Use non-ferrous tags or labels stamped or printed to correspond with markings on the drawings or marked so that feeder or cable may be identified readily. If suspended tags are provided, attach with nylon line or cable lacing.
10. Connect branch circuits to the breakers in multi-phase panelboards required to balance loads.
11. Provide handle ties for multiwire branch circuits per NEC requirements.
12. Low Tension Cables: Provide separation from power wiring and lighting fixtures as follows:
    a. Lighting fixtures - at least 6 in..
    b. Power branch circuit wiring with MC type cable - at least 12 in..
    c. Power branch circuit wiring in metal conduit - at least 6 in..
13. When low-tension cables are not in conduit or trays, support cables from the deck and/or beams, spacing supports no farther apart than 6 feet. on center. Provide hangers, clips or other approved method of grouping the cables and keeping them away from other systems. Take care to ensure that ties, clips and other support devices do not compress the cable or damage cable insulation; use J-hooks whenever possible.
14. Cable Supports:
    a. Provide cable supports for vertical feeders required by the referenced Electrical Code.
    b. Support vertical feeders at each floor level.
    c. Support and secure metal-clad cable Type MC at intervals not exceeding 6 feet. and within 12 inch from every outlet box, junction box or cabinet.
    d. Support metal clad cable Type MC with cable supports equal to Caddy WMX-6, MX-3, and clamps equal to Caddy 449. Where cables are supported by the structure and only need securing in place, then cable ties will be acceptable.
15. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
16. Use manufacturer-approved pulling compound or lubricant where necessary; compound used shall not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
17. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
18. For wiring in high temperature areas or high temperature equipment (i.e. boiler rooms, water heaters/boosters), furnish conductors for 90 degrees C dry and wet rating.

2.04 ACCESS PANELS

A. General: Furnish access panels for installation by General Contractor, at all new and existing construction where required for access to the Work of this Section.
B. Provide access panels for access to concealed junction boxes and to other concealed parts of system that require accessibility for operation and maintenance. In general, electrical work shall be laid out so access panels are not required. Provide fire rated panels for rated partitions, shafts.
C. Refer to Section 08 31 00 – Access Doors and Panels, for all product requirements for furnishing access panels.
D. Coordinate locations and schedule with the work of trades involved with construction in which access panels will be installed.

2.05 SLEEVES, INSERTS, AND OPENINGS

A. Sleeves: Provide sleeves of proper sizes for all openings required in concrete floors and walls. Sleeves passing through floors shall be set with top of sleeve one inch above finished floor. Core drilling will also be acceptable if in accordance with any structural standards. Any unsleeved openings shall be waterproofed.
B. Inserts: Provide inserts or other anchoring devices in concrete and masonry construction to support raceways and equipment.

C. Openings: Where an opening is required in concrete slabs to allow passage of a multitude of raceways, give adequate notice to General Sub-Contractor so he may box out opening in form work.
D. Any openings through fire rated surfaces shall be closed off with fireproofing materials providing the same rating as the surface penetrated.
    1. Acceptable Manufacturers:
        a. Specified Technologies Inc.
        b. Thomas and Betts
        c. International Protective Coatings Corp.
        d. 3M Fire Protection Products
        e. Dow Corning
        f. Or equal

2.06 FLOOR OUTLETS (FLUSH TYPE)

A. Section includes flush floor boxes equal to Wiremold RFB Series. Provide appropriate floor box model that meets the intent of what is shown on the drawings. Hubbel and Thomas and Betts are considered equals.
B. Quality Assurance
    1. Electrical Raceways and Components: Comply with requirements of applicable local codes, NEC, UL, and NEMA Standards pertaining to raceways and components. Listed and labeled in accordance with NFPA 70, Article 100.
C. Floor Boxes
    1. RFB4 and RFB4-4DB Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 12-3/4 inch Long by 10 inch Wide by 3-7/16 inch High [324mm by 254mm by 87mm]. Provide the box with four independent wiring compartments that allow capacity for up to four duplex receptacles, communication and/or audio/video services. The RFB4 Series Box shall permit tunneling from end power compartment to end power compartment. The RFB4-4DB Series Box shall permit tunneling from adjacent or opposite compartments. Two of the four compartments shall have a minimum wiring capacity of 16.4 cubic in [269cu cm], one compartment shall have a minimum capacity of 32.3 cubic in [529cu cm], and one compartment shall have a minimum capacity of 50 cubic in [820cu cm]. Four compartments shall have a minimum of two inch of space behind the device plates. The box shall include the following number of conduit knockouts: one 1/2-inch [12.7mm], three one-inch [25mm], six 3/4-inch [19.1mm], and six 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [47.7mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

2. RFB4-CI-1 and RFB4-CI-NA Series Floor Boxes: Manufactured from cast-iron and approved for use on grade and above grade floors. The box shall be 14-1/2 inch Long by 11-7/8 inch Wide by 3-7/16 inch High [368mm by 302mm by 87mm]. Provide the box with four independent wiring compartments that allow capacity for up to four duplex receptacles and/or communication services. The box shall permit tunneling from adjacent or opposite compartments. Two of the four compartments shall have a minimum wiring capacity of 27 cubic in [443cu cm], and two compartments shall have a minimum wiring capacity of 36 cubic in [590cu cm]. Four compartments shall have a minimum of two inch of space behind the device plates. The box shall include the following number of conduit hubs: four one-inch [25mm] and four 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [48mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
3. RFB4-SS Series Floor Boxes: Manufactured from stamped-steel and approved for use on above grade floors. The box shall be 13-5/8 inch Long by 10 inch Wide by 2-7/16 inch High [346mm x 254mm x 62mm]. Provide the box with four independent wiring compartments that allow capacity for up to four duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two of the four compartments shall have a minimum wiring capacity of 15.7 cubic in [257cu cm] and two compartments shall have a minimum wiring capacity of 31.2 cubic in [511cu cm]. Four compartments shall have a minimum of two inchof space behind the device plates. The box shall contain the following number of conduit knockouts: two 1/2-inch [12.7mm], six 3/4-inch [19.1mm], and eight one-inch [25mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [48mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
4. RFB6 Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8 inch Long by 12-1/2 inch Wide by 3-1/4 inch High [333mm by 317mm by 83mm]. Provide the box with six independent wiring compartments that allow capacity for up to six duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two of the six compartments shall have a minimum wiring capacity of 23 cubic in [376cu cm] and four compartments shall have a minimum wiring capacity of 52 cubic in [850cu cm]. Four of the six compartments shall have a minimum of 3-1/4 inch of space behind the device plates and two of the six compartments shall have a minimum of 2-3/8 inch of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four 1-inch [25mm], and twelve one-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

5. RFB6E Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8 inch Long by 12-1/2 inch Wide by 4 inch High [333mm by 317mm by 102mm]. Provide the box with six independent wiring compartments that allow capacity for up to six duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments through 1-1/4-inch grommet openings. Two of the six compartments shall have a minimum wiring capacity of 23 cubic in [376cu cm] and four compartments shall have a minimum wiring capacity of 52cubic in [850cu cm]. Four of the six compartments shall have a minimum of 3-1/4 inch of space behind the device plates and two of the six compartments shall have a minimum of 2-3/8 inch of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four one-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
6. RFB6E-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8 inch Long by 12-1/2 inch Wide by 4 inch High [333mm by 317mm by 102mm]. Provide the box with six independent wiring compartments that allow capacity for up to six duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two of the six compartments shall have a minimum wiring capacity of 23 cubic in [376cu cm] and four compartments shall have a minimum wiring capacity of 52 cubic in [850cu cm]. Four of the six compartments shall have a minimum of 3-1/4 inch of space behind the device plates, and two of the six compartments shall have a minimum of 2-3/8 inch of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four one-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

D. Activation Covers
1. FloorPort FPCT, FPBT, and FPFFT Series Covers: Manufactured of die-cast aluminum or die-cast zinc, and available in brushed aluminum finish and powder-coated paint finishes (black, gray, bronze, nickel and brass). Activation covers shall be available in flanged and flangeless versions. Covers shall be available with options for tile or carpet inserts, or flush covers. The cover's hinge shall allow for the cover to open 180 degrees. The furniture feed covers shall come equipped with one one-inch trade size screw plug opening and one combination 1-1/4-inch and two-inch trade size screw plug.
    a. Flanged covers shall be 7-3/4 inch Long by 6-9/16 inch Wide [197mm by 167mm].
    b. Flangeless covers shall be 6-3/4 inch Long by 5-9/16 inch Wide [171mm by 142mm].

2. 6CT, 6CTC, 6CFFTC, 8CTC, and 8CT Series Covers: Manufactured of die-cast aluminum alloy and available in powder-coated gray, black, brass, nickel or bronze finish. The covers shall be available in carpet and tile versions. Provide covers with two gaskets (one for carpet and one for tile) to go under the trim flange to maintain scrub water tightness. The activation cover for the 8CTC and 8CT series shall be 9-1/4-inch [235mm] in diameter. The activation cover for the 6CT and 6CTC series shall be 7-1/4-inch [184mm] in diameter and the activation cover for the 6CFFTC series shall be 7-3/4-inch [197mm] in diameter. The carpet covers shall be surface mounted and the tile covers shall be flush with the finished floor covering. The covers shall have spring loaded slides to allow cables to egress out of the unit and maintain as small an egress opening as possible.
3. The covers shall have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors.

E. Communication Modules Mounting Accessories
1. The floor box manufacturer shall provide a complete line of faceplates and bezels to facilitate mounting of UTP, STP (150 ohm), fiber optic, coaxial, and communication devices. The box shall provide a series of device mounting plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, and other open system devices.

F. Installation
1. Strictly comply with manufacturer's installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.
2. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer’s installation sheets.
3. Accessories: Provide accessories required for a complete installation, including insulated bushings and inserts where required by manufacturer.
4. Unused Openings: Close unused box openings using manufacturer's recommended accessories.
5. Provide a minimm concrete pour depth of 3-7/16-inch [87mm] plus 1/16-inch [1.6mm] above the top of the box for the RFB4, RFB4-4DB, RFB2, and the RFB2-OG Series Boxes; 2-7/16-inch [62mm] plus 1/16-inch [1.6mm] for the RFB4-SS and RFB2-SS Series Boxes; and 3-7/16-inch [87mm] plus 13/16-inch [21mm] above the top of the box for the RFB4-CI-1, RFB6, and RFB6-OG Series Boxes; and 4-1/16-ich. [103mm] above the top of the RFB4E and RFB4E-OG Series Boxes; and 4-inch [102mm] above the top of the RFB6E and RFB6E-OG Series Boxes. Provide the box with four locations to accommodate leveling for pre-concrete pour adjustment and include four leveling screws for the pre-pour adjustment.

G. Cleaning and Protection
1. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.
2. Protect boxes and fittings until acceptance.

H. Poke-Through Assemblies:
1. Basis-of-Design Product: The design for recessed outlet poke-thru devices is based on Evolution™ Series Poke-Thru Devices manufactured by Legrand/Wiremold:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell.
   b. Pass and Seymour.
   c. Thomas and Betts Corporation.
   d. Wiremold
   e. Or equal

3. Recessed Outlet Poke-Thru Devices: [6AT] [8AT] Poke-Thru Devices manufactured by Legrand/Wiremold.
    a. Poke-thru devices provide an interface between power, communication and audio/visual (A/V) cabling in an above grade concrete floor and the workstation or activation location where power, communication and/or A/V device outlets are required. These devices provide recessed device outlets that will not obstruct the floor area. Refer to the Drawings for types.
    b. Poke-thru devices shall be compatible with the complete line of Ortronics® workstation connectivity outlets and modular inserts, Wiremold's CM open system adapters, or a variety of audio/video devices from most manufacturers, and other open system devices.
    c. Poke-thru device use is limited by the UL Fire Resistance Directory to a minimum spacing of two feet. (610mm) on center and not more than one device per 65 square feet. (6m2) of floor area in each span.
4. Classification and Use: Poke-thru device shall have been examined and tested by Underwriters Laboratories Inc. to comply with UL514A and/or UL514C and Canadian Standard C22.2, No. 18-98 and bear the U.S. and Canadian UL Listing Mark. Poke-thru device shall also have been tested by UL and classified for fire resistance and bear the U.S. and Canadian UL Classification Mark. The poke-thru device shall conform to the standards set in the National Electrical Code, Section 300-21.
    a. Poke-thru devices shall be classified for use in 1, 1-1/2, or two-hour rated floors and one, 1-1/2, or two hour rated floors employing unprotected steel floor units and concrete toppings (D900 Series designs), or concrete floors with suspended ceilings. Fire resistive designs with suspended ceilings shall have provisions for accessibility in the ceiling below the poke-thru device fittings.
    b. Poke-thru device shall have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors.
    c. These devices are not suitable for wet or damp locations, or other areas subject to saturation with water or other liquids such as commercial kitchens.
    d. Poke-thru device shall be suitable for use in air handling spaces in accordance with Section 300-22C of the National Electrical Code.
5. 6AT Poke-Thru Assembly: Poke-thru device assemblies shall consist of an insert and an activation cover. Assembly length: 16-3/4 inch (425mm).
    a. Insert: Insert body shall recess the devices a minimum of 2-3/4 inch (69mm) and have a polyester based backing enamel finished interior; ivory color. Furnish with necessary channels to provide complete separation of power and communication services. Provide three compartments that allow for up to three duplex receptacles that can be wired as a standard receptacle or isolated ground and/or 12 communication ports and/or 10 Legrand AVIP AV devices or 10 Extron® Electronics MAAP™ and/or two AAP™ devices.
    b. Body consists of an intumescent firestop material to maintain fire rating of the floor slab. Hold intumescent material securely in place in insert body. Intumescent material will not have to be adjusted to maintain fire rating of the unit and the floor slab. Provide insert with a retaining feature to hold the poke-thru device in the floor slab without additional fasteners. Poke-thru insert shall also consist of a 3/4-inch trade size conduit stub that is connected to the insert body and a 24.5 cubic in (402ml) stamped steel junction box for wire splicing and connections. Stamped steel junction box shall also contain the means necessary to electrically ground the poke-thru device to the system ground.

c. Activation Cover: Manufactured of die-cast aluminum alloy; finished in powder-coated [gray] [black] [brass] [nickel] [bronze]. Provide with two gaskets (one for surface and one for flush) to go under the trim flange to maintain scrub water tightness. Activation cover is 7-1/4 inch (184mm) in diameter. Provide cover with spring-loaded slides to allow cables to egress out of the unit and maintain as small an egress opening as possible. Color to be selected by the architect.

d. Communication Modules Mounting Accessories: Provide activation unit with three locations to mount communication connectors. Mount connectors using a mounting bracket capable of accepting up to 12 Ortonics® TracJack™ Category 6 insert modules or TechChoice™ Category 6 discrete keystone connectors. Also provide unit with two Category 6 discrete keystone connectors and two industry standard keystones and accommodate a mechanism to permit protection of communication cabling. Fabricate mechanism from stamped steel construction. Mechanism shall accept both flexible and rigid 3/4-in., 1-1/4-inch or two-inch trade size conduit.

6. 8AT Poke-Thru Assembly: Poke-thru device assemblies shall consist of an insert and an activation cover. Assembly length: 16-3/4 inch (425mm).
   a. Insert: Insert body shall recess the devices a minimum of 2-3/4 inch (69mm) and have a polyester based backing enamel finished interior; ivory color. Furnish with necessary channels to provide complete separation of power and communication services. Provide five compartments that allow for up to five duplex receptacles that can be wired as a standard receptacle or isolated ground and/or 22 communication ports and/or 16 Legrand AVIP AV devices or 16 Extron® Electronics MAAP™ and/or four AAP™ devices.
   b. Body consists of an intumescent firestop material to maintain fire rating of the floor slab. Hold intumescent material securely in place in insert body. Intumescent material will not have to be adjusted to maintain fire rating of the unit and the floor slab. Provide insert with a retaining feature to hold the poke-thru device in the floor slab without additional fasteners. Poke-thru insert shall also consist of a 3/4-inch trade size conduit stub that is connected to the insert body and a 24.5 cubic in (402ml) stamped steel junction box for wire splicing and connections. Stamped steel junction box shall also contain the means necessary to electrically ground the poke-thru device to the system ground.
   c. Activation Cover: Manufactured of die-cast aluminum alloy; finished in powder-coated [gray] [black] [brass] [nickel] [bronze]. Provide with two gaskets (one for carpet and one for tile) to go under the trim flange to maintain scrub water tightness. Activation cover is 9-1/4 inch (235mm) in diameter. Provide cover with spring-loaded slides to allow cables to egress out of the unit and maintain as small an egress opening as possible. Architect to select finish.
   d. Communication Modules Mounting Accessories: Provide activation unit with three locations to mount communication connectors. Mount connectors using a mounting bracket capable of accepting up to 12 Ortonics® TracJack™ Category 6 insert modules or TechChoice™ Category 6 discrete keystone connectors. Also provide unit with two Category 6 discrete keystone connectors and two industry standard keystones and accommodate a mechanism to permit protection of communication cabling. Fabricate mechanism from stamped steel construction. Mechanism shall accept both flexible and rigid 3/4-in., 1-1/4-inch or two-inch trade size conduit.
7. 6AFF Poke-Thru Assembly: Poke-thru device assemblies shall consist of an insert and an activation cover. Assembly length: 16-3/4 inch (425mm).
   a. Insert: Insert body shall have the necessary channels to provide complete separation of power and communication services. Provide two channels that allow up to 10 #10 AWG conductors in the power channel and 28 Category 6A data cables in the communication channel.

b. Body consists of an intumescent firestop material to maintain fire rating of the floor slab. Hold intumescent material securely in place in insert body. Intumescent material will not have to be adjusted to maintain fire rating of the unit and the floor slab. Provide insert with a retaining feature to hold the poke-thru device in the floor slab without additional fasteners. Poke-thru insert shall also consist of a 3/4-inch trade size conduit stub that is connected to the insert body and a 24.5 cubic in (402ml) stamped steel junction box for wire splicing and connections. Stamped steel junction box shall also contain the means necessary to electrically ground the poke-thru device to the system ground.

c. Activation Cover: Manufactured of die-cast aluminum alloy; finished in powder-coated [gray] [black] [brass] [nickel] [bronze]. Provide with two gaskets (one for carpet and one for tile) to go under the trim flange to maintain scrub water tightness. Activation cover is 7-3/4 inch (196mm) in diameter. Provide cover with one 3/4-inch (19.05mm) trade size opening for power and one 1-1/4-in./2-inch (31.75/50.8mm) combination trade size opening for communications.

d. Provide surface mounted activation cover that accommodates a carpet floor finish.

8. Copper Wire Cross Sectional Area:

Copper Cross Sectional Area of Commonly Used Conductors	
Size	**Solid or Stranded**
#24	.00032 sq in (.206mm^2)
#22	.00050 sq in (.322mm^2)
#14	.00323 sq in (2.083mm^2)
#12	.00512 sq in (3.303mm^2)
#10	.00815 sq in (5.258mm^2)
#8	.01296 sq in (8.361mm^2)

a. Maximum copper cross sectional area for 6AT outer compartment only is .0154 square inch (9.9mm2). Maximum copper cross sectional area for the center compartment only is .0387 square inch (24.9mm2).

b. Maximum copper cross sectional area for 6ATCFF power compartment only is .0815 square inch (52.6mm2). Maximum copper cross sectional area for the center communication compartment only is .0686 square inch (44.3mm2). The maximum copper cross sectional area for the outside communication compartment only is .0187 square inch (12.1mm2).

c. Maximum copper cross sectional area for 8AT outer compartment only is .0154 square inch (9.9mm2). Maximum copper cross sectional area for the center compartment only is .0775 square inch (16.6mm2).

d. Maximum copper cross sectional area for 10AT outer compartment only is .0288 square inch (18.6mm2). Maximum copper cross sectional area for the center compartment only is .0960 square inch (61.9mm2).

9. Strictly comply with manufacturer's installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.

a. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer’s installation sheets.

b. Electrical Security: Metal raceway shall be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.

c. Raceway Support: Raceway shall be supported at intervals not exceeding 5 feet. or in accordance with manufacturer’s installation sheets.

d. Accessories: Provide accessories for a complete installation, including insulated bushings

and inserts where required by manufacturer.

e. Unused Openings: Close unused raceway openings using manufacturer's recommended accessories.

10. Install unit to permit all wiring to be completed at floor level.
11. Mount the [6AT and 6ATCFF units in a 6-1/16-inch (154mm) cored hole] [8AT units in an 8-1/16-inch (205mm) cored hole
12. Complete unit installation by pushing it down into the cored hole.

2.07 WIRING DEVICES

A. Manufacturers:
   1. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
      a. Cooper Wiring Devices.
      b. Hubbell.
      c. Leviton.
      d. Pass and Seymour.
      e. Or equal.

B. Straight Blade Receptacles:
   1. Duplex Receptacles: Comply with NEMA WD 1, NEMA WD 6 configuration NEMA5-20R, UL 498 and FS W-C-596. Specification grade industrial series, straight-blade, 2-pole 3-wire grounding type, back and side wired, nylon face, rated for 120 volts, 20 amperes. Hubbell No.5362 or equal. Hubbell No.5362WR or equal for weather-resistant listed receptacles. Receptacles that are controlled by an automatic control device shall be marked per NEC with the international power symbol. Provide as indicated on the drawings with one controlled face and split circuit hot tab equal to Hubbell BR20C1 series.
   2. Ground fault interrupter (GFI) receptacles: Duplex receptacles conforming to UL 943, specification grade heavy duty, feed-through type, rated for 120 volt, 20 amperes, NEMA 5-20R, GFI Class "A" with a sensitivity to leakage 5 milliamps, weather-resistant and tamper-resistant listed. Hubbell No. GF20LA or equal.
   3. Transient-Voltage Surge-Suppressor (TVSS) Receptacles: Duplex type, NEMA 5-20R configuration, with integral transient-voltage surge protection in a minimum of three modes: line-to-ground, line-to-neutral, and neutral-to-ground; listed as complying with UL 1449. Hubbell HBL5362SA or equal.
   4. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Specification grade, straight-blade, 2-pole 3-wire grounding type, back and side wired. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. Listed as tamper-resistant with “T” marking. Hubbell BR20TR or equal.
   5. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. Straight blade; equipment grounding contacts connected only to the green grounding screw terminal of the device, with inherent electrical isolation from mounting strap. Hubbell CR 5253IG or equal.
   6. Duplex Receptacles with Integral USB jacks, 125 V, 20 A: Specification grade, straight-blade, 2-pole 3-wire grounding type, back and side wired. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. “USB” marking indicates USB receptacle duplex grounding type NEMA 5-20R equal to Hubbell MX20X2 or equal

C. All standard 15 and 20 ampere, 125 and 250 volt non-locking type receptacles located five ft.-six inch or elow within Auditorium, Gymnasium, Pre-schools and elementary school age classrooms, medical clinic areas, dental offices and any other areas that are listed in NEC 406.12 shall be tamper resistant type receptacles whether indicated or not by the “T” marking on the drawings.

D. Exterior Outlets with Lockable Covers:
   1. Provide exterior outlets with lockable covers at all exterior outlet locations. Provide GFCI Circuit Breakers on all branch circuits. Provide in-use weatherproof locking covers with cord retention. Provde Taymac MX3200 for single gang vertical MX3300 for single gang horizontal and MX6200 for double duplex.
      a. Equal manufactuers
         1) RACO
         2) Hubbell
         3) Leviton
         4) Or equal

E. Hazardous (Classified) Location Receptacles:
   1. Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Cooper Crouse-Hinds.
         2) Appleton Electric.
         3) Hubbell.
         4) KH Industries.
         5) Or equal.

F. Twist-Locking Receptacles:
   1. Single Convenience Receptacles, 125 V and 250 V, 20 A: Comply with NEMA WD 1, NEMA WD6 and UL 498. Hubbell HBL2310 (L5-20R), HBL2320 (L6-20R), or equal.

G. Cord Reels
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell.
      b. Cooper Crouse-Hinds.
      c. Appleton Electric.
      d. KH Industries.
      e. Or equal.
   2. Industrial grade retractable power cord reel with the following features:
      a. Cast Aluminum construction, including mounting base
      b. 12 position adjustable guide arm
      c. Adjustable ratchet can be engaged (positive lock) or disengaged (constant tension)
      d. Adjustable ball stop
      e. Six feet. Feeder Cord included
      f. White powder-coat finish
      g. Universal mounting overhead, wall or detached from bracket completely.
      h. Adjustable cable stop.
      i. Voltage 125 VAC
      j. Slip Ring Rating 600V/30A
      k. Payout End Blk Duplex/Duplex Outlet Box
      l. Feeder End 5-20P
      m. Max. Amperage 20 Amps
      n. Gauge/Conductor 12/3
      o. Cord Length 25 Feet.
      p. Mounting Bracket with 340 degrees pivot base.
      q. Cord Type/Color SJO/White Cord Reel
      r. Color White
      s. Hubbell Model#HBLI25123GF220M1 or equal.
   3. For WP Cord Reel provide as follows:

a. Hubbell Model#HBLW25123 or equal.
b. Hubbell Model#HBLPOB1 receptacle enclosure
c. Install two duplex receptacles in receptacle enclosure.
d. Provide GFCI type circuit breaker for all WP Cord Reels

H. Snap Switches:
1. Comply with NEMA WD 1 and UL 20.
2. Switches, heavy duty, side wired, 120/277V, 20A:
3. Products: Subject to compliance with requirements, provide one of the following:
a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way).
b. Hubbell; C1221 (single pole), C1222 (two pole), C1223 (three way).
c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way).
d. Pass and Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way).

I. Securely fasten wiring devices in place, plumb, level, and true to finished lines and surfaces.

J. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

K. Provide gaskets on all wiring device plates where devices are on walls separating conditioned and non-conditioned spaces and exterior walls.

L. Composition material of wiring devices to be nylon with ivory finish. Outlets intended for computer use shall be grey finish, outlets on emergency shall be red finish.

M. Wall Plates:
1. Single and combination types to match corresponding wiring devices.
a. Plate-Securing Screws: Metal with head color to match plate finish.
b. Material for Finished Spaces: Satin-finished Type 302 stainless steel.
c. Material for Unfinished Spaces: Galvanized steel.
d. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."
2. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant**,** die-cast aluminum.

N. Finishes:
1. Color: Wiring device catalog numbers as specified do not designate device color.
a. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by referenced Electrical Code or device listing.
b. Wiring Devices Connected to Emergency Power System: Red.
c. Isolated-Ground Receptacles: Orange.

O. Extra Materials:
1. Provide ten 20A, duplex receptacles as attic stock.

2.08 LIGHTING FIXTURES

A. General
1. Submit the following in accordance with project submittal procedures:
a. Catalog Data: Submit catalog data describing luminaires, and drivers. Include data substantiating that materials comply with specified requirements. Arrange data for luminaires in the order of fixture designation.
b. Performance Curves/Data:
1) Submit certified photometric data for each type of luminaire.
2) Submit supply-air, return-air, heat-removal, and sound performance data for air handling luminaires.
c. Drawings: Submit shop drawings for non-standard luminaires.
d. Calculations: Submit as requested to support equal product proposals.
e. Warranty: Submit warranties for luminaires and for electronic ballasts.
2. All lamps, ballasts, led sources, drivers, and controls shall meet the latest utility company

incentive requirements. Refer to the latest program requirements documentation and coordinate with the utility company to ensure compliance.

B. Quality Assurance
   1. Comply with the National Electrical Code (NEC) and the Massachusetts Building Code (MBC) for components and installation.
   2. Provide luminaires listed and labeled by a nationally recognized testing laboratory (NRTL) for the application, installation condition, and the environments in which installed.
   3. Use manufacturers that are experienced in manufacturing luminaires, lamps and ballasts similar to those indicated for this Project and have a record of successful in-service performance.
   4. Coordinate luminaires, mounting hardware and trim with the ceiling system.
   5. Lighting fixture package submittals shall be fully coordinated between the electrical Sub-Sub-Contractor, lighting fixture representative(s), and lighting manufacturers to ensure all product, installation, and control requirements are met prior to submission for review. It is the electrical contractors responsibility to provide a package meeting all requirements of the project for a complete and fully functional lighting system.

C. LED Assemblies
   1. LED luminaires shall conform to UL 1598 and to UL 8250 – Safety Standard for Light-Emitting Diode (LED) Light Sources for Use in Lighting Products.
   2. Products shall be lead and mercury free.
   3. Photometric characteristics shall be established using IESNA LM-79-08, IESNA Approved Method for the Electrical and Photometric Measurement of Solid-State Lighting Products.
   4. Color characteristics of LED luminaires shall be as follows in accordance with ANSI C78.377 – Specifications for the Chromaticity of Solid State Lighting Products.
   5. LED and driver cooling system shall be passive and shall resist the buildup of debris.
   6. LED luminaire output after 50,000 hours of operation shall be not less than 70 percent of the initial lumen output when determined in accordance with IESNA LM-80-08 – IESNA approved Method for Measuring Lumen Maintenance of LED Lighting Sources.
   7. LED source package electrical characteristics:
      a. Supply voltage: 120 V, 208 V, 240 V, 277 V, or 480 V as indicated on the Drawings. Provide step-down transformers if required to match driver input voltage rating.
      b. Total harmonic distortion (current): Not more than 10 percent
      c. Power factor: Not less than 90 percent
      d. RF interference: Meet FCC 47 CFR Part 15/18
      e. Transient protection: IEEE C62.41 Class A.
   8. LED luminaires shall have initial efficiency of at least 100 lumens/watt.

D. Extra Materials
   1. Furnish the following extra materials matching products installed. Package with protective covering for storage and identify with labels describing contents.
      a. Two LED source packages of each fixture type.
      b. One louver and/or lense of each fixture type.
      c. Two LED drivers of each fixture type.
      d. Ten single faced exit signs of each type.
      e. Ten double faced exit signs of each type.

E. Interior General:
   1. Furnish interior luminaries that comply with requirements specified below, indicated on the Drawings, and coordinated to meet conditions of installation.
   2. Metal parts shall be free from burrs and sharp corners and edges.
   3. Metal components shall be formed and supported to prevent sagging and warping.
   4. Steel parts shall be finished with manufacturer's standard finish applied over a corrosion-resistant primer. Finish shall be free from runs, streaks, stains, holidays or defects.

5. Doors and frames shall be smooth operating and free from light leakage under operating conditions. Relamping shall be possible without the use of tools. Doors, frames, lenses and diffusers shall be designed to prevent accidental falling during relamping and when secured in the operating position.
6. Luminaires shall have minimum reflecting surface reflectance as follows unless specified otherwise on the Drawings:
    a. White Surfaces: 85 percent
    b. Specular Surfaces: 83 percent
    c. Diffusing Specular Surfaces: 75 percent
7. Lenses, diffusers, covers and globes shall be 100 percent virgin acrylic unless specified otherwise on the Drawings. Lenses shall have 0.125 inch minimum thickness.
8. Luminaires shall conform to UL 1598 - Luminaires. Provide product with damp location listing or wet location listing per installation location.

F. Interior Accessories
1. Provide stud supports, mounting brackets, frames, plaster rings and other accessories required for luminaire installation.
2. Furnish hangers as specified below and per conditions of installation:
    a. Stem hangers shall be made of 1/2-inch steel tubing with 45 degrees swivel ball hanger fitting and ceiling canopy. Finish the same as the luminaire.
    b. Rod hangers shall be made of 1/4 inch threaded zinc-plated steel rod.
    c. Provide hook hangers that are integrated assemblies matched to the luminaire and line voltage; equip with threaded attachment, power cord and locking type plug. Provide a safety chain or cable for each luminaire that will attach to the building structure, the ballast housing, and to the reflector/diffuser assembly.
3. Use NRTL-listed T-bar safety clips for lay-in fluorescent luminaires.

G. Interior Installation
1. Install interior lighting system in accordance with the NEC, manufacturer's installation instructions, approved shop drawings, and NECA National Electrical Installation Standards.
2. Have the manufacturer’s installation instructions available at the Project site.
3. Mounting heights specified or indicated on the Drawings are to the bottom of the luminaire for ceiling-mounted fixtures and to the center of the luminaire for wall-mounted fixtures.
4. Where the ceiling forms the protective membrane of a fire resistive assembly, install protective coverings over luminaires in accordance with NRTL requirements.
5. Install slack safety wires as described below for luminaires in or on suspended ceilings.
    a. Wire shall be minimum 12 gage galvanized soft annealed steel wire conforming to ASTM A641.
    b. Attach wire to the building structure directly above the attachment point on the box or luminaire; make trapezes of framing channel material to span obstacles
    c. Secure wire(s) at each end with not less than three tight turns in 1-1/2 in..
6. Support pendant-mounted or cable-supported luminaires directly from the structure above using a 9 gage wire or an approved alternate support without using the ceiling suspension system for direct support.
    a. Install seismic restraints for pendant-mounted and cable-supported luminaires.
    b. Pendants, rods, cables, or chains four feet or longer shall be braced to prevent swaying using three cables at 120 degrees separation.
7. Connect luminaires in suspended ceilings using six feet. lengths of flexible wiring method arranged accommodate not lea than 4 inch of differential seismic movement in any direction.

H. Interior Quality Control
   1. Make electrical connections, clean interiors and exteriors of luminaires, install lamps, energize and test luminaires, inspect interior lighting system, and deliver spare parts in accordance with manufacturer's instructions and NECA National Electrical Installation Standards:
   2. Test electronic dimming ballasts for full range dimming capability.
      a. Check for visually detectable flicker over the full dimming range.

I. Exterior - General
   1. Furnish exterior luminaires that comply with requirements specified in this Section and in the luminaire schedule on the Drawings.
   2. Luminaire photometric characteristics shall be based on IESNA approved methods for photometric measurements performed by a recognized photometric laboratory.
   3. Luminaire housing shall be primarily metal.
      a. Metal parts shall be free from burrs and sharp corners and edges.
      b. Sheet metal components shall be fabricated from corrosion-resistant aluminum, formed and supported to prevent sagging and warping.
      c. Exposed fasteners shall be stainless steel.
   4. Doors and frames shall be smooth operating and free from light leakage under operating conditions.
      a. Relamping shall be possible without the use of special tools.
      b. Doors, frames, lenses and diffusers shall be designed to prevent accidental falling during relamping and when secured in the operating position.
      c. Door shall be removable for cleaning or replacing lens.
   5. Luminaires shall have minimum reflecting surface reflectance as follows unless scheduled otherwise:
      a. White surfaces: 85 percent
      b. Specular surfaces: 83 percent
      c. Diffusing specular surfaces: 75 percent
   6. Provide lenses, diffusers, covers and globes as scheduled on the Drawings fabricated from materials that are UV stabilized to be resistant to yellowing and other changes due to aging or exposure to heat and ultraviolet radiation.
   7. Doors shall have resilient gaskets that are heat-resistant and aging-resistant to seal and cushion lens and refractor.
   8. All non-emergency lighting will be automatically controlled to turn off after hours. Manual override capability shall be provided through the automated lighting control system for after-hours use with timed automatic shut-off.

J. Exterior Poles and Accessories
   1. Furnish poles and accessories that comply with requirements specified in this Section and the luminaire schedule on the Drawings.
   2. Pole, base, and anchorage shall carry the luminaires, supports, and appurtenances at the indicated height above grade without deflection or whipping.
   3. Mountings, fastenings and other appurtenances shall be fabricated from corrosion-resistant materials that are compatible with poles and luminaires and will not cause galvanic action at contact points. Mountings shall correctly position luminaires to provide scheduled light distribution.
   4. A reinforced access handhole shall be located in the wall of each metal pole.
   5. A welded 1/2 inch grounding lug shall be accessible through the handhole of each metal pole. Grounding connection shall be designed to prevent electrolysis when used with copper ground wire.
   6. Metal poles shall have anchor type bases and galvanized steel anchor bolts and leveling nuts.
   7. Metal poles shall have a metal base cover that covers the entire base plate and anchorage.

8. Protect painted, anodized, or brushed pole finishes during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.
9. Aluminum poles shall be fabricated from corrosion resistant aluminum Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys or Alloy 356-T4 for cast alloys.
    a. Poles shall be square or round, tapered or straight as indicated on the Drawings.
    b. Aluminum poles over 30 feet. tall shall include factory-installed vibration dampers.
    c. Poles shall be seamless extruded or spun seamless type with minimum 0.188 inch wall thickness.
    d. Tops of shafts shall be fitted with a round or tapered cover.
    e. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B 108/B 108M, Standard Specification for Aluminum-Alloy Permanent Mold Castings and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded.
    f. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel.
10. The poles EPA capacity shall meet the wind rating in the geographical area in which its installed. Refer to AASHTO wind map and provide appropriate wind rating with the paired light fixture. Wind rating shall be a minimum of 100MPH with 130MPH gust rating.
11. Anchor bolts shall be steel rod having minimum yield strength of 50,000 Pounds per square foot. The top 12 inch of the anchor bolt shall be galvanized in accordance with ASTM A153/A153M.
12. Manufacturers: Subject to compliance with requirements, provide products as scheduled or specified on the Drawings.
13. Fuses and Fuse holders
    a. Furnish fuse overcurrent protection for each pole-mounted luminaire to isolate faulted ballasts from the lighting circuit.
    b. Use 600 volt, Class CC, time-delay, current-limiting fuses.
    c. Select fuses rated between 200 percent and 300 percent of the luminaire ballast or driver maximum current.
14. Furnish in-line fuse holders for installation in pole hand hole or transformer base.
    a. Use non-breakaway type fuse holders unless breakaway poles are indicated on the Drawings.
    b. Use breakaway type fuse holders where breakaway poles are indicated on the Drawings.
    c. Load and line terminal sizes and types shall correspond to line and load conductor sizes and quantities.
    d. Both breakaway and non-breakaway fuse holders shall have insulating boots.

2.09 ELECTRICAL POWER EQUIPMENT

A. Motor Controls :
1. Individually-mounted magnetic starters shall be NEMA rated across-the-line type with thermal overload on each phase, single-speed, two-speed, or reduced voltage start as indicated.
2. Motor Starters shall be furnished by Electrical Sub-Sub-Contractor unless part of package mechanical equipment such as rooftop units.
3. Starters shall be of maintained contact type, of size and type required for particular motor horsepower and voltage. Minimum size starter to be size 1 FVNR, unless noted otherwise.
    a. Starters shall have OL reset button, green push-to-test type pilot light to indicate "ON", and "HAND-OFF-AUTO" switch in cover.
    b. Starters to have 120 volt control transformers with fused output being provided for those units operating on 277/480 volt system.
    c. Provide Class 20 fixed heater overloads with auto/manual reset.
    d. Provide four sets of auxiliary contacts of convertible type N.O. to N.C. for each starter.

e. Motor starters shall have NEMA I enclosures. Those in wet locations shall be NEMA 3R.
f. Manufacturers:
1) Square D/Groupe Schneider

4. Manual motor starters shall have pilot lights and shall be furnished with thermal overloads on each phase.

B. Motors: Each motor shall have disconnect switch and starter provided under this section.
1. Provide motor terminal boxes for each motor not furnished with same.

C. Disconnect Switches:
1. Disconnect (safety) switches shall conform to industrial standards of NEMA, be UL listed and shall be heavy duty type, quick-make, quick-break type with interlocking cover mechanism and provisions for padlocking switch handle in "OFF" position. Three pole toggle switches are not acceptable as substitute for disconnect switches.
2. Disconnect switches shall be of fused or unfused type as indicated with number of disconnecting poles indicated. The grounded conductor shall not be switched. Switches for use with current limiting fuses shall be rejection type and those used in conjunction with motors shall be horsepower rated. Provide oversize termination lugs if required by conductor size.
3. Enclosures shall be of proper NEMA type for intended location and shall be phosphate coated or equivalent code gauge galvanized sheet steel with ANSI #24 dark gray baked enamel finish.
4. Manufacturers:
a. Square D/Groupe Schneider

D. Fuses:
1. Provide a complete set of fuses for each item of fusible type equipment.
2. Turn over to authorized representative of Owner upon completion a spare set of fuses of each different type and ampere rating installed. These spares shall be bound with twine and tagged.
3. Secondary system fuses, rated at 600 volts or less, shall be UL listed and constructed in conformance with the applicable standards set forth by NEMA and ANSI. All fuses of a particular class shall be of same manufacturer.
4. All fuses in distribution panelboards and switchboards shall be class "L" above 600 amperes and class "RK1" for 600 amperes and below.
5. Main, Feeder, and Branch Circuits:
a. Circuits 601 amperes and above shall be protected by (Bussmann type KRP-C LOW-PEAK) current limiting time delay fuses.
b. Circuits 0-600 amperes shall be protected by (Bussmann "LOW-PEAK" dual element), time delay current limiting fuses, LPN-RK (250 volts), LPS-RK (600 volts), UL class RK-1.
6. Manufacturers:
a. Bussmann, Division of McGraw
b. Gould/Shawmut
c. GEC-ALSTHOM
d. Or equal

2.10 ELECTRICAL SYSTEM CONTROLS AND INSTRUMENTS

A. Provide a complete power system consisting of branch circuits, motor disconnect switches, pushbutton stations, motor starters, and other devices to connect up and leave in operating condition each piece of electrically operated equipment provided either under this section or other Divisions.

B. All control wiring, not indicated in the electrical specifications or not shown on electrical drawings, shall be provided by Temperature Control Subcontractor.

C. CENTRALIZED CONTROL CENTER

1. Basis of Design: Provide Draper Smart Gym Control System in locations as shown on drawings or approved equal. System to include:
a. 503024 Smart Gym Processor Assembly

b. 503340 Smart Gym 10.1" Color Graphic Touchscreen

c. 503361 32 Relay Smart Gym Relay Box

2. EC to provide:

a. All conduits complete with wire from power source to control processor, from power source to relay panels, from relay panels to devices being operated, from control processor to relay panels (low voltage) from control processor to touch screen (Ethernet).

b. Appropriate wall box for specific touch screen as indicated on submittal document for that product.

2.11 GROUNDING SYSTEM

A. All equipment and systems shall be grounded. Refer especially to NEC Section 250 Requiring Connections to Building Steel, Foundation, Water Service, and Interior Piping. Provide transformer pad grounding in accordance with utility company standards.

B. The grounded conductor shall be supplemented by an equipment grounding system.

C. The equipment grounding system shall be installed so all conductive items in close proximity to electrical circuits operate continuously at ground potential and provide a low impedance path for ground fault currents.

D. Grounding conductors shall be so installed as to permit shortest and most direct path to ground.

E. Maximum measured resistance to ground of 5.0 ohms shall not be exceeded. Ground separately derived systems (dry type transformers) in accordance with Article 250-30 by grounding neutral to transformer ground lug and providing insulated grounding electrode conductor to nearest effectively grounded building steel or, if unavailable, to nearest available effectively grounded metal water pipe.

F. Equipment grounding conductors and straps shall be sized in compliance with Code Table 250-122.

G. Grounding conductors shall be insulated with green color. Grounding conductors for use on isolated ground receptacles shall be green with trace color to differentiate between normal ground conductors.

H. Branch circuits shall consist of phase and grounded conductor installed in common metallic raceway. All receptacle circuits shall have dedicated neutrals. All circuits shall have a separate insulated grounding conductor installed. Any flexible cable system or non metallic raceway system shall have an insulated grounding conductor. Any cable system for use on isolated ground circuits shall have both an isolated ground conductor as well as an equipment ground conductor, both of which shall be insulated.

I. Each electrical expansion fitting shall be furnished with a bonding jumper. Provide grounding bushings and ground connections for all raceways terminating below equipment where there is no metal to metal continuity.

J. Continuity between all metallic and nonmetallic raceway systems and equipment shall be maintained.

K. Outdoor lighting fixtures shall be grounded and bonded in common with building system via a separate grounding conductor.

L. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

M. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

N. Ground Rods: Drive rods until tops at least 6 inch below finished floor or final grade, unless otherwise indicated. Interconnect ground rods with grounding electrode conductor below grade.

O. Dry type transformer: Install an insulated grounding conductor from a transformer neutral to the building steel by means of copper wire, as scheduled on the drawings.
P. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors in conduit, from a grounding bus of the building's main service equipment to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
Q. Refer to Technology Specifications for additional grounding requirements.

2.12 MAIN BUILDING SWITCHBOARD

A. Main building switchboard shall be constructed in accordance with UL 891 and ANSI standards and of the required number of vertical sections bolted together to form one metal enclosed rigid structure. The sides, top, and rear shall be covered with removable plates. Switchboard shall include all protective services and equipment as listed on drawings with necessary interconnections, instrumentation, and control wiring. Buses shall be copper. Provide oversize termination lugs for any terminations requiring same due to conductor sizing.
B. Record drawings shall be furnished providing the following: Complete rating, short circuit withstand ability of bus and of lowest rated device, overall outline dimensions, including space available for raceways, circuit schedule showing circuit number, device description, device fuse clip ampere rating, conductor ratings and one line diagram with each circuit device numbered.
C. Each section shall be 90 inch high, self supported, and same depth as incoming line section, approximately 36 inch deep. Main protective device shall be individually mounted with front coverplate and bus connection straps. Where called for on schedule, "space" shall mean to include necessary bus, supports, and connections, leaving out only the breaker itself. Bus structure shall be arranged to permit future additions.
D. Switchboard shall be arranged for operation as follows:
   1. Voltage - 480Y/277 volts
   2. Frequency - 60 cycles
   3. Service - 3 phase, 4 wire, ampere capacity as indicated on drawings.
   4. Neutral - full capacity
   5. Available short circuit current at line terminals - 65,000 RMS amperes symmetrical.
   6. Integrated equipment rating - 65,000 AIC
   7. Copper ground bus, full length
   8. UL service entrance label
E. Provide electrical metering and voltage protection system equal to Square D Power Logic, Westinghouse IQ Data Plus or Siemens 4900 Series at main breaker. Coordinate Baud rate for meter with BMS system to ensure compatibility for communication.
F. Main service entrance device shall be an insulated-case circuit breaker (ICCB): Rating as shown on drawings, 100 percent rated, sealed circuit breaker with interrupting capacity rating to meet available fault current.
   1. Fixed circuit-breaker mounting.
   2. Two-step, stored-energy closing.
   3. Microprocessor-based trip unit with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
   4. Instantaneous trip.

5. Long- and short-time time pick-up and time delay adjustments.
6. Ground-fault pickup level, time delay, and I2t response.
7. Safety features: Phase loss protection.
8. Provide maintenance mode arc flash reduction feature on main circuit breaker.

G. Branch Devices shall be standard molded case circuit breakers, current limiting circuit breakers, or other devices as scheduled. Branch devices shall be mounted in panelboard type construction.

H. Switchboard feeder protective devices shall be molded case circuit breakers. The circuit breakers 200 amperes and larger shall be with a solid-state trip, all other circuit breakers shall be of thermal-magnetic type. Breakers shall be built, tested, and labeled in accordance with UL 489.

I. Include space and provisions for utility company metering. Refer to electric service section of this Division.

J. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with field-replaceable rating plug and the following field-adjustable settings:
4. Instantaneous trip.
5. Long- and short-time pickup levels.
6. Long- and short-time time adjustments.
7. Ground-fault pickup level, time delay, and I2t response.
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
9. Standard frame sizes, trip ratings, and number of poles.
10. Lugs: Suitable for number, size, trip ratings, and conductor material.
11. Application Listing: Type HACR for heating, air conditioning and refrigeration equipment power feeders.
12. Shunt Trip: 120-V trip coil energized from separate circuit, where shown on the drawings.

K. Acceptable Manufacturers:
1. Eaton
2. Square D/Groupe Schneider
3. Siemens
4. General Electric/ABB
5. Or equal

2.13 PANELBOARDS

A. Panelboards shall be dead-front, door in door safety type equipped with single or multi-pole circuit breakers suitable for 120/208 volt or 277/480 volt, 3 phase, 4 wire operation.

B. Buses shall be copper. Panelboards shall have a circuit directory card mounted in a frame with plastic cover on inside of door. Panelboards to have a copper ground bus with terminals for each circuit. Panelboards serving isolated ground receptacles shall have a separate ground bus for terminations of the isolated grounds. The isolated ground bus shall be mounted to the panel tub via non conducting means with a separate grounding conductor run to the normal panel ground bus. Provide oversize lugs for any termination requiring same due to oversize conductors. Provide 200 percent neutral buses on all 120/208 volt panelboards fed from K-rated transformers.

C. Cabinets shall be minimum of 20 inch wide and be made of code gauge steel. Surface type shall be ordered without knockouts.

D. Trims shall be made of code gauge steel, surface or flush as indicated. Panelboards shall be keyed alike. Trims shall be provided with full length piano hinge on one side, and secured to tub with sufficient quantity of latches opposite the hinge side to allow trim to fit flush with tub and when released, allow full access to wiring gutters. Inner door shall allow access to circuit breakers only.

E. Panelboards shall be of the following types with minimum circuit breaker frame sizes listed below. Refer to schedules for larger circuit breaker frame sizes due to fault current availability.
   1. 120/208 volt, three phase, four wire. Symmetrical interrupting capacity 22,000 AIC.

Style	
Square D type NQOD	QOB Breakers (bolt-on)
Eaton/Cutler-Hammer	BAB Breakers (bolt-on)
Siemens type CDP-7BQ	Breakers (bolt-on)
General Electric Type AQ	HHQB Breakers (bolt-on)

   2. 277/480 volt, three phase, four wire. Symmetrical interrupting capacity 65,000 AIC.

Style	
Square D type NEHB	EHB Breakers (bolt-on)
Eaton/Cutler-Hammer	GHB Breakers (bolt-on)
Siemens type CDP-7BQCH	Breakers (bolt-on)
General Electric Type AE	TEY Breakers (bold-on)

   3. Distribution Panels:
      a. Where scheduled as circuit breaker type, symmetrical interrupting capacity 65,000 AIC.

Square D I Line type	FA Breakers
Eaton/Cutler-Hammer	FD Breakers
Siemens SPP	FXD6 Breakers
General Electrical Spectra	THED Breakers

F. Panelboards and distribution panels shall be of same manufacturer as switchboard. Refer to drawings where higher interrupting are required.
   1. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
      a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 150 A and larger.
      b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
      c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
      d. Instantaneous trip.
      e. Long- and short-time pickup levels.
      f. Long- and short-time time adjustments.
      g. Ground-fault pickup level, time delay, and I2t response.
      h. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (5-mA trip).
      i. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
      j. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.

G. All power panels fed from K-13 transformers shall have surge protection within the panelboard. Coordination and Arc flash study shall be submitted with shop drawing submittal. All circuit breaker selection shall meet and be provided per study recommendations.
H. Electrical Sub-contractor shall provide infrared scanning of all panelboards after three months past substantial completion. Provide report indicating status of all terminations at respective panelboards per phase.
I. Extra Materials:
    1. Provide ten 20A, single-pole breakers as attic stock.

2.14 DRY-TYPE TRANSFORMERS

A. TRANSFORMER SPECIFICATION
    1. Compatibility: This product shall facilitate the ability of the electrical system to supply a sinusoidal voltage in order to improve the long-term compatibility of the electrical system with all types of linear and nonlinear connected loads today and in the future. All national and international standards on harmonics and power quality set limits on levels of voltage distortion to maintain compatibility.
    2. Copper-wound, 3-phase, common core, ventilated, dry-type, isolation transformer built to NEMA ST20 and relevant NEMA, UL and IEEE standards; 200 percent rated neutral; 60Hz rated; Transformers 750 kVA and less, 600 volt primary and less, shall be U.L. and CSA Listed and bear the label. All terminals, including those for changing taps, shall be readily accessible by removing a front cover plate. Windings shall be continuous with terminations brazed or welded. 10kV BIL.
    3. Insulation System:
        a. Shall be NOMEX-based with an Epoxy Co-polymer impregnant for lowest environmental impact, long term reliability and long life expectancy
        b. Class: 220 degrees Celsius
        c. Impregnant Properties for low emissions during manufacturing, highest reliability and life expectancy
        d. Epoxy co-polymer
        e. VOC: less than 1.65 lbs/gal (low emissions during manufacturing)
        f. Water absorption (24hrs at 25 Celsius): less than 0.05 percent (superior insulation, longer life)
        g. Chemical Resistance: Shall have documented excellent performance rating by supplier
        h. Dielectric Strength: minimum of 3200 volts/mil dry (for superior stress, overvoltage tolerance)
        i. Dissipation Factor: max. 0.02 at 25 Celsius to reduce aging of insulation, extending useful life
    4. Operating Temperature Rise: 130 degree C in a 40 degree C maximum ambient
    5. Noise levels:
        a. Per NEMA ST-20
        b. Production Test every unit. Data to be available upon request.
    6. UL Listed and Labeled K-Rating: K-7 or higher
    7. Maximum No Load Losses
        a. Transformers are energized 2four hours a day for their entire life, potentially 40 years or more. These losses are incurred whether the transformer is loaded or not, and cost the user many times the purchase price of the transformer even at current energy rates.
        b. No load losses shall not exceed: 15kVA: 60W, 30kVA: 99W, 45kVA: 130W, 75kVA: 180W, 112.5kVA: 260W, 150kVA: 330W, 225kVA: 450W, 300kVA: 560W, 500kVA: 850W
    8. Efficiency at 35 percent loading
        a. Data shows that transformers are typically very lightly loaded for extended periods of time,

therefore to minimize operating cost under real world loading conditions, efficiency at 1/6 loading shall be maximized.

b. Efficiency at 35 percent load shall meet or exceed: 15kVA: 89 percent, 30kVA: 98.23 percent, 45kVA: 98.40 percent, 75kVA: 98.6 percent, 112.5kVA: 98.74 percent, 150kVA: 98.83 percent, 225kVA: 98.94 percent, 300kVA: 99.02 percent, 500kVA: 99.14 percent, 750kVA: 99.23 percent

9. Voltage Taps: For transformers 30kVA-300kVA, provide two 2-1/2 percent full capacity taps above and below nominal primary voltage. For transformers 15kVA and smaller as well as 500kVA and larger provide one 5 percent full capacity tap above and below nominal primary voltage.
10. Impedance: Between 3.5 percent and 5.8 percent unless otherwise noted.
11. Enclosure type: Ventilated NEMA 2, drip-proof
12. Maximum Footprint for 130 degree C rise model in a NEMA 1 enclosure:
    a. 17 inch Wide by 17 inch Deep by 27 inch High for 15kVA.
    b. 26 inch Wide by 18 inch Deep by 30 inch High for 30kVA, 45kVA
    c. 33 inch Wide by 22 inch Deep by 40 inch High for 75kVA, 112.5kVA
    d. 38 inch Wide by 28 inch Deep by 52 inch High for 150kVA
    e. 38 inch Wide by 32 inch Deep by 52 inch High for 225kVA, 300kVA
    f. 52 inch Wide by 38 inch Deep by 61 inch High for 500kVA
    g. 63 inch Wide by 46 inch Deep by 67 inch High for 750kVA

B. TRANSFORMER FEATURES
1. Electrostatic Shield: Each winding shall be independently single shielded with a full-width copper electrostatic shield.
2. All transformers shall meet Department of Energy 2016 efficiency standards.

C. Double Deflection Neoprene Mounts
1. At each transformer install double deflection neoprene mounts for vibration isolation and improved acoustics.
    a. Provide Mason industries, inc. ND double deflection neoprene mounts or equal
    b. Install size and rated capacity appropriate for the transformer that it is being mounted to.

D. ACCEPTABLE MANUFACTURERS
1. Powersmiths International Corp., General Electric, Eaton, Square D, ACME, Jefferson Electric, Siemens, or equal.

2.15 ELECTRIC SERVICE

A. Coordinate and cooperate with National Grid, hereinafter called utility company, with respect to providing service and metering.

B. Provide all primary manholes, system raceways, elbows, pull wires, foundation pads and all pad grounding. Utility company will provide pad mounted transformer and primary conductors including making up of all terminations and connections.

C. Provide secondary service complete including all conductors, raceways, and connectors at transformer. Provide oversize lugs if required due to conductor sizing. Attachment of secondary conductors to the transformer terminals shall be done by the E.C.

D. General Contractor shall do all excavation and back filling in accordance with utility company standards.

E. All work to be done in accordance with utility company standards.

F. Metering: All usage will be on one secondary meter. Utility Company will furnish current transformers and potential transformers to be installed in transformer. Meter socket and meter will be provided by Utility Company.

2.16 FIRE ALARM AND DETECTION SYSTEM (Voice Evacuation required with Integrated Mass Notification Devices)

A. Description:

1. This This section of the specification includes the furnishing, installation, connection and testing of the microprocessor controlled, intelligent reporting fire alarm equipment required to form a complete, operative, coordinated system. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, Fire Alarm Control Panel (FACP), Mass Notification Control Panel(s), auxiliary control devices, annunciators, and wiring as shown on the drawings and specified here-in.
2. The fire alarm and mass notification system shall comply with requirements of latest NFPA Standard 72 for Protected Premises Signaling Systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.
3. The fire system manufacturer shall be of the highest caliber and insist on the highest quality. The system shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001-1994.
4. The FACP and peripheral devices shall be manufactured 100 percent by a single U.S. manufacturer (or division thereof).
5. The system and its components shall be Underwriters Laboratories, Inc. listed under the appropriate UL testing standard as listed herein for fire alarm applications and shall be in compliance with the UL listing.
6. Each designated zone shall transmit separate and different alarm, supervisory and trouble signals to the Fire Command Center (FCC) and designated personnel in other buildings at the site via a multiplex communication
7. The installing company shall employ NICET (minimum Level II Fire Alarm Technology) technicians on site to guide the final check-out and to ensure the systems integrity.

B. Scope:

1. An An intelligent reporting, microprocessor controlled fire detection and system shall be installed in accordance with the specifications and drawings.
2. Basic Performance:
   a. Alarm, trouble and supervisory signals from all intelligent reporting devices shall be encoded onto NFPA Style 7 (Class A) Signaling Line Circuits (SLC).
   b. Initiation Device Circuits (IDC) shall be wired Class A (NFPA Style D).
   c. Addressable Notification Appliance Circuits (NAC) shall be wired Class A (NFPA Style Z).
   d. Digitized electronic signals shall employ check digits or multiple polling.
   e. Power for initiating devices and notification appliances shall be from the main fire alarm control panel, the transponder to which they are connected or to a Field Charging Power Supply (FCPS).
   f. A single ground or open on any system signaling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
   g. Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
3. Basic System Functional Operation: When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
   a. The FACP alarm LED on the FACP shall flash.
   b. A local piezo-electric signal in the FACP control panel shall sound.

   c. The 80-character LCD display on the local FACP node and on the intelligent network display shall indicate all information associated with the fire alarm condition, including the type of alarm point, and its location within the protected premises. This information shall also be displayed on the network reporting terminal.
   d. Printing and history storage equipment shall log the information associated with the fire alarm control panel condition, along with the time and date of occurrence.
4. All system output programs assigned via control-by-event interlock programming to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated on either local outputs or points located on other network nodes.
5. When a mass notification (MNS) condition is initiated and reported by one of the system initiating devices, the following functions shall immediately occur:
   a. The FACP priority 2 alarm LED on the FACP shall flash.
   b. A local piezo-electric signal in the FACP control panel shall sound.
   c. The 80-character LCD display on the local FACP node and on the intelligent network display shall indicate all information associated with the MNS alarm condition, including the location within the protected premises. This information shall also be displayed on the network reporting terminal.
   d. Printing and history storage equipment shall log the information associated with the MNS alarm control panel condition, along with the time and date of occurrence.
   e. All system output programs assigned via control-by-event interlock programming to be activated by the particular point in alarm shall be executed, and the associated system outputs (notification appliances and/or relays) shall be activated on either local outputs or points located on other network nodes.
   f. Owner defined prerecorded messages shall be sounded throughout the building or to groups of speakers as defined by the Owner.
   g. The digital alarm communicating transmitter shall summons the police department via a Ul listed central station.
   h. Activate message boards in common areas to display any one of 32 user defined messages.
   i. Signals shall be sent to the integrated security alarm system to lock doors in accordance with the Owners Mass Notification procedures.
   j. Activate predefined cameras for display and recording as defined by the Owner
6. Software Modifications:
   a. Provide the services of a factory trained and authorized technician to perform all system software modifications, upgrades or changes. Response time of the technician to the site shall not exceed four hours.
   b. Provide all hardware, software, programming tools and documentation necessary to modify the fire alarm network on site. Modification includes addition and deletion of devices, circuits, zones and changes to system operation and custom label changes for devices or zones. The system structure and software shall place no limit on the type or extent of software modifications on-site. Modification of software shall not require power-down of the system or loss of system fire protection while modifications are being made.
7. Certifications:
   a. Together with the shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of installation and the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer and trained on network applications. Include names and addresses in the certification.

C. Applicable Publications:

The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only.

1. National Fire Protection Association (NFPA) - USA:

No. 72	National Fire Alarm Code
No. 70	National Electric Code
No. 101	Life Safety Code

2. Underwriters Laboratories Inc. (UL) - USA:

No. 50	Cabinets and Boxes
No. 268	Smoke Detectors for Fire Protective Signaling Systems
No. 864	Control Units for Fire Protective Signaling Systems
No. 268A	Smoke Detectors for Duct Applications
No. 521	Heat Detectors for Fire Protective Signaling Systems
No. 228	Door Closers-Holders for Fire Protective Signaling Systems
No. 464	Audible Signaling Appliances
No. 38	Manually Actuated Signaling Boxes
No. 346	Waterflow Indicators for Fire Protective Signaling Systems
No. 1481	Power supplies for Fire Protective Signaling Systems
No. 1076	Control Units for Burglar Alarm Protective Signaling Systems
No. 1971	Visual Notification Appliances

3. Local and State Building Codes.
4. All requirements of the Authority Having Jurisdiction (AHJ).

D. Approvals:

1. The system shall have proper listing and/or approval from the following nationally recognized agencies:

UL	Underwriters Laboratories Inc.
FM	Factory Mutual
MEA	Material Equipment Acceptance (NYC)
CSFM	California State Fire Marshal

2. The fire alarm control panel shall meet the modular labeling requirements of Underwriters Laboratories, Inc. Each subassembly, including all printed circuits, shall include the appropriate UL modular label. Systems which do not include modular labels which may require return to the manufacturer for system upgrades, and are not acceptable.

E. Equipment and Material - General:

1. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.
2. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, and physical equipment sizes before beginning system installation. Refer to the riser/connection diagram for all specific system installation/termination/wiring data.
3. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place. (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

4. Submittals
    a. Submit complete documentation for the Fire Alarm/Life Safety System showing the Model Number, type, rating, size, style, Manufacturer's Names, and Manufacturer's Catalog Data Sheets for all items to ensure compliance with these Specifications. Submittals shall be prepared by a NICET level III and reviewed signed and dated by a NICET IV.
    b. Upon Contract Bid approval, and prior to start of system installation, submit Shop Drawings to and obtain written approval from the Fire Department, prior to ordering fire alarm equipment. General requirements are as follows:
        1) Submittal of fire rated sealant for penetrations.
        2) A complete point to point riser diagram of the fire alarm system. (Typical riser diagrams are not acceptable).
        3) Floor plans detailing all devices in the system with addresses, circuiting and circuit calculations.
        4) A complete point to point installation diagram. (Typical installation diagrams are not acceptable).
        5) A complete list of current drain requirements during normal supervisory, trouble, and alarm condition.
        6) Battery standby calculations showing total standby power required to meet the specified system requirements.
        7) Supplier’s qualifications indicating years in business, service policies, warranty definitions, and list of similar installations.
        8) Electrical Subcontractor qualifications, indicating years in business, prior experience with installations that include the type of equipment that is to be supplied, and installers license number and type of license.
        9) Circuit calculations for all Notification Appliance Circuits. Calculations shall conform to UL864 10th edition and shall be performed using 19vdc starting voltage with a drop allowance to minimum nameplate voltage for the devices on each circuit. Amplifiers shall be calculated based on the following tap settings:
            a) A Gym, Cafeteria, Auditorium, rooms greater than 1,000 square feet. and mechanical rooms shall be set at 8watts
            b) Corridors shall be at .5watts
            c) Classrooms shall be at 1 watt
            d) Offices shall be at .25
            e) Provide One back up amplifier for each 50 watts provided to support the system.
            f) Provide 25 percent spare capacity on all notification and indicating appliance circuits

F. Conduit and Wire:
1. Conduit:
    a. Conduit shall be in accordance with the National Electrical Code (NEC), local and state requirements.
    b. All wiring shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.
    c. Cable shall be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760-29.

d. Wiring for 24 volt control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.
e. Conduit shall not enter any FACP, or any other remotely mounted control panel equipment or backboxes, except where conduit entry is specified by the FACP manufacturer.
f. Conduit shall be 3/4 inch (19.1 mm) minimum.

2. Wire:
   a. All fire alarm system wiring shall be new, unless specified herein.
   b. Wiring shall be in accordance with local, state and national codes (e.g., NEC Article 760) and per recommentations by the manufacturer of the fire alarm system. Number and size of conductors shall be recommeded by the fire alarm system manufacturer, but not less than 16 AWG (1.02 mm) for initiating device circuits and signaling line circuits, and 14 AWG (1.32 mm) for notification appliance circuits.
   c. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
   d. Wiring used for the SLC multiplex communication loop shall be twisted and shielded unless specifically accepted by the fire alarm equipment manufacturer.
   e. All field wiring shall be completely supervised.
3. Terminal Boxes, Junction Boxes and Cabinets: All boxes and cabinets shall be UL listed for the intended purpose.
4. Initiating circuits shall be arranged to serve like categories (manual, smoke, waterflow). Mixed category circuitry shall not be permitted except on signaling line circuits connected to intelligent reporting devices.
5. The FACP shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution Panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The FACP cabinet shall be grounded securely to either a cold water pipe or grounding rod.

G. Fire Alarm Control Panel and Fire Command Center:
1. Fire alarm control panel shall be an Autocall 4100ES, Notifier NFS3030, Edwards EST3, or equal. The performance specification herein is based on the Autocall 4100ES system and any other system provided shall meet the same general performance criteria to be considered equal. FACP shall contain a microprocessor based central processing unit (CPU). The FACP shall communicate with and control the following types of equipment used to make up the system: intelligent detectors, addressable modules, transponders, local and remote operator terminals, printers, annunciators, and other system controlled devices. Main FACP shall include a built-in, integral microphone with selector switches (eight minimum) for fire fighter paging all within the same main panel. FACP shall be fully ethernet enabled and provide email, text and other messaging via Owner's LAN.
2. Node Capacity and General Operation:
3. NOTE: Since this system shall utilize a mass notification feature, the main fire alarm panel shall include an auxiliary audio input card which shall allow for external audio into the fire alarm panel. It shall also include a dedicated switch bank (eight switches with integral red/green switch for each toggle switch). These shall be used for manual activation of mass notification devices.
   a. Each node shall provide, or be capable of, expansion to 2500 intelligent addressable devices per loop plus 2048 annunciation points per system. FACP shall support a minimum of 10 intelligent loops.

b. Each FACP node shall include a full featured operator interface control and annunciation panel which shall include a backlit Liquid Crystal Display (LCD), individual, color coded system status LEDs, and an alpha-numeric keypad for field programming and control of the node.
c. All programming or editing of the existing programming the system shall be achieved without special equipment or interrupting the alarm monitoring functions of the fire alarm control panel.
d. The system shall include emergency voice communications utilizing distributed amplification and intelligence such that loss of operation by the main FACP will not result in the loss of evacuation signal throughout the balance of the building.
e. Each FACP node shall provide the following features:

Block Acknowledge	Printer Interface
Charger rate Control	CRT Display Interface
Control-by-Time	Non-Alarm Module Reporting
Day/Night Sensitivity	Periodic Detector Test
Device Blink Control	Remote Page
Drift Compensation	Trouble Reminder
NFPA 72, Sensitivity Test	Upload/Download to PC computer
System Status Reports	Verification
	Counters
Security Monitor Points	Walk Test
Alarm Verification	Maintenance Alert

f. System shall contain eight user defined messages for distribution to any user defined circuit selected, Provide eight switches for message selection.

4. Loop Interface Board (LIB):
   a. Loop interface boards shall be provided to monitor and control each of the Signaling Line Circuit (SLC) loops in the network node. The loop interface board shall contain its own microprocessor and shall be capable of operating in local mode in the case of a failure in the main CPU of the control panel. In local mode, the loop interface board shall detect alarms and activate output devices on its own SLC loop.
   b. The LIB shall not require any jumper cuts or address switch settings to initialize SLC Loop operations.
   c. The loop interface board shall provide power to, and communicate with, all of the intelligent detectors and addressable modules connected to its SLC Loop over a single pair of wires. This SLC Loop shall be capable of operation as NFPA Style 4, Style 6, or Style 7.
   d. The LIB shall be able to drive two Style 4 SLC loops, each up to 10,000 feet. in length, for an effective loop span of 20,000 feet.
   e. The loop interface board shall receive analog information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular detector. The loop interface board software shall include software to automatically adjust and compensate for dust accumulation to maintain detector performance as it is affected by environmental factors. The analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.
   f. The LIB shall communicate with each intelligent addressable detector and addressable module on its SLC loop and verify proper device function and status. Communication with up to 198 intelligent devices shall be performed every 6 seconds or less.
5. Enclosures:
   a. Control panels shall be housed in UL listed cabinets suitable for semi-flush mounting. Cabinets shall be corrosion protected, given a rust-resistant prime coat, and the manufacturer's standard finish.

b. The back box and door shall be constructed of .060 steel with provisions for electrical conduit connections into the sides and top.
c. The door shall provide a key lock and include a transparent opening for viewing all indicators. For convenience, the door shall have the ability to be hinged on either the right or left-hand side.
d. The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.

6. FACP nodes shall be designed so that it permits continued local operation of remote transponders under both normal and abnormal network communication loop conditions. This shall be obtained by having transponders operate as local control panels upon loss of network communication.
7. FACP nodes shall be modular in construction to allow ease of servicing. Each CPU and transponder shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems, which require use of external programmers or change of EPROM's are not acceptable.
8. The CPU and associated equipment are to be protected so that they will not be affected by voltage surges or line transients including RFI and EMI.
9. FACP Power Supplies:
   a. Main power supplies shall operate on 120 VAC, 60Hz, and shall provide all necessary power for the FACP.
   b. Each main supply shall provide 9.0 amps of usable notification appliance power, using a switching 24 VDC regulator.
   c. The main power supply shall be expandable for additional notification appliance power in 9.0 ampere steps.
   d. Battery backup shall be provided to meet current NFPA requirements of 2four hours standby and 15 minutes of alarm.
   e. The supply shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults on sensitive addressable modules.
   f. It shall provide meters to indicate battery voltage and charging current.
   g. The main power supply shall be power-limited per 1995 UL864 requirements.
   h. Booster (SNAC) panels are not allowed. Main FACP and any corresponding transponders shall include all necessary intelligence to drive initiating and notification devices (including addressable cards, notification circuits, amplifiers (digital, not analog) for a complete system. Main FACP shall include LCD annunciator and controls. Transponders shall include metal cabinets and covers as well as integral battery backup.
10. System Circuit Supervision:
    a. Each FACP node shall supervise all circuits to intelligent devices, transponders, annunciators and peripheral equipment and annunciate loss of communications with these devices. The FACP CPU shall continuously scan the above devices for proper system operation and upon loss of response from a device shall sound an audible trouble, indicate which device or devices are not responding and print the information on the printer.
    b. Sprinkler system valves, standpipe control valves, PIV, and main gate valves shall be supervised for off-normal position.
11. Field Wiring Terminal Blocks: For ease of service, all wiring terminal blocks shall be the plug-in type and have sufficient capacity for 18 to 12 AWG wire. Fixed terminal blocks are not acceptable.

12. Operators Terminal: Provide the following functions in addition to any other functions required for the system.
    a. Acknowledge (ACK/STEP) Switch:
        1) Activation of the control panel Acknowledge switch in response to a single new Alarm and/or trouble condition shall silence the local panel piezo electric signal and change the system alarm or trouble LED from flashing mode to steady-ON mode. If additional new alarm or trouble conditions exist or are detected and reported in the system, depression of this switch shall advance the 80-character LCD display to the next alarm or trouble condition.
        2) Depressing the acknowledge switch shall also silence all remote annunciator piezo sounders.
    b. Signal Silence Switch: Activation of the signal silence switch shall cause all programmed alarm notification appliances and relays to return to the normal condition after an alarm activation. The selection of notification circuits and relays which are silence able by this switch shall be fully field programmable within the confines of all applicable standards.
    c. System Reset Switch: Activation of the system reset switch shall cause all local electronically-latched initiating devices, software zones, output devices and circuits, to return to their normal condition.
    d. If an alarm condition(s) still exists, or if they reoccur in the system after system reset switch activation, the system shall then resound the alarm conditions.
    e. System Test Switch: Activation of the system test switch shall initiate an automatic test of all intelligent/addressable detectors in the local system. The system test shall activate the electronics in each intelligent sensor, simulating an alarm condition and causing the transmission of the alarm condition from that sensor to the fire alarm control panel. The fire alarm control panel shall interpret the data from each sensor installed in the system. A report summarizing the results of this test shall be displayed automatically on the system LCD and on any CRTs or printers in the system.
    f. Lamp Test Switch: Activation of the lamp test switch shall sequentially turn on all LED indicators, system liquid crystal display and local piezo signal, and then automatically return the fire alarm control panel to the previous condition.
13. Field Programming:
    a. The system shall be programmable, configurable and expandable in the field without the need for special tools or electronic equipment and shall not require field replacement of electronic integrated circuits.
    b. All local FACP node programming shall be accomplished through the FACP keyboard or through the video display terminal.
    c. All field defined programs shall be stored in non-volatile memory.
    d. The programming function shall be enabled with a password that may be defined specifically for the system when it is installed. Two levels of password protection shall be provided in addition to a key-lock cabinet. One level is used for status level changes such as zone disable or manual on/off commands. A second (higher-level) is used for actual change of program information.
14. Specific System Operations:
    a. Smoke Detector Sensitivity Adjust: Means shall be provided for adjusting the sensitivity of any or all analog intelligent detectors in the FACP node from each system keypad or from the keyboard of the video terminal. Sensitivity range shall be within allowed UL limits.
    b. Alarm Verification: Each of the intelligent addressable detectors in the system may be independently selected and enabled for alarm verification. Each FACP shall keep a count of the number of times each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.

c. System Point Operations:
   1) All devices in the FACP node may be enabled or disabled through the local keypad or video terminal.
   2) Any FACP node output point may be turned on or off from the local system keypad or the video terminal.

d. Point Read: The FACP node shall be able to display the following point status diagnostic functions without the need for peripheral equipment. Each point will be annunciated for the parameters listed:
   1) Device Status
   2) Device Type
   3) Custom Device Label
   4) Software Zone Label
   5) Device Zone Assignments
   6) Detector Analog Value
   7) All Program Parameters

e. System Status Reports: Upon command from a password-authorized operator of the system, a status report will be generated, and printed, listing all local FACP system status.

f. System History Recording and Reporting: Each FACP node shall contain a history buffer that shall be capable of storing a minimum of 400 system events. Each local activation will be stored and time and date stamped with the actual time of the activation, until an operator requests that the contents be either displayed or printed. The contents of the history buffer may be manually reviewed, one event at a time, and the actual number of activations may also be displayed and or printed.

   The history buffer shall use non-volatile memory. Systems which use volatile memory for history storage are not acceptable.

g. Automatic Detector Maintenance Alert: Each FACP node shall automatically interrogate each intelligent system detector and shall analyze the detector responses over a period of time.

   If any intelligent detector in the system responds with a reading that is below or above normal limits, then the system will enter the trouble mode, and the particular intelligent detector will be annunciated on the system display, network display and printed on the optional system printer. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.

H. Addressable Devices – General:
   1. Device addressing shall be performed in the base rather than the sensor to avoid troubles when devices are removed for cleaning and replaced with a different sensor than the one that was originally removed.
   2. Detectors shall be intelligent (analog) and addressable, and shall connect with two wires to the FACP signaling line circuit.
   3. Addressable smoke and thermal detectors shall provide dual alarm and power/polling LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the LED flash shall have the ability to be removed from the system program. An output connection shall also be provided in the base to connect an external remote alarm LED.
   4. Smoke detector sensitivity shall be set in the fire alarm control panel and shall be adjustable in the field through the field programming of the system. Sensitivity may be automatically adjusted by the panel on a time-of-day basis.

5. Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72, Chapter 7.
6. The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature. Base shall include a sounder base with a built-in (local) sounder rated at 85 DBA minimum, a relay base and an isolator base designed for Class A applications.
7. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
8. Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (Ion, Photo, Thermal).
9. Detectors will operate in an analog fashion, where the detector simply measures its designed environment variable and transmits an analog value to the FACP based on real-time measured values. The FACP software, not the detector, shall make the alarm/normal decision, thereby allowing the sensitivity of each detector to be set in the FACP program and allowing the system operator to view the current analog value of each detector.
10. A magnetic test switch shall be provided to test each detector for 100 percent obscuration, reported to the FACP.
11. Addressable devices shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. LED(s) shall be provided that shall flash under normal conditions, indicating that the device is operational and is in regular communication with the control panel.
12. A magnetic test switch shall be provided to test detectors and modules. Detectors shall report an indication of an analog value reaching 100 percent of the alarm threshold.

I. Addressable Pull Box (manual station):
1. Addressable pull boxes shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key. Manual pull stations shall be of the double action type.
2. All operated stations shall have a positive, visual indication of operation and utilize a key type reset.
3. Manual stations shall be constructed of Lexan with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inch or larger.
4. Stations shall be suitable for surface mounting or semiflush mounting as shown on the plans, and shall be installed not less than 42 inch, nor more than 48 inch above the finished floor.
5. Provide Stopper II cover with audible alarm where shown on the plans.

J. Intelligent Photoelectric Smoke Detector:
1. The detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.

K. Intelligent Thermal Detectors:
1. Thermal detectors shall be intelligent addressable devices rated at 135 degrees Fahrenheit (58 degrees Celsius) and have a rate-of-rise element rated at 15 degrees Fahrenheit (9.4 degrees Celsius) per minute. It shall connect via two wires to the fire alarm control panel signaling line circuit. Up to 99 intelligent heat detectors may connect to one SLC loop.

L. Intelligent Duct Smoke Detector:
   1. The in-duct smoke detector housing shall accommodate either an intelligent ionization detector or an intelligent photoelectric detector, of that provides continuous analog monitoring and alarm verification from the panel.
   2. When sufficient smoke is sensed, an alarm signal is initiated at the FACP, and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.
   3. Include sensor tube and remote test station with integral alarm LED for each duct detector provided.
   4. Combustible Gas Detector (CH4)
      a. Wall or duct-mounted gas detector for monitoring methane (CH4) installed as a standalone device with single-gas monitoring.
         1) Size 20.56 by 14.90 by 6.72cm (8.09 by 5.87 by 2.65 in.) (H by W by D); Remote Sensor: 3.5 by 4.5 by 6.5 cm (1.36 by 1.75 by 2.56 in.)
         2) Power Requirement 24 Vac nominal (17-27Vac), 50/60 Hz, 0.35 A; 24Vdc nominal (20-38Vdc); with remote sensor: 7 W max.
         3) Optional Main AC Input 120Vac nominal, ± 10 percent (with on-board transformer)
         4) Relay Output 2 DPDT relays, 5A at 250Vac; 5A at 30Vdc
         5) Communications 4-20mA
         6) Operating Environment Commercial, Indoor, Extreme Temperature Environments Operating Temperature H2S, NO2, O2, CH4, H2, C3H8: -40 to 50 degrees C (-40 to 122 degrees F) CO: -20 to 50 degrees C (-4 to 122 degrees F)
         7) Sensor Type Electrochemical cell (CO, NO2, H2S, O2); catalytic (CH4, H2, C3H8,)
         8) Response Time T90 less than 50 seconds With ECLAB T90 less than 240 seconds
         9) Display 8 character, 2 line backlit LCD
         10) Visual Indicators Green LED: Power Amber LED 1: Alarm/Fault Amber LED 2: Alarm/Fault
         11) Audible Alarm greater than 85 dBA at 3 m (10 ft)
         12) Accuracy ± 3 percent of full scale at 25 degrees C
         13) Enclosure Polycarbonate
         14) Certification CSA C22.2 No. 61010-1, UL 61010-1; FCC part 15; ICES-003 issue 4; ISO 9001-2008
      b. Provide monitor module for each gas detector.

M. Duct mounted carbon monoxide detector:
   1. Manufactured by Air Products and Controls Model SL-701 or Equal
   2. Product Specifications

Voltages available:	230VAC, 115VAC, 24VAC, 24VDC
APPROVALS	Electrochemical Carbon Monoxide Sensor is a UL Recognized component in accordance with the requirements of UL2034. Also meets EN50291 requirements. SL-2000 Series Duct Smoke Detector Fire Alarm Certifications referenced side one: UL and CUL Listed (UL268A, UROX, UROX7) File # S2829 CSFM Listed (3240-1004:105); MEA Accepted (73-92-E, VOL. 27)

SAMPLING TUBES Provide required length for duct coordinate with HVAC drawings	Sectional sampling tube Metal sampling tube for 6 inch to 2.5 feet. duct width Metal sampling tube for 2.5 feet. to 5.0 feet. duct width Metal sampling tube for 5.0 feet. to 10.0 feet. duct width		
ACCESSORIES	MSR-50/CO remote accessory TG-701 aerosol test gas T-PB power supplies WP-2000 weatherproof enclosure (All available from Air Products and Controls Inc.)		
POWER REQUIREMENTS	Input Power	Standby Current	Alarm Current
	24VAC	55mA	190mA
	24VDC	14mA	68mA
	115VAC	22mA	32mA
	230VAC	12mA	18mA
RELAY CONTACT RATING:			
Alarm Contacts	Resistive load: 2 sets form “C” rated at 10 Amps at 115VAC Resistive load: One set form “A” rated at 2 Amps		
Trouble Contacts	Resistive load: One set form “C” rated at 10 Amps at 115VAC		
AIR VELOCITY	100 to 4,000 feet. /minute.		
AMBIENT TEMPERATURE	32 degrees F to 158 degrees F (0 degrees C to 70 degrees C)		
HUMIDITY	10 percent to 85 percent RH Non-Condensing / Non-Freezing		
WIRING	Solid or stranded: #12 to #22 AWG terminals		
MATERIAL	Grey plastic back box, clear plastic cover (Makrolon 94V-0) Do not expose to corrosive atmospheres.		
DIMENSIONS	13 ½ inch L by 4 ½ inch W by 2 ¼ inch D		
MAX. NET WT.:	2 ½ lbs.		
HARDWARE	7 inch exhaust tube, FAST Tube starter sampling tube, sampling tube end cap, mounting template, and mounting hardware included.		

N. Addressable Dry Contact Monitor Module:
   1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panel SLC loops.
   2. The monitor module shall mount in a 4-inch square, 2-1/8 inch deep electrical box.
   3. The IDC zone may be wired for Style D or Style B operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.
   4. For difficult to reach areas, the monitor module shall be available in a miniature package and shall be no larger than 2-3/4 inch by 1-1/4 inch by 1/2 inch This version need not include Style D or an LED.

O. Two Wire Detector Monitor Module:
   1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional 2-wire smoke detectors or alarm initiating devices (any N.O. dry contact device).
   2. The two-wire monitor module shall mount in a 4-inch square, 2-1/8 inch deep electrical box or with an optional surface backbox.

3. The IDC zone may be wired for Class A or B (Style D or Style B) operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.

P. Addressable Control Module:
1. Addressable control modules shall be provided to supervise and control the operation of one conventional NACs of compatible, 24 VDC powered, polarized audio/visual notification appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay.
2. The control module shall mount in a standard 4-inch square, 2-1/8 inch deep electrical box, or to a surface mounted backbox.
3. The control module NAC may be wired for Style Z or Style Y (Class A/B) with up to 1 amp of inductive A/V signal, or 2 amps of resistive A/V signal operation, or as a dry contact (Form-C) relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100 percent of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
4. Audio/visual power shall be provided by a separate supervised power loop from the main fire alarm control panel or from a supervised, UL listed remote power supply.
5. The control module shall be suitable for pilot duty applications and rated for a minimum of .6 amps at 30 VDC.

Q. Isolator Module:
1. Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop. At least one isolator module shall be provided for each floor or protected zone of the building.
2. Include isolator bases for addressable devices for every 25 initiating devices shown on the plans.
3. If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.
4. The isolator module shall not require any address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.
5. The isolator module shall mount in a standard 4-inch deep electrical box or in a surface mounted backbox. It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

R. LCD Alphanumeric Display Annunciator:
1. The alphanumeric display annunciator shall be a supervised, back-lit LCD display containing a minimum of 80 characters for alarm annunciation in clear English text.
2. The LCD annunciator shall display all alarm and trouble conditions from either the network node or complete network, via the INA.
3. Up to 32 LCD annunciators may be connected to a specific (terminal mode) EIA 485 interface. LCD annunciators shall not reduce the annunciation capacity of the system. Each LCD shall include vital system wide functions such as, system acknowledge, silence and reset.
4. LCD display annunciators shall mimic the local control panel 80 character display or network annunciator and shall not require special programming.
5. If a remote annunciator is shown on the plans, then a microphone for paging included in the same panel shall be included for each location indicated.

S. Batteries and External Charger:
1. Battery:
   a. Batteries shall be 12 volt, Gell-Cell type.
   b. The battery shall have sufficient capacity to power the fire alarm system for not less than 60 hours plus 15 minutes of alarm upon a normal AC power failure per current NFPA

requirements.

c. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills and leakage shall not be required.

T. Addressable Speaker/Strobe Units for Fire and Mass Notification application:

1. The audible notification appliance network consists of addressable Hi-fidelity speakers located to provide intelligible instructions at areas as indicated. Several areas are identified as acoustically distinguishable spaces Refer to the design documents for the locations and requirements of such spaces.
   a. Acoustically distinguishable Spaces include: Corridors, Offices, Classrooms, Conference rooms, nurses area, and Administrative areas.
2. The Mass Notification System announcements shall take priority over all other audible announcements of the system including the output of the fire alarm system in a normal or alarm state. When a mass notification announcement is activated during a fire alarm, all fire alarm system functions shall continue in an alarm state except for the output signals of the fire alarm audible and visual notification appliances.
3. One-way Tone/Voice Communication:
   a. The evacuation alarm and alert signals shall be capable of being initiated automatically from the fire alarm control panel (FACP) and transmitted to any speaker circuit, selected speaker circuits or all speaker circuits.
   b. The alarm signal, alert signal and live and pre-recorded voice announcements shall be capable of manual transmission from the FACP to any speaker circuit, selected speaker circuits or all speaker circuits by manual selection of the associated speaker circuit control switches.
   c. Live voice announcements, via the hand-held microphone or patched in external source, by use of speaker control switches, shall take priority over all previously activated alarm inputs. In addition to NFPA 72 requirements, the system shall be capable of priority live voice announcements over subsequent alarm conditions. In no case shall subsequent alarms disrupt emergency live voice announcements. Mass notification activation is the only condition allowed to override the fire alarm event.
   d. Alarm speaker amplification equipment shall be sized, at 1 watt for every speaker location shown.
   e. As a minimum, alarm speaker amplification equipment shall be sized to provide the above indicated wattage of input power to each location type of alarm speaker shown on the Drawings, plus 20 percent (20 percent) spare capacity to permit the addition of future alarm speakers. Include one back up amplifier for every 100 watts of primary power supplied.
   f. Within the individual assembly occupancies in this project, an alarm received during a program occupancy shall sound an alert alarm at a constantly attended location and perform the following actions:
      1) Deliver a field programmable, digitized custom evacuation message to the occupants, detailing evacuation instructions.
      2) A simultaneous message shall be delivered via all alarm speakers installed in remainder of the building directing evacuation using exits other than the assembly occupancy exit path.
      3) Perform all control functions as detailed elsewhere in this specification
      4) An automatic announcement or tone evacuation signal shall be capable of interruption by the operation of the system microphone to give voice evacuation instructions overriding the pre-programmed sequences
   g. Addressable Visual Unit (Xenon Strobe) and Visual/Fire/MNS unit:
      1) Combination white/amber strobe/MNS units - Provide Truealert Synchronized white strobe (fire)/yellow strobe (MNS event) all in one unit. Unit shall be red with “Fire” in white lettering. Yellow strobe shall include “Alert” in white lettering.

2) Provide candela rating indicated on drawings and in accordance with NFPA requirements.
3) Adjacent to all combination visual units shown on drawings provide an addressable speaker
4) Systems that require separate wiring and control modules to support the specified addressable functionality shall be provided at/or no additional cost.

h. Visual Unit (Xenon Strobe) unit:
1) Provide yellow strobe (MNS event) unit and include “Alert” in white lettering.

i. Combination Alarm Devices: Addressable audible and visible alarm device in a single mounting assembly, consisting of 24-V DC strobe lights with clear polycarbonate lens and high-intensity xenon flash tube, factory-wired to screw terminals; and voice/tone speaker. Alternate systems shall provide an addressable signal module for each signaling device.
1) Strobe Lamp: Peak intensity 75 candela, unless otherwise shown on the drawings.
2) Voice/Tone Speakers: Comply with UL 1480, "Speakers for Fire Protective Signaling." Frequency response 400 Hz to 4000 Hz for fire alarm use, multiple power taps .5 to 2 watts to achieve sound levels 82 dB to 88 dB at 10 feet., varnish-impregnated, sealed, with matching transformer. Match transformer tap range and speaker power rating to the acoustical environment of the speaker location.
3) Mounting: Wall or ceiling semi-flush as shown on the drawings.

U. Mass Notification Local Operator Console:
1. Local Operator Console is designed for indoor use with the Edwards control panel for mass notification applications. The LOC shall contain an A100-9814 InfoAlarm Command Center with 320 by 240 LCD display, In addition to the switches and controls provided inherently with the Command Center, Provide an additional eight black push on/push off illuminated push buttons for speaker circuit selection, eight illuminated push buttons for message selection, and a microphone for live messages. The speaker circuits shall be fully user defined and not be contingent on circuit wiring. Circuits shall be defined through system software. Controls shall be installed in a cabinet with glass door and magnetic lock. Panel shall be labeled “Emergency Communications”. The controls shall be fully replicated at the main FACP in the vent that office personnel are unable to initiate emergency messages.
2. Standard features:
a. 24I/O Module
b. 16 illuminated push buttons
c. Magnetic latch
d. 16.5 inch w by 12.63 inch h by 4 inch d 16 ga CRS enclosure
e. Indoor, surface or semi-flush mount
f. Platinum powder coat finish with white silk screened lettering
3. Remote Microphone Assembly
a. The remote microphone assembly uses power from the panel of the LED. All other interfaces do not draw any additional power other than what is already accounted for on the host interface, which is used for supervising the keyswitch, push-to-talk (PTT), and microphone wiring.
b. Operating Voltage
1) 24V as provided by 4003 or 24 Point I/O Module.
2) 24V battery current drawing - 25mA max.
c. Environmental Operating Rang
1) 32 degrees Fahrenheit to 120 degrees Fahrenheit (0 degrees Celsius to 49 degrees Celsius)
2) 90 degrees (32 degrees Celsius) at 10 percent to 93 percent relative humidity (non-condensing).
4. Addressable Textual Notification Appliance (MNS): Textual Notification Appliance is to operate on a compatible Signaling Line Circuit (SLC) and is to provide a high visibility, multi-color LED text

message display.

a. Textual Notification Appliance shall be Listed to UL 1638 Visual Signaling Appliances.
b. Appliance shall be capable of up to 32 pre-programmed message selections that can be activated in response to pre-defined emergency situations or linked to specific system point status conditions.
c. Textual Notification Appliance shall be capable of displaying dual or single line emergency instructions. Instructions can show as static, flashing, or scrolling with a variety of appearance/transition options. Instructions shall be capable of displaying using multi-colors to emphasize instructions content.
d. Textual Notification Appliance shall be capable of providing non-emergency information during non-emergency conditions. Emergency conditions will override non-emergency message/instructions and display emergency instructions.
e. Textual Notification Appliance shall be capable of scrolling instructions of at least 512 characters in length.
f. Textual Notification Appliance shall be viewable from a distance of 100 feet.
g. Textual Notification Appliance shall be powered by the fire alarm MNS power supply at 24VDC with battery back-up included if system battery calculations.
h. Textual Notification Appliance shall be capable of wall or ceiling mounting options.
    1) Accessories: The Electrical Sub-Sub-Contractor shall furnish the necessary accessories.

V. Digital Dialer:
1. Provide a digital dialer in accordance with Fire Department requirements and connect to telephone demarcation point in MDF/Headend with two CAT 5 telephone cables by device to transmit alarms to a UL listed remote central station.

W. Exterior Strobe-unit:
1. Provide wall mounted, 24 VDC strobe, color red with corresponding wall bracket.

X. Magnetic Door Holders:
1. Provided by Door Hardware, Installed and wired by Electrical Sub-Sub-Contractor. Door holders will be 24V D.C. with catch plate.

Y. Graphic Map: Provide graphic map to the fire department and engineer for review and approval.
1. Graphic map shall show all initiation devices and control panel and other control locations annunciator and key boxes. All devices shall be labelled, and all final room numbers shall be indicated. The map shall be installed behind a plexiglass enclosure along with a frame equal to spage age electronics GD graphic display frame.

Z. Key Repository Box:
1. Provide a key repository box(es) in accordance with fire department requirements. Provide with tamper switch wired to security panel.
    a. Key repository boxes shall be knoxbox or equal
        1) Provide Key repository box for fire fighters
            a) Color black with red reflective 3M tape
        2) Provide Key repository box for police
            a) Color shall be Aluminum with blue 3M reflective tape

AA. Field Quality Control
1. Manufacturer's Field Services: Provide services of a Fire Alarm Technicians with a minimum of eight years of experience (NICET Level IV) utilized to test and certify the installation of the fire alarm/mass notification devices, cabinets and panels. The Fire Alarm technicians testing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.
2. Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Examples of qualified personnel shall be permitted to include, but shall not be limited to, individuals with the following qualifications:
    a. Factory trained and certified.

b. National Institute for Certification in Engineering Technologies (NICET) fire alarm certified.
c. International Municipal Signal Association (IMSA) fire alarm certified.
d. Certified by a state or local authority.
e. Trained and qualified personnel employed by an organization listed by a national testing laboratory for the servicing of fire alarm systems.

3. Pretesting: Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved.
4. Final Test Notice: Provide a ten-day minimum notice in writing when the system is ready for final acceptance testing.
5. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72. Provide two year service contract to perform NFPA 72 required testing.
6. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
7. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log.
8. Provide a point list with address devices to be reviewed and approved by the fire department and engineer prior to programming the system.
9. Perform Db level testing prior to fire department test.
10. Intelligibility Tests:
    a. Intelligibility testing of the System shall be accomplished in accordance with NFPA 72 for Voice Evacuation Systems and IEC 60268-16.
    b. Following are the specific requirements for intelligibility tests:
        1) Intelligibility Requirements: Verify intelligibility by measurement after installation.
        2) Ensure that a CIS value greater than the required minimum value is provided in each area where building occupants typically could be found. The minimum required value for CIS is .8. Rounding is permitted such that an intelligibility score of 0.75 may be rounded to 0.80. Acoustically Distinguishable Spaces (ADS) where passing intelligibility scores are not expected will be indicated on the drawings.
        3) Areas of the building provided with hard wall and ceiling surfaces (such as metal or concrete) that are found to cause excessive sound reflections may be permitted to have a CIS score less than the minimum required value if approved by the Engineer and Architect, and if building occupants in these areas can determine that a voice signal is being broadcast and they walk no more than 33 feet. to find a location with at least the minimum required CIS value within the same area.
        4) Areas of the building where occupants are not expected to be normally present are permitted to have a CIS score less than the minimum required value if personnel can determine that a voice signal is being broadcast and they walk no more than 50 feet. to a location with at least the minimum required CIS value within the same area.
        5) Take measurements near the head level applicable for most personnel in the space under normal conditions (e.g., standing, sitting, sleeping, as appropriate).
        6) The distance occupants must walk to the location shall meet the minimum required CIS value shall be measured on the floor or other walking surface as follows:
            (1) Along the centerline of the natural path of travel, starting from any point subject to occupancy with less than the minimum required CIS value.
            (2) Curving around any corners or obstructions, with a 12 inch clearance there from.
            (3) Terminating directly below the location where the minimum required CIS value has been obtained.

d. Use commercially available test instrumentation to measure intelligibility as specified by ISO 7240-19 and ISO 7240-16 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

c. Record and submit to the Engineer intelligibility scores prior to final test with authority having jurisdiction

11. Final Test, Certificate of Completion, and Certificate of Occupancy:
    a. Test the entire system 100 percent devices in accordance with the Authority Having Jurisdiction in order to obtain a certificate of occupancy. Prior to that, and as a requisite, a separate test will be witnessed by the Engineer of Record.
12. Engage a factory-authorized service representative to train Owner's maintenance personnel and building supervisors to adjust, operate, utilize, troubleshoot, conduct software installation, and maintain the fire alarm control panel and fire command center. Provide eight five-hour training sessions for Owner's personnel. Training shall be held on site in classroom. Manufacturer shall professionally video record training by Factory Personnel and provide media to Owner. Provide a hard copy of manuals, instructional videos, and recorded training session(s) on USB Thumb Drive.

2.17 SURGE PROTECTIVE DEVICES

A. Scope:
   1. This section describes the materials and installation requirements for surge protective devices (SPD) for the protection of all main service and panelboards.

B. Submittals:
   1. Submit shop drawings and product information for approval and final documentation in the quantities listed according to the Conditions of the Contract. All transmittals shall be identified by customer name, customer location, and customer order number.
   2. Submittals shall include UL 1449 3rd Edition Listing documentation verifiable by visiting www.UL.com, clicking "Certifications" link, searching using UL Category Code: VZCA and VZCA2:
      a. Short Circuit Current Rating (SCCR)
      b. Voltage Protection Ratings (VPRs) for all modes
      c. Maximum Continuous Operating Voltage rating (MCOV)
      d. I-nominal rating (I-n)
      e. SPD shall be UL listed and labeled as Type 1 or Type 4 intended for Type 1 or Type 2 applications
   3. Upon request, an unencapsulated but complete SPD formally known as TVSS shall be presented for visual inspection.
   4. Minimum of ten year warranty

C. Related Standards:
   1. IEEE C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits,
   2. IEEE C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits,
   3. IEEE C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
   4. National Electrical Code: Article 285
   5. UL 1283 - Electromagnetic Interference Filters
   6. UL 1449, Third Edition, effective September 29, 2009 – Surge Protective Devices

D. Quality Assurance:
   1. Manufacturer Qualifications: Engage a firm with at least five years experience in manufacturing transient voltage surge suppressors.
   2. Manufacturer shall be ISO 9001 or 9002 certified.
   3. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of ten years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

4. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

E. Delivery, Storage and Handling:
   1. Handle and store equipment in accordance with manufacturer's Installation and Maintenance Manuals. One copy of this document to be provided with the equipment at time of shipment.

F. Manufacturers:
   1. Provide an internally mounted Surge Protective Devices (SPD) formerly called Transient Voltage Suppressor (TVSS) by:
      a. Siemens Industry.
      b. Current Technology
      c. LEA
      d. Liebert
      e. APT
      f. Or equal

G. Electrical Distribution Equipment
   1. Service Entrance
      a. SPD shall be UL 1449 labeled as Type 1 or Type 4 intended for Type 1 or Type 2 applications, verifiable at UL.com, without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal overtemperature controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.
      b. SPD shall be factory installed integral to electrical distribution equipment.
      c. SPD shall be UL labeled with 20kA I-nominal (I-n)
      d. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR).
      e. Standard 7 Mode Protection paths: SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
      f. True 10 Mode Protection paths: SPD shall provide "directly connected protection elements" between all possible modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
      g. SPD shall meet or exceed the following criteria:
         1) Maximum 7-Mode surge current capability shall be [300kA] per phase.
         2) Maximum 10-Mode surge current capability shall be [300kA] per phase.
         3) UL 1449 - Third Edition Revision; effective September 29, 2009 Voltage Protection Ratings shall not exceed the following:

VOLTAGE	L-N	L-G	N-G	L-L	MCOV
208Y/120	800V	800V	800V	1200V	150V
480Y/277	1200V	1200V	1200V	2000V	320V

      h. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

System Voltage	Allowable System Voltage Fluctuation (percent)	MCOV
208Y/120	25 percent	150V
480Y/277	15 percent	320V

      i. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
      j. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.
      k. SPD shall include a serviceable, replaceable module.
      l. SPD shall be equipped with the following diagnostics:
         1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and

one red service LED.
2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
3) Form C dry contacts
4) Optional – Surge Counter

m. No other test equipment shall be required for SPD monitoring or testing before or after installation.
n. SPD shall have a response time no greater than 1/2 nanosecond.
o. SPD shall have a 10 year warranty.

2. Distribution Panel
a. SPD shall be UL 1449 labeled as Type 4 intended for Type 1 or Type 2 applications, verifiable at UL.com, without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal overtemperature controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.
b. SPD shall be factory installed integral to electrical distribution equipment.
c. SPD shall be UL labeled with 20kA I-nominal (I-n)
d. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR).
e. Standard 7 Mode Protection paths: SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
f. SPD shall be connected to the buss of the distribution equipment with an appropriately sized 200kA SCCR rated disconnect.
g. SPD shall meet or exceed the following criteria:
1) Maximum 7-Mode surge current capability shall be 100kA per phase.
2) Maximum 10-Mode surge current capability shall be 150kA per phase.
3) UL 1449 - Third Edition Revision; effective September 29, 2009, Voltage Protection Ratings shall not exceed the following:

VOLTAGE	L-N	L-G	N-G	L-L	MCOV
208Y/120	800V	800V	800V	1200V	150V
480Y/277	1200V	1200V	1200V	2000V	320V

h. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

System Voltage	Allowable System Voltage Fluctuation (percent)	MCOV
208Y/120	25 percent	150V
480Y/277	15 percent	320V

i. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
j. Suppression components shall be heavy duty ‘large block’ MOVs, each exceeding 30mm diameter.
k. SPD shall include a serviceable, replaceable module.
l. SPD shall be equipped with the following diagnostics:
1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
3) Form C dry contacts
4) Optional – Surge Counter
No other test equipment shall be required for SPD monitoring or testing before or after installation.
m. SPD shall have a response time no greater than 1/2 nanosecond.
n. SPD shall have a 10 year warranty.

3. Branch Panels
    a. The panelboard shall be UL 67 Listed and the SPD shall be UL 1449 labeled as Type 1 or as Type 4 intended for Type 1 or Type 2 applications.
    b. SPD shall be facotry installed, integral to electric panels.
    c. SPD shall meet or exceed the following criteria:
        1) Maximum 7-Mode surge current capability shall be 100kA per phase.
        2) Maximum 10-Mode surge current capability shall be 150kA per phase.
        3) UL 1449 - Third Edition Revision; effective September 29, 2009, Voltage Protection Ratings shall not exceed the following:

VOLTAGE	L-N	L-G	N-G	L-L	MCOV
208Y/120	800V	800V	800V	1200V	150V
480Y/277	1200V	1200V	1200V	2000V	320V

    d. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

System Voltage	Allowable System Voltage Fluctuation (percent)	MCOV
208Y/120	25 percent	150V
480Y/347	15 percent	320V

    e. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
    f. Suppression components shall be heavy duty ‘large block’ MOVs, each exceeding 30mm diameter.
    g. SPD shall include a serviceable, replaceable module.
    h. SPD shall be equipped with the following diagnostics:
        1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
        2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
        3) Form C dry contacts
        4) Optional – Surge Counter

            No other test equipment shall be required for SPD monitoring or testing before or after installation.
    i. SPD shall have a response time no greater than 1/2 nanosecond.
    j. SPD shall have a 10 year warranty.
    k. The unit shall have removable interior.
    l. The main bus shall be copper and rated for the load current required.
    m. The unit shall include a 200 percent rated neutral assembly with copper neutral bus.
    n. The unit shall be provided with a safety ground bus.

H. Installation:
    1. Install per manufacturer’s recommendations and contract documents.

I. Adjustments and Cleaning:
    1. Remove debris from installation site and wipe dust and dirt from all components.
    2. Repaint marred and scratched surfaces with touch up paint to match original finish.

J. Testing:
    1. Check tightness of all accessible mechanical and electrical connections to assure they are torqued to the minimum acceptable manufacture’s recommendations.
    2. Check all installed panels for proper grounding, fastening and alignment.

K. Warranty:
    1. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than 18 months from date of shipment.

2.18 AUTOMATED LIGHTING CONTROL SYSTEM

A. SUMMARY
1. SECTION INCLUDES:
   a. Automated Lighting Control systems. Systems are composed of:
   b. Network integrated power switching systems.
   c. Network integrated dimming systems.
   d. Standalone power switching and dimming systems.
   e. Automation control processors.
   f. Sensors
   g. User Interfaces:
      1) Keypad
      2) Touch screen
      3) Virtual touch screen
   h. System Functions and Sequences
2. DEFINITIONS
   a. Control: Effecting a change in state by one PC program onto a microprocessor or device.
   b. Scene: Predetermined light level of a single fixture of group of fixtures.
   c. RS-485: A serial network protocol complying with TIA-485-A.
   d. UTP: Unshielded twisted pair.
3. COORDINATION
   a. Contractor shall place daylight and occupancy sensors per plans to achieve optimal performance. Proper placement shall be coordinated with others in order to avoid interference with prescribed lighting levels.
   b. Contractor shall provide luminaries and lamps that are compatible with the lighting control system to be installed.
   c. Contractor shall locate touch screen and keypad stations as per plans.
   d. Contractor shall notify engineer of record of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.
4. SYSTEM DESCRIPTION
   a. Web Accessible, network connected, lighting control system utilizing preset control software, central signal microprocessor, lighting control panel including integrated branch circuit protection, and power switching modules and relays, dimming modules, sensors and user interfaces.
5. SUBMITTALS
   a. Product Data: For each type of product required for complete network lighting control system, demonstrating compliance with requirements.
   b. Shop Drawings: Indicated the following:
      1) Schematic diagram showing complete network lighting control system and accessories.
      2) Circuits and emergency circuits with capacity and phase, control zones, load type and voltage per circuit.
6. CLOSEOUT SUBMITTALS
   a. Operating and maintenance manuals.
7. QUALITY ASSURANCE
   a. Manufacturer Qualification: Manufacturer of network lighting controls with minimum [five] years record of satisfactory manufacturing and support of components comparable to basis of design system.
   b. Source Requirements: Provide Automated Lighting Control System through a single source from a single manufacturer.
   c. Manufacturer Qualifications: Approved manufacturer of Automated Lighting Control System listed in this Section with minimum ten years record of satisfactory manufacturing and support of components comparable to basis of design system.
      1) Approval of Comparable Products: Submit the following in accordance with project substitution requirements, within time allowed for substitution review:
         a) Product data, including certified independent test data indicating compliance with requirements.
         b) Samples of each component.
         c) Sample submittal from similar project.

d) Project references: Minimum of five installations not less than five years old, with f) Owner and Architect contact information.
e) Sample warranty.
2) Substitutions following award of contract are not allowed except as stipulated in Division 01 General Requirements.
d. Approved manufacturers shall comply with separate requirements of Submittals Article.
e. Electrical Components, Devices, and Accessories: UL listed and labeled per NFPA 70.
8. COORDINATION
a. Coordinate integrated lighting and dimming controls with systems and components specified in the following sections:
1) Division 11 Section "Audio-Visual Equipment".
2) Division 23 Section "Instrumentation and Control for HVAC".
3) Division 26 Section "Panelboards".
4) Division 26 Section "Wiring Devices".
5) Division 26 Section "Lighting Devices".
6) Division 26 Section "Interior Lighting".
7) Division 27 Section "Communications Horizontal Cabling".
8) Division 27 Section “Audio-Video Systems”
9) Division 28 Section "Electronic Access Control and Intrusion Detection".
9. PROJECT CONDITIONS
a. Environmental Conditions Range:
1) Temperature: 32 – 104 degrees Fahrenheit (0 - 40 degrees Celsius).
2) Relative Humidity: 10 – 90 percent, noncondensing.
10. WARRANTY
a. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of modular dimming controls system the fail in materials or workmanship within the specified warranty period following substantial completion.
b. Warranty Period: Commercial lighting dimmers and switches, sensors, keypads, lighting enclosures, terminal blocks, power supplies, thermostats, and control processors, when dedicated for use as part of a commercial lighting control system: five year warranty
c. Manufacturer's Extended Support Service: Extended telephone support: Unlimited period.

B. MANUFACTURERS
1. MANUFACTURERS: Subject to compliance with requirements, provide products by one of the following Manufacturers:
a. Crestron Electronics INC.
b. Alternate manufacturer’s indicated in drawings.
2. Substitutions:
a. All substitutions must be submitted in writing to the Engineer of Record within 14 days prior to bid date.
b. Proposed substitutions must be documented with a compliance review.

C. GENERAL
1. Contractor shall provide system hardware that is manufactured and warranted by a single manufacturer.
2. Provide control system with compatibility for BACNET/IP.
3. System shall provide time clock functionality as well as support for multiple interface devices.
4. System must automatically adjust for daylight savings time and leap year.
a. ZUM Wired Dimming Solutions
1) Load Controllers
a) ZUMNET-Junction Box Zone Controllers
1) Junction box mounted using ½” knockout.
2) 120/277 VAC input
3) Real-time Power monitoring
4) Connections
a) ZUMLINK RJ45 ports x 2 (Cresnet)
b) ZUMNET RJ45 ports x 2 (Ethernet)
c) Occ Sensor Input (24V, G, OCC)

d) Photo Sensor Input (24V, G, PHO)
e) Override Input (OVR, G)
f) Integrated Ethernet Switch allowing daisy chaining (up to 20 devices)

5) Products:
CRESTRON ZUMNET-JBOX-16A-LV (16A, 0-10V)

b) ZUMLINK-Junction Box Zone Controllers
1) Junction box mounted using ½" knockout.
2) 120/277 VAC input
3) Real-time Power monitoring
4) Connections
a) ZUMLINK RJ45 ports x 2 (Cresnet)
b) Occ Sensor Input (24V, G, OCC)
c) Photo Sensor Input (24V, G, PHO)
d) Override Input (OVR, G)
5) Products:
a) CRESTRON ZUMLINK-JBOX-16A-LV (16A, 0-10V)
b) CRESTRON ZUMLINK-JBOX-20A-SW (20A, SWITCHED)
c) CRESTRON ZUMLINK-JBOX-20A-PLUG (20A, SWITCHED PLUG LOAD)
d) CRESTRON ZUMLINK-JBOX-DIMU. (5A UNIVERSAL PHASE DIMMING)

c) Emergency ZUMLINK-Junction Box Zone Controllers
1) Junction box mounted using ½" knockout.
2) 120/277 VAC input
3) Real-time Power monitoring
4) UL-924 Certified
5) Connections
a) ZUMLINK RJ45 ports x 2 (Cresnet)
b) Occ Sensor Input (24V, G, OCC)
c) Photo Sensor Input (24V, G, PHO)
d) Override Input (OVR, G)
6) Products:
a) CRESTRON ZUMLINK-JBOX-16A-LV-EM (16A, 0-10V)

5. User Interfaces
a. ZUMLINK-keypads
1) Field configurable remote keypad, engravable programmable buttons in number indicated, with Single Green LED indicator, configured to fit in standard single-gang box.
2) Trimmed using decorator style faceplate (not included) or Crestron decorator-style faceplates (FP-G series)
3) RJ45 connection for power and communication (2 x RJ45 ZUMLINK ports facing up)
4) Bluetooth connectivity
5) Colors White, Gray, Black, Red
6) Minimum Buttons: two, Maximum Buttons: eight. (engraving options available)
a) Button kits required
1) ZUMLINK-BTNR
2) ZUMLINK-BTN2
3) ZUMLINK-BTN4
4) ZUMLINK-BTN6
5) ZUMLINK-BTN8
7) Color shall be White
8) Mounting: Mounts in a 1-gang or larger electrical box or mud ring
9) Products
a) ZUMLINK-KP-R

6. Motion Sensors
a. Product: ZUMLINK-DT-QUATTRO-DLS
1) Characteristics

a) Sensing Technology: Passive infrared (PIR), single pyro, 11 detection levels, 520 switching zones, ultrasonic 40 kHz.
b) Mounts to a four inch octagon box.
c) Time Delay Setting
d) Light Level Setting: 1 - 100 fc (10 - 1000 lux)
e) Dip Switch Settings
f) Test Mode: Dip switch setting or programming remote
g) Ultrasonic Coverage at nine feet. (2.7 m):
    1) Presence: Maximum 20 feet. by 20 feet. (6 by 6 m) or 400 sf (36 sm).
    2) Radially and Tangentially: Maximum 32 feet. by 32 feet. (10 by 10 m) or 1,000 sf (100 sm).
h) PIR Detection Zones:
    1) Presence: Maximum 10 feet. by 10 feet. (3 by 3 m) or 100 sf (9 sm).
    2) Radially: Maximum 13 feet. by 13 feet. (4 by 4 m).
    3) Tangentially: Maximum 26 feet. by 26 feet. (8 by 8 m).

7. Networking the wired Spaces
    a. Zumwired spaces shall be networked together to enable time clock, load shedding and global management features.
    b. The space shall be networked using a ZUMNET RJ45 ports (Ethernet)
    c. Networking the space shall incorporate BMS integration as specified hereto after.
8. Devices
    a. Processor
        1) 4-Series control system with 2 GB SDRAM and 8 GB flash memory
        2) Embedded 4-Series multicore CPU processor
        3) iPhone®, iPad®, and Android™ device control app support
        4) XPanel computer and web based control
        5) Modular programming architecture
        6) Onboard IR/serial, COM, I/O, relay, Cresnet® network, and high-speed gigabit Ethernet control ports
        7) Control subnet port providing a dedicated local network for Crestron® devices
        8) High-speed USB 2.0 host port and rear panel memory card slot
        9) Crestron Fusion® software room monitoring and scheduling support
        10) Crestron XiO Cloud™ service provisioning and management support
        11) Enterprise-class network security and authentication
        12) SNMP V3 remote IT management support
        13) Native BACnet network/IP support
        14) Installer setup via software, web browser, or cloud
        15) 1 rack unit mounted
        16) Product: ZUM-HUB4

D. DAYLIGHT SENSORS
1. Indoor Daylight Sensor (Open/Closed loop)
    a. Open Loop Function
        1) Continually monitors daylight entering window or skylight to enable daylight harvesting applications to provide control of room lighting based on presence of daylight.
        2) Light sensitivity sliders:
            a) OL: 3-300 foot-candles (factory setting)
            b) OL: 30-3000 foot-candles
            c) OL: 60-6000 foot-candles
        3) Center Axis OL:90°
    b. Closed Loop Function
        1) Continually monitors daylight at work station location to enable daylight harvesting or lumen maintenance applications to provide control of room lighting based on lighting level at workstation.
        2) Light sensitivity slider:
            a) CL: 3 to 300 foot-candles
        3) Center Axis CL:45°

c. Equipped with 3-wire interface for direct connection to control system utilizing control processor; 24 VDC power from network control bus.
d. Mounting: Surface or flush ceiling mount directly to drywall or drop-tile
e. Product: Crestron GLA-LDL-PC-0-10

2. Outdoor Daylight and Color Temperature Sensor
   a. Measures true color temperature and intensity of natural sunlight.
   b. Communicates over serial to control system to match indoor lighting with the outdoors.
   c. Outdoor rated for rooftop installation.
   d. IP67 for watertight operation.
   e. CCT of 2,000K to 25,000K.
   f. 0 to 100,000 lux.
   g. 360 degree semispherical.
   h. Product: GLS-LCCT

E. CONTROL PROCESSOR PANEL AND DISTRIBUTION PANELS
1. Control processor Panels shall be provided in quantities and locations per the contract drawings, for a fully networked lighting control system.
2. Control processor panels shall be factory assembled in a UL508 Panel shop
3. Shall include the following equipment to support lighting control devices
   a. Cabinets
      1) Made of 16AWG galvanized steel
      2) NEMA 1 rated
      3) Product: DIN-EN
   b. Processors
      1) Crestron 4-series control system
      2) Modular architecture supports multiple simultaneous running programs.
      3) Ethernet 10/100Base-T and Cresnet Connected
      4) Astronomical time clock with events stored in non-volatile RAM
      5) Native BACnet/IP with support for up to 500 BACnet objects
      6) Built-In Web Server: IIS v.6.0
      7) SNMP remote management.
      8) Active Directory support.
      9) IPv6 ready.
      10) DHCP and DNS Support
      11) Native Email Client
      12) Remote Diagnostics
      13) Remote Program Loading and Administration
      14) SSL security plug in
      15) Support user assigned or dynamic IP address.
      16) Product: Crestron DIN-AP4
   c. Power Supplies
      1) Provide regulated 24 VDC power supplies to support lighting control equipment
      2) 120 VAC input
      3) Product: Crestron DIN-PWS60
   d. Cresnet to Ethernet Bridge
      1) 24v DC Input
      2) IEEE 802.3 Power of ethernet connection.
      3) Serial communication
      4) USB 2.0 for setup.
      5) Product: DIN-CENCN-2-POE
   e. Ethernet Distribution
      1) 48V DC Input, 100-240 VAC 50/60 Hz Supply
      2) (5) [16] IEEE 802.3 Ethernet Ports
      3) 32 to 104 degrees Fahrenheit
   f. Floor Hub
      1) Contain astronomical time clock.
      2) Maintenance is performed via standard web browser.

3) 1 rack unit mounted
4) Product: Crestron ZUM-HUB4

g. ZUML-HUB4-CN-PAK
1) Enclosure: DIN-EN-6X18
a) 16AWG Galvanized steel backbox
b) 120 Volts AC, 60 Hz
c) Height: 38.88 in (989 mm)
d) Width: 14.38 in (366 mm)
e) Depth: 4.44 in (113 mm)
f) DIN Rail Detail: six 342 mm x 35 mm rails

F. UL924 EMERGENCY OVERIDE
1. Automatic Load Control Relays (ALCR)
a. 4-Wire dimming loads
1) UL924 listed 4-wire automatic load control relay shall bring emergency life safety lights on to 100 percent upon loss of power
2) Upon the loss of normal power, the ALCR shall bypass the control device allowing emergency power to access the load regardless of switch position.
3) The ALCR shall contain a normally open relay to open the control wires allowing the lights to come to full bright.
4) The ALCR shall allow for integration with fire alarm.
5) Product: Crestron GLA-EPC-FLV

G. PROGRAMMING AND CONFIGURATION SOFTWARE
1. Lighting system configuration software shall allow custom programming for lighting control system.
2. Lighting system configuration software shall generate custom software control interface modules for communication with compatible remote integrated systems.
3. The lighting system configuration software shall be GUI based for programming and development.
4. The custom software control interface shall include the following control data:
a. Complete lighting system control functions.
b. System specific control sets for sub systems and supervisory systems
c. Bidirectional digital and analog data communication.
d. Bidirectional serial data communication.

H. CONDUCTORS AND CABLING
1. Power Supply Side of Remote-Control Power Sources: Comply with requirements of Division 26 Section "Low-Voltage Electrical Power Conductors."
2. UTP Cable: 100-ohm, UTP. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
3. Communications Control Cable, Non-Plenum Rated: 22 AWG data pair stranded bare copper, and 18 AWG power pair stranded bare copper, Type CM.
a. Product: Crestron CRESNET-NP.
4. Communications Control Cable Plenum Rated: 22 AWG data pair, stranded bare copper and 18 AWG power pair, stranded bare copper, Type CMP, complying with NFPA 262.
a. Product: Crestron CRESNET-P.
5. Communications High-Power Control Cable, Non-Plenum Rated: 22 AWG stranded bare copper data pair, and 12 AWG stranded bare copper power pair, Type CM.
a. Product: Crestron CRESNET-HP-NP.

I. FIXTURE TESTING
1. Contractor shall provide lighting control factory test reports for each fixture specified on this project
2. Test report shall include
a. Confirmation of compatibility with control device
b. Dimming Range
c. Performance notations

J. PLUG LOAD CONTROL
1. Plug load controls as shown on the contract drawing shall be part of the lighting control system.
2. Plug loads shall operate in occupancy mode (Auto-on, Auto-off) unless otherwise directed;

time schedule control or manual OFF switching shall be programmable features.

K. ENGRAVING
   1. Keypad buttons shall be factory engraved using laser technology
   2. Initial shipment of keypads shall be factory engraved per the sequence of operations specified herein and shown on the contract documents
   3. Custom keypad engravings shall be provided as part of the close out procedures.

L. BMS INTEGRATION
   1. The lighting control system shall be integrated with the BMS system as specified in DIV. 25.
   2. Communication shall occur using BACNET/IP Protocol.
   3. Contractor shall provide licenses for each of the following objects and shared amongst the BMS system
      a. Occupancy Status
      b. Zone On/Off/Dim
      c. Photocell reading
   4. The lighting control system shall also accept time clocked events from the BMS system
   5. Provide necessary coordination labor for integration of all BACNET objects listed.

M. AV INTEGRATION
   1. The lighting control system shall be integrated with the AV solutions as specified in DIV.26
   2. The lighting and AV systems shall interface via Ethernet communication or RS232.
   3. Contractor shall provide ethernet drops for the lighting control system to connect to the AV system.
   4. The following objects shall be shared with the AV system:
      a. Occupancy Status
      b. Zone On/Off/Dim
      c. Photocell reading
      d. Scene preset recalls
   5. Provide necessary coordination labor for integration of all AV objects listed hereto before.

N. SYSTEM FUNCTIONS AND SEQUENCES
   1. The system shall be capable of the following lighting control functions:
      a. Scene Creation: Store levels of selected fixture circuits in preset groups.
      b. Scene Recall: recall previous stored scenes.
      c. All zones off
      d. Raise/lower level of all zones
      e. Password entry for touchscreen access
      f. Room/Zone selection
      g. Raise/lower room shades
      h. Schedule events to be automatically recalled

O. USER INTERFACE CONTROL FUNCTIONS
   1. The keypad interface shall be capable of the following system control functions:
      a. Scene Recall
      b. Raise/Lower
      c. Off
   2. Touchscreen and Virtual touch screen interfaces shall be capable of the following system control functions:
      a. Password Entry
      b. Multiple levels
      c. Room/Zone selection
      d. Scene Recall
      e. Raise/Lower
      f. Shade Control
      g. Timeclock Events
      h. Customer logo and color scheme
   3. Optional control sequences for advanced control:
      a. Occupancy adjustments
      b. Sensor Timeout
      c. Control logic (occupancy or vacancy)

d. Lighting Scenes
e. Individual zone control override
f. Timeclock adjustments
g. Modify timeclock activation schedule
h. Select/unselect pre-programmed timeclock events
i. Display all timeclock events
j. Daylight Harvesting Adjustments
k. Low end trim
l. Response time
m. Zone control
n. Scene Recall
o. Fade time
p. Color scene recall

P. TIME CLOCK EVENTS
1. The lighting control system shall have astronomical time clocked events. 6-time clock events shall be provided.
2. End user shall have the option to create additional time clock events via touch screen or XPANEL interfaces.

Q. INSTALLATION
1. Prior to installation, examine work area to verify measurements, and that commencing installation complies with manufacturer's requirements.
2. Comply with requirements of Division 26 Sections "Common Work Results for Electrical."
3. Do not install network power controls until space is enclosed, HVAC systems are running, and overhead and wet work in space are complete.
4. Install network power switching controls in accordance with manufacturer's instructions.
5. Grounding: Provide electrical grounding in accordance with NFPA 70.

R. MANUFACTURER SUPPORTED SERVICES
1. Pre-wire
a. Manufacturer trained and authorized personnel shall provide on-site visit during the rough-in stage of the installation. At this time wiring topologies and terminations shall be reviewed with the Electrical Subcontractor.
2. Startup
a. Provide manufacturer's certified system startup and adjustment.
b. Switch each load on and off with manual line test feature of the power switching module before installing processors.
c. Perform operational testing to verify compliance with Specifications. Coordinate adjustments with the Architect and Owner.
3. Tuning
a. Within three months of the date of Substantial Completion provide onsite service to adjust the system to account for actual occupied conditions.
4. Training
a. Within 30 days, Factory authorized service representative to instruct owner's staff to adjust, operate and maintain network power switching systems; and provide instruction using the system software.
b. Demonstration: Schedule demonstration with Owner.
c. Training: Train Owner's personnel to operate, maintain, and program network power switching systems.
d. Furnish set of approved submittals, and record drawings of actual installation for Owner's personnel in attendance at training session.

2.19 LADDER TRAY/WIREWAYS

A. Provide 12 inch wide aluminum ladder tray with six inch rung spacing with four inch side rail. Ladder tray shall be as manufactured by B-Line. “Ladder Type”. Provide all hangers required. The width of the tray shall be as indicated on the drawings.

1. Acceptable Manufacturers:
a. B-Line

b. Chalfant
c. Chatsworth
d. PW Industries
e. Or equal

B. Wireway:
1. This specification covers NEMA type 1 wireway used to house ad protect communication cable. The wireway system shall consist of wireway and appropriate fittings to complete the installation per the electrical drawings.
2. Metal wireway (NEMA type 1) is to be utilized in dry interior locations only as covered in article 362 part a of the national electrical code, as adopted by the National Fire Protection Association and per the American National Standards Institute. The wiremold c" or "sp" series is listed by underwriters' laboratories under file no. E137690 guide zoyx.
3. The wireway system specified herein shall be the "c" or "sp" system as manufactured by the wiremold company. Systems of other manufacturers may be considered equal if, in the opinion, and the written approval of the engineer, they meet all the performance standards specified herein.
4. The wireway and all system components shall be UL Listed in full compliance with their standard ul870, "electrical wireways, auxiliary gutters and associated fittings". It shall be manufactured from 16-gauge cold rolled steel, finished in ASA 61 gray powder coat paint. All sizes larger than six inch by six inch shall be manufactured from 14-gauge cold rolled steel, finished in ASA 61 gray powder coat paint. A factory installed divider shall be available to separate power and low voltage wring housed n the same wireway sections.
5. A full compliment of fittings for the raceway shall be available including, but not limited to, 45 degrees and 90 degrees flat, vertical inside ad outside elbows, tee and cross fittings, couplings for joining sections of wireway, reducers, hangers, end blanks, a field installed divider and all other components necessary to make the system workable. The fittings shall have an ASA 61 gray powder coat paint finish to match the wireway.
6. Prior to and during installation, refer to system layout drawing containing all elements of the system. Installer shall comply with detailed manufacturer's instruction sheets which accompany system components as well as complete system instruction sheets, whichever is applicable.
7. All wireway systems shall be mechanically continuous and connected to all electrical boxes and cabinets, in accordance with manufacturer's installation sheets.
8. All connections shall be checked to make sure they are correctly tightened and to insure that all wireway shall be electrically continuous and bonded in accordance with the national electric code for proper grounding.
9. All wireway systems shall be installed complete. Work shall include fastening all wireway and appropriate fittings to install a complete wireway system as indicated on the electrical and/or communication drawings and in the applicable specifications

2.20 SEALS

A. Water Tight Seals
1. Conduits entering from the exterior or below grade shall have water tight fittings on the outside and on the inside of the conduit.
a. Fittings on the outside of the conduit shall be O-Z Gedney type FSK or approved equal. Provide type WSK if penetration is within two feet. of the high water table. Provide grounding attachment.
b. Fittings on the inside of the conduit shall be O-Z Gedney type CSBI or approved equal. Provide type CSBG if penetration is within two feet. of the high water table. Provide a blank fitting to seal spare or empty conduits.
c. O-Z Gedney type CSM fitting may be used when sealing within a sleeve or cored hole.

2. Submit on seals to be used.

B. Environmental Seals
   1. Provide seals on raceways exposed to widely different temperatures, as in refrigerating or cold storage areas. Install seal to prevent circulation of air from warmer to colder sections through the raceway.

C. Hazardous Area Seals
   1. Provide explosion proof seals per the Electric Code for the following areas.
      a. Explosion proof exhaust fans.

D. Smoke and Fire Stopping Seals
   1. Provide a seal around raceways or cables penetrating full height walls (slab to slab), floors or ventilation or air handling ducts so that the spread of fire or products of combustion shall not be substantially increased.
   2. Penetrations through fire-resistant-rated walls, partitions, floors or ceilings shall be firestopped using approved methods and NRTL listed products to maintain the fire resistance rating.
   3. Fire stopping in sleeves or in areas that may require the addition or modification of installed cables or raceways shall be a soft, pliable, non-hardening fire stop putty. Putty shall be water resistant and intumescent. Provide for all sleeves and raceways.
   4. Firestopping in locations not likely to require frequent modification shall be NRTL listed putty, caulk or mortar to meet the required fire resistant rating.
   5. Box penetrations into a fire rated wall or shaft shall have a fire stopping pad installed on the back of the box.
   6. Firestopping of cable trays or busways through walls shall be within a non-hardening putty or with seal bags.
   7. Firestopping materials shall be NRTL listed to UL 1479 (ASTM E814). Installation methods shall conform to a UL firestopping system. Submit specifications and installation drawings for the type of material to be used. Firestopping materials shall be as manufactured by 3M, International Protective Coatings Corp., RayChem or approved equal.

2.21 UNDERGROUND DUCTBANKS

A. General: Furnish and install the ductbanks as herein specified and as shown on drawings.

B. Division of Work:
   1. The General Conditions shall be responsible for the work and material required for the following:
      a. Excavation
      b. Backfill
      c. Installation of handholes/manholes
      d. Brick or concrete collars to bring handhole frames and covers up to grade. Installation of frames and collars which are to be furnished by the Electrical Sub-Sub-Contractor.
      e. Concrete Encasement
   2. All other material, equipment, and labor required for the complete ductbank shall be furnished and installed by the Electrical Sub-Sub-Contractor under this Section, including the following:
      a. Service raceways.
      b. Grounding material.
      c. Ductbank warning tape.
      d. Furnishing pre-cast handholes/manholes.
      e. Conduit spacers.

C. Materials:
   1. Conduit: UL listed, schedule 40 PVC in accordance with NEMA standard TC-2.
   2. See Basic Materials Section.
   3. Conduit Supports (duct system): Shall be molded plastic with interlocking lugs and skeletonized structure, minimum separation three in..
   4. Tags: Non-ferrous metal or fibre, 1/4 inch high letters.

5. Warning tape shall be yellow polyethylene four mil thick, six inch wide terratape, similar to REEF Industries, Houston, Texas and shall be installed above all ductbanks both high and low tension.
6. Installation of Underground nonmetallic raceways shall be in accordance with NEMA Standards Publication TCB-2-2017.

D. Duct System:
1. The duct system shall consist of Schedule 40 PVC conduit except where otherwise specified. The size and number of conduits shall be as indicated on the drawings. Provide a pull wire in each conduit.
2. The entire length between handholes and end of ductbank shall be excavated and graded before any conduit is laid.
3. The ductbank shall be set on undisturbed earth.
4. The conduit shall be installed so that top is a minimum of 36 inch below finished grade unless otherwise indicated, and shall be laid to a minimum grade of four inch for each 100 feet. of length. Duct system shall drain to manholes/handholes.
5. Changes in direction shall be made by long sweep bends, minimum radius 25 feet. except that at the end of a run, within 10 feet. of termination. Manufactured ends may be used having a minimum radius of 36 inch.
6. Conduit base and intermediate spacers shall be installed a maximum of five feet. on centers. Spacers shall not be placed one above the other, but shall be staggered a minimum of six in..
7. All conduit joints shall be made watertight by means of a sealing compound before the coupling is installed. Joints in conduit shall be staggered, minimum space between joints in adjacent conduit shall be six in..
8. When the required number of conduits has been installed, securely tie the assembly together at distances not exceeding seven feet. Tie shall consist of three turns of No. 18 iron wire. Separate ties required for low tension and high tension conduit runs.
9. Duct envelope shall be vibrated to eliminate voids.
10. Ductbanks shall not be covered until the conduit installation has been observed by the utility company and Architect.
11. Warning tape shall be installed during backfilling and shall be placed approximately 12 inch above the conduits.
12. After the installation is completed, each conduit shall be cleaned and identified. A standard flexible mandrel and a stiff bristle brush shall be pulled through each conduit. The mandrel shall not be less than 12 inch long and the diameter approximately ¼ inch less than the conduit.

2.22 VARIABLE FREQUENCY DRIVES

A. The variable frequency drives (VFD's) shall be solid state, with a Pulse Width Modulated (PWM) output waveform (VVI, six-step, and current source drives are not acceptable). The VFD package as specified herein shall be enclosed in a NEMA 1 enclosure, completely assembled and tested by the manufacturer. The VFD shall employ a full wave rectifier (to prevent input line notching), DC Line Reactor, capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device (SCR's, GTO's and Darlington transistors are not acceptable). The drive efficiency shall be 97 percent or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads.

B. Specifications at 480 volts:
1. Input VAC +/-10 percent (capable of operation to 550 VAC), 3 phase, 48-63Hz. Output 0 - Input Voltage, 3 phase, 0 to 500 Hz for drives up to 75 HP; 0 to 120 Hz for drives over 75 HP. Operation above 60 Hz. shall require programming changes to prevent inadvertent high speed operation. Environmental operating conditions: 0 to 40 Celsius at 3 kllz switching frequency, 0 to 3300 feet. above sea level, less than 95 percent humidity, non-condensing. Units shall be UL, CUL and CA approved.

C. All VFD's shall have the following standard features:
   1. All VFD's shall have the same customer interface, including digital display, keypad and customer connections; regardless of horsepower rating. The keypad is to be used for local control, for stepping through the displays and menus.
   2. The VFD shall give the user the option of either (1) displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last reference revised, or (4) cause a Warning to be issued, if the input reference (4-20mA or 2-10V) is lost; as selected by the user. The VFD shall provide a programmable relay output for customer use to indicate the loss of reference condition.
   3. The VFD's shall utilize plain English digital display (code numbers and letters are not acceptable). The digital display shall be a 40-character (2 line by 20 characters/line) LCD display. The LCD shall be backlit to provide easy viewing in any angle. All set-up parameters, indications, faults, warnings and other information shall be displayed in words to allow the user to understand what is being displayed without the use of a manual or cross-reference table.
   4. The VFD's shall utilize pre-programmed application macro's specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time.
   5. The VFD shall have the ability to automatically restart after an overcurrent, overvoltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable. If the time between reset attempts is greater than zero, the time remaining until reset occurs shall count down on the display to warn an operator that a restart will occur.
   6. The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).
   7. The VFD shall be equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and not inertia. Removing power from the motor is not an acceptable method of increasing power loss ride-through.
   8. The customer terminal strip shall be isolated from the line ground.
   9. Prewired 3-position Hand-Off-Auto switch and speed potentiometer. When in "Hand", the VFD will be started, and the speed will be controlled from the speed potentiometer. When in "Off", the VFD will be stopped. When in "Auto", the VFD will start via an external contact closure, and its speed will be controlled via an external speed reference.
   10. The drive shall employ three current limit circuits to provide trip free operation.
   11. The Slow Current Regulation limit circuit shall be adjustable to 125 percent (minimum) of the VFD's variable torque current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load. The Rapid Current Regulation limit shall be adjustable to 170 percent (minimum) of the VFD's variable torque current rating. The Current Switch-off limit shall be fixed at 255 percent (minimum, instantaneous) of the VFD's variable torque current rating. The overload rating of the drive shall be 110 percent of its variable torque current rating for 1 minute every 10 minutes, and 140 percent of its variable torque current rating for 2 seconds every 15 seconds, input line fuses standard in the drive enclosure. VFD shall have a DC Line Reactor to reduce the harmonics to the power line and to increase the fundamental power factor.
   12. The VFD shall be optimized for a 4 kHz carrier frequency to reduce motor noise and provide high system efficiency. The carrier frequency shall be adjustable by the start-up engineer in ACH 501 units. The VFD shall have a manual speed potentiometer in addition to using the keypad as a means of controlling speed manually.

D. All VFD's to have the following adjustments:
   1. Five programmable critical frequency lockout ranges to prevent the VFD from continuously operating at an unstable speed.
   2. PI Setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VFD, using the microprocessor in the VFD for the closed loop control.
   3. Two programmable analog inputs shall accept a current or voltage signal for speed reference or for reference and actual (feedback) signals for PI controller. Analog inputs shall include a filter; programmable from 0.01 to 10 seconds to remove any oscillation in the input signal. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0-20 MA and 0-10 Volts. Additionally, the reference shall be able to be scaled so that maximum reference can represent a frequency less than 60 Hz, without lowering the drive maximum frequency below 60 Hz.
   4. Six programmable digital inputs for maximum flexibility in interfacing with external devices. One digital input is to be utilized as a customer safety connection point for fire, freeze, and smoke interlocks (Enable). Upon remote, customer reset (reclosure of interlock), drive is to resume normal operation.

E. The following operating information displays shall be standard on the VFD digital display. The display shall be in complete English words (alpha-numeric codes are not acceptable):
   1. Output Frequency
   2. Motor Speed (RPM, percent or Engineering units)
   3. Motor Current
   4. Calculated Motor Torque
   5. Calculated Motor Power
   6. DC Bus Voltage
   7. Output Voltage
   8. Heatsink Temperature
   9. Analog Input Values
   10. Keypad Reference Values
   11. Elapsed Time Meter
   12. kWh meter

F. Speed Command Input shall be via:
   1. Keypad.
   2. Two Analog inputs, each capable of accepting a 0-20mA, 4-20mA, 0-10V, 2-10V signal. Input shall be isolated form ground, and programmable via the keypad for different uses.
   3. Floating point input shall accept a three-wire input from a Dwyer photohelic (or equivalent type) instrument.

G. Accessories to be furnished and mounted by the drive manufacturer.
   1. Customer Interlock Terminal Strip-provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external interlocks and start/stop contacts shall remain fully functional whether the drive is in hand, Auto or Bypass.
   2. All wires to be individually numbered at both ends for ease of troubleshooting.
   3. Door interlocked thermal magnetic circuit breaker which will disconnect all input power from the drive and all internally mounted options. The disconnect handle shall be thru-the-door type, and be padlockable in the "Off" position.

4. Manual transfer to line power via contactors. Include motor thermal overload and fuse or circuit breaker protection while in bypass operation. A three position selector switch to control the bypass contactor and the drive output contactor is to be mounted on the enclosure door. When in the "Normal" mode, the bypass contactor is open and the drive output contactor is closed. In the "Test" position both contactors are open, and in the "Bypass" position, the drive output contactor is open, and the bypass contactor is closed. The drive output contactor shall also open when a stop command is given, isolating the motor from the drive. Start/stop signals and safety interlocks will work in drive and bypass modes.
5. Pilot or LED's lights shall be provided for indication of "Normal" operation, "Bypass" operation, and "External Fault". All pilot lights shall be push-to-test type.
6. Service contactor (drive input contactor) which provides the ability to service the drive (electrically isolate the drive while in bypass operation without having to remove power from the motor). The service contactor shall open when the drive is switched to bypass, and also be controlled by a switch which is mounted inside the drive enclosure so that its access is limited to service personnel only.
7. A class 20 bimetallic thermal motor overload relay shall be provided to protect the motor in bypass.

H. Compliance to IEEE - 519
1. The VFD manufacturer shall provide calculations specified to this installation showing that the Total harmonic Distortion for the VFD's, reflected into the electrical distribution system is limited to the level defined by IEEE - 519 (latest edition) for general systems. Harmonic analysis shall be included with VFD submittal for approval by the engineer.
2. The VFD manufacturer shall conduct on site harmonic measurements before and after start up of the VFD's. Results of the measurements, showing harmonic contribution of the VFD's, shall be provided to the engineer one month after start up.
3. Three phase A. C. input line reactors shall be provided as a minimum, with all VFD's. The line reactors are to provide attenuation of line side voltage transients, thus preventing overload trips or other unnecessary V.F.D. shutdown, and provide a reduction in harmonic distortion.
4. Line reactors shall have the following requirements:
   a. Two or Three percent line impedance (line side of drive).
   b. 150 percent continuous current rating for one minute.
   c. Saturation rating no less than 2.5 times the continuous current rating.
   d. U.L. recognized.

I. General: Install variable frequency drives where indicated, in accordance with manufacturer's published installation instructions, complying with recognized practices to ensure that variable frequency drives comply with requirements and serve intended purposes.

J. Access: Provide access space around control panels for service as indicated, but in no case less than that recommended by manufacturer.

K. Support: Install drive control panels on walls where indicated on drawings. Provide necessary Unistrut and structural steel to provide adequate support per manufacturer's recommendations.

L. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

M. Start-Up
1. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

N. Adjusting and Cleaning:
   1. Alignment: Check compatibility of control panel to motor and where necessary, adjust frequency and provide necessary filters to assure noise free operation of motors. Verify response from control panel to motor to assure turn down ratio specified and that static pressure signals are being received and that drives are controlling as specified and within recommended tolerances by manufacturer. Provide start-up report prepared by manufacturer's representative to assure operation is as specified.
   2. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

O. Acceptable Manufacturers:
   1. Allen – Bradley
   2. ABB
   3. Siemens
   4. Square D
   5. Or equal

2.23 LIGHTNING PROTECTION SYSTEM

A. SUMMARY
   1. Furnish all labor, components and items of service required for the completion of a functional and unobtrusive lightning protection system.
   2. If any departures from the contract drawings are deemed necessary by the Sub-Sub-Contractor, submit details of such departures and reasons as soon as possible to the architect for approval. No such departures shall be made without the prior written approval of the architect.

B. QUALITY ASSURANCE
   1. Underwriters Laboratories (UL) or Applied Research Laboratories, Inc. (ARL) shall list the components and provide certification of the lightning protection system installation (inspect and certify) for compliance with UL 96A and NFPA 780 standards.
   2. The system shall be the standard product of a manufacturer regularly engaged in the production of lightning protection systems and shall be the manufacturer's latest approved design.
   3. All components specified for this work shall be manufactured by Heary Bros. Lightning Protection Co., Inc., Springville, New York, or equal. Thompson Lightning Protection, Harger, East Coast Lightning Protection or Robbins Lightning are considered equals.

C. SUBMITTALS
   1. Submit complete shop drawings, showing the type, size, cable routings, ground rods and locations of all equipment, to the architect for approval, prior to start of work.
   2. Submit samples and pertinent catalog data to the architect for approval upon request.

D. PRODUCTS
   1. All equipment shall be new, the product of a single manufacturer as outlined above, and of a design and construction to suit the application where it is used in accordance with accepted industry standards.

E. EQUIPMENT
   1. All components shall be aluminum and of the size, weight and construction to suit the application where used in accordance with requirements for Class I structures.
   2. Roof conductors shall be aluminum, 24 strands 14-gauge, 98,600 circular mils, net weight 110 lbs. / 1000 feet..
   3. Down conductors shall be copper, 29 strands 17-gauge, 65,600 circular mils, net weight 190 lbs./1000 feet.
   4. Air terminals shall be solid round aluminum 1/2 inch by 12 inch minimum, and shall project 10 inch minimum above the object to be protected.

5. Mid-roof air terminals shall be solid round aluminum 1/2 inch by 48 inch minimum, and shall be supported with a tripod brace.
6. Air terminal bases shall be aluminum with bolt pressure cable connectors and shall be securely mounted with stainless steel screws or bolts.
   a. Offset type bases shall be used at parapets and secured with stainless steel screws or anchors.
   b. Adhesive type bases shall be secured with an adhesive compound which is compatible with the roofing system. The roofing manufacturer shall approve the adhesive compound.
7. Ground rods shall be 5/8 inch by 10 feet.-0 inch minimum. They shall be connected to the system with a two-bolt copper clamp having a minimum length of 1-1/2 inch and employing stainless steel cap screws.
8. Cable fasteners shall be substantial in construction, galvanically compatible with the conductor and mounting surface.
9. Bonding devices, cable splicers and connectors shall be of aluminum with bolt pressure cable connectors.
10. Equipment on stacks and chimneys shall be protected from corrosion and sized in accordance with requirements.
11. Bolts, nuts and screws shall be stainless steel.

F. INSTALLATION
1. The installation shall be accomplished by an experienced installer. The installer shall work under the direct supervision of a manufacturer as listed above or a qualified distributor of such manufacturer's products.
2. All equipment shall be installed in a neat workmanlike manner in the most inconspicuous manner possible.
3. Provide complete cable network on the roof including; air terminals, splices, bonding connectors and cable downleads to ground rods. Down conductors shall run in one inch PVC conduit concealed within the building construction to ground.
4. The electrical Sub-Sub-Contractor shall furnish and install all necessary PVC conduit and junction boxes.
5. A bimetal transition fitting shall be used where aluminum roof conductor and copper down conductor are spliced together.

G. COORDINATION
1. Work with other trades to insure a correct, neat and unobtrusive installation.
2. Assure a sound bond to the main water service and to assure interconnection with other building ground systems, including both telephone and electrical.
3. Install proper arresters on the power and telephone service by either the utility or the electrical Sub-Sub-Contractor as applicable.

H. COMPLETION
1. Provide an as-built drawing to the architect, for the owner, upon completion of the installation.

I. INSPECTION AND LISTING LABORATORY
1. Applied Research Laboratories, Inc. or
2. Underwriters Laboratories

2.24 STANDBY ELECTRICAL SYSTEM

A. Summary
1. Work Included: Packaged diesel engine driven electric plant including engine generator set, cooling system, fuel system, combustion air intake and engine exhaust systems, starting system, and the following additional features:
   a. Weatherproof and soundproof housing.
   b. Automatic load transfer control to provide automatic starting and stopping of the plant and switching of the load within 10 seconds.

c. Automatic transfer switches

d. Remote annunciator panel.

e. 10 feet exhaust stack for generators rated 300KW and above.

2. Provide control and alarm circuits wiring as shown on the manufacturer's diagrams and required for a complete installation.

3. Provide labor, materials, tools, equipment, transportation, insurance, temporary protection, supervision and incidental items which are usually provided with this equipment, or which are essential for proper installation and operation, even though not these may not be specifically mentioned or indicated on the drawings.

B. REFERENCED STANDARDS

1. National Electrical Manufacturers' Association: NEMA MG1 - Motors and Generators.

2. UL142 - Steel aboveground tanks for flammable and combustible liquids.

3. UL2200 – Stationary engine generator set assemblies.

4. Massachusetts DEP regulations and Federal EPA certification.

C. SUBMITTALS

1. Product Data: Submit product data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, automatic transfer switches, battery, battery rack, battery charger, exhaust silencer, vibration isolators, radiator, enclosure and remote annunciator. Submit manufacturer's installation instructions.

a. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

b. Include thermal damage curve for generator.

c. Include time-current characteristic curves for generator protective device.

d. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.

e. Include airflow requirements for cooling and combustion air in cubic feet per minute at 0.8 power factor, with air-supply temperature of 104 degrees Fahrenheit. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.

f. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactance's, and short-circuit current capability.

2. Shop Drawings: Prepare and submit complete shop drawings of the emergency generator set and enclosure, including plan and elevation views with overall and interconnection point dimensions, fuel consumption rate curves at various loads, and electrical diagrams, including schematic and interconnection diagrams.

a. Include plans and elevations for engine generator and other components specified. Indicate access requirements.

b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

c. Identify fluid drain ports and clearance requirements for proper fluid drain.

d. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

e. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.

f. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams indicating terminal markings for engine generators and functional relationship between all electrical components.

g. Certified summary of prototype-unit test report.

h. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

i. Report of factory test on units to be shipped for this Project, indicating evidence of compliance with specified requirements.

j. Report of sound generation.

k. Report of exhaust emissions indicating compliance with applicable regulations.

l. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

3. Test Reports: Submit certified copies of reports of factory testing required by this section.

4. Closeout Submittals: For inclusion the Operating and Maintenance Manual specified in Division 1, provide the required number of copies of operating and maintenance information, parts manuals, and schematic and wiring diagrams.

5. Provide an excel spreadsheet all maintenance requirements and schedule of service/maintenance to the owner to be input into Dude solutions maintenance program.

D. QUALITY ASSURANCE

1. Installer: Company specializing in performing the work of this section with minimum three years experience.

2. NEMA Standards: Furnish and install motors to conform to NEMA MG1.

3. Code: Furnish and install emergency generator to comply with provisions of the referenced Electrical Code.

E. CLOSEOUT SUBMITTALS

1. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

b. Operating instructions laminated and mounted adjacent to generator location.

c. Training plan.

F. REFERENCED STANDARDS

1. National Electrical Manufacturers' Association: NEMA MG1 - Motors and Generators.

2. UL142 - Steel aboveground tanks for flammable and combustible liquids.

3. UL2200 – Stationary engine generator set assemblies.

4. Massachusetts DEP regulations and Federal EPA certification.

G. QUALITY ASSURANCE

1. Installer: Company specializing in performing the work of this section with minimum three years experience.

2. NEMA Standards: Furnish and install motors to conform to NEMA MG1.

3. Code: Furnish and install emergency generator to comply with provisions of the referenced Electrical Code.

4. Manufacturer Qualifications: Current certificate holder for compliance with ISO 9001.

5. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

6. Testing Agency Qualifications: Accredited by NETA.

a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

H. DELIVERY, STORAGE, AND HANDLING

1. Deliver, store, and protect products under provisions of Section 26 00 01.

2. Accept packaged engine generator set and accessories on site in crates and verify damage.

3. Protect equipment from dirt and moisture by securely wrapping in heavy plastic.

I. WARRANTY

1. Provide written warranty, signed by the manufacturer and installer of the emergency generator equipment, agreeing to repair or replace at no cost to the Owner, equipment which is defective either in material or workmanship.
    a. Warranty Period: Five years from the date of Substantial Completion of construction.
2. On-going system service and support shall be available from multiple factory certified vendors. Include generator package the recommended service agreement. Provide recommended service agreement pricing at the time of bid for one year post completion.

J. MAINTENANCE MATERIALS

1. Furnish one set of tools required for preventative maintenance of the engine generator system. Package tools in adequately sized metal tool box.
2. Provide two additional sets of each fuel oil, and air filter elements required for the engine generator system.

K. Provide one 600 kW, 750 kVA at .8 PF standby power rated diesel fired generator set, mounted in perfect alignment on an all welded, fabricated steel sub-base which shall allow for attachment of all necessary engine and generator accessories.

1. Acceptable Manufacturers:
    a. Kohler
    b. Caterpillar
    c. Onan/Cummings
    d. Generac
    e. MTU Onsite Energy
    f. Or equal

L. Engine

1. Water cooled with unit-mounted radiator. Provide starter and all field wiring required by manufacturer
2. Dry-type replaceable element air cleaners.
3. Full flow lube oil filters and bypass oil filter.
4. Twelve volt starting motor, 12 volt, 3 ampere battery charging alternator.
5. Engine instrument panel to include ammeter, lube oil pressure gauge, lube oil temperature gauge, water temperature gauge, and hour meter.
6. Engine-mounted safety control to provide alarm signals for engine shutdown in event of low oil pressure, high coolant temperature, over speed, over crank, and pre-alarms for high water temperature and low oil pressure.
7. Jacket water heater, 2000 watt, 120 or 208 volt, single phase or as recommended by generator manufacturer.

M. Generator: 600 kW, 750 kVA, 277/480 volt, 3 phase, 4 wire, 60 Hz, 1800 RPM revolving field type main generator with brushless exciter and permanent magnet. Voltage regulation plus 1 percent from no load to full load.

N. Cooling System: Unit mounted radiator with flange attached.

O. Starting System: 12 volt heavy duty lead acid storage battery, connected for 12 volt DC output.

P. Battery rack, cables, and connectors shall be provided.

Q. Provide 10 amp battery charger fed from a 120 volt, single phase, 60 Hz service. Battery charger to include high and low battery voltage alarm relays for derangement panel. Battery charger shall meet NFPA 110 Standards.

R. Exhaust System: Furnish one Maxim M-51 three inch critical silencer, three inch side inlet, and one three inch end outlet complete with two, three inch companion flanges. Furnish one three inch by 18 inch flexible stainless steel exhaust connector, flanged on one end, threaded nipple on opposite end. Generator shall meet all applicable emission standards.

1. Furnish a stainless steel 10' stack exhaust extension supported from the generator housing with rain cap and all necessary components for a complete installation in accordance with Commonwealth of Massachusetts regulations. Stack shall be powder coated with black heat resistant paint.

S. Vibration Isolators: Set of four Korfund rubber type vibration isolators for installation between steel base and concrete foundation.

T. Generator Control Panel:

1. To completely control operation of engine generator set. Panel to have automatic start control, AC volt meter, AC ammeter, pointer type frequency meter, volt meter, ammeter and selector switch. Alarm signals to indicate pre-low oil pressure, pre-high coolant temperature, and alarm signals to shut down engine in event of a low oil pressure, high coolant temperature, engine over speed, or over crank. Lights on face of panel to indicate failure. Provide dry contacts for remote disarrangement signal and louvers. Locate remote annunciator in administration area.
2. Terminal strip shall be included with alarms and prewarning devices prewired for remote annunciator specified herein. Provide wiring between generator and remote annunciator panel. Generator control switch shall be mounted on control panel face. A flashing light for selector switch "OFF" shall be included.
3. Provide molded case line circuit breakers mounted on generator in oversized terminal box.
4. Generator Overcurrent Protection: The generator set shall be provided with a UL Listed/CSA Certified protective device that is coordinated with the alternator provided to prevent damage to the generator set on any possible overload or overcurrent condition external to the machine. The protective device shall be listed as a utility grade protective device under UL category NRGU. The control system shall be subject to UL follow-up service at the manufacturing location to verify that the protective system is fully operational as manufactured. Protector shall perform the following functions:
    a. Initiates a generator kW overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
    b. Under single phase or multiple phase fault conditions, or on overload conditions, indicates an alarm conditions when the current flow is in excess of 110 percent of rated current for more than 10 seconds.
    c. Under single phase or multiple phase fault conditions, operates to switch off alternator excitation at the appropriate time to prevent damage to the alternator.
    d. The operator panel shall indicate the nature of the fault condition as either a short circuit or an overload.
    e. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot greater than 120 percent of nominal voltage.

U. Automatic Transfer Switches:

1. Provide automatic transfer switches as shown on drawings for operation on 277/480 volts, 3 phase, 4 wire operation. Units to be housed in a NEMA 1 enclosure and shall be 4 pole. Transfer switches over 400 amperes shall have an AIC rating of 65,000 ARMS.
2. Transfer switches 400 amperes or less shall be rated for 42,000 ARMS and fed from a current limiting breaker on the normal side.
3. Entire switch shall be listed under UL 1008.
    a. Acceptable Manufacturers:
    b. Russ Electric
    c. ASCO

d. Kohler

e. Or equal

4. Unit shall be provided with standard accessories as follows.

a. Voltage and Frequency Sensing:

5. Close differential voltage sensing on all phases of normal pickup adjustable 85-100 percent. Dropout 75-98 percent

6. Voltage sensing of emergency source. Adjustable pickup 85-100 percent.

7. Frequency sensing of emergency source. Adjustable pickup 90-100 percent.

a. Time Delays:

8. Time delay to override momentary normal source outages. Adjustable 0.5 to 6 seconds.

9. Retransfer to normal with 5 minute cooldown timer.

a. Engine Control:

10. Contact to close when normal source fails.

11. Contact to open when normal source fails.

12. Test switch to simulate normal source failure.

a. Indicators: Pilot lights to indicate switch in normal position or emergency position.

b. Auxiliary Contacts: Two to close on normal. Two to close on emergency.

13. Engine Start Control and Monitoring:

a. Contact to close when normal source fails.

b. Contact to open when normal source fails.

c. Test switch to simulate normal source failure.

d. The Engine Start Control and Monitoring Modules shall be ASCO 5101 Engine Start Modules or approved equal. The solution must cover and provide complete compliance to the 2020 NEC 700.10 code.

e. The ATS shall provide continuous monitoring of the entire remote start circuit. Visual and audible annunciation of generator malfunction shall be initiated if the integrity of the start circuit is compromised.

f. There shall be minimum time delay (less than 5 seconds) in annunciation of any compromised condition such as an open or short circuit. A system which annunciates compromised conditions only after a generator start signal is initiated via a redundant path does not meet the intent of this specification.

g. The detection of a compromised start circuit shall initiate and latch the generator start circuit.

h. Each Generator Engine Start Module shall be din-rail mounted and accept up to eight ATS Engine Start. Each channel must have its own dedicated tri-colored status LED.

i. Each Engine Start channel must have its own dedicated switch with ability to enable or disable monitoring function.

j. Engine-start circuit shall be a single pair of typical hardwire used in legacy applications. Additional wiring and components beyond specified herein does not meet the intent of this specification.

k. Coordinate placement of required components within the generator controls with the specified manufacturers.

14. Indicators: Pilot lights to indicate switch in normal position or emergency position.

15. Auxiliary Contacts: Two to close on normal. Two to close on emergency.

16. Optional Accessories:

a. Plant exerciser.

b. In-phase monitor (Motor Load Transfer). (ATS-OS)

c. Manual transfer to normal source.

d. Elevator control transfer module. A load control circuit consists of two sets of single pole, double throw contacts that operate three seconds before transfer in either direction. Contacts rated 3 amperes, 208 volts AC or 10 amperes, 32 VDC, for signal to elevator of generator power available. Provide 2 #14AWG conductors in 3/4 inch conduit, interlock wiring to each elevator controller from each switch controlling elevator power.

e. Engine Start control and Monitoring

f. The Engine Start Control and Monitoring Modules shall be ASCO 5101 Engine Start Modules or equal. The solution must cover and provide complete compliance to the 2020 NEC 700.10 code.

g. The ATS shall provide continuous monitoring of the entire remote start circuit. Visual and audible annunciation of generator malfunction shall be initiated if the integrity of the start circuit is compromised.

h. There shall be minimum time delay (less than 5 seconds) in annunciation of any compromised condition such as an open or short circuit. A system which annunciates compromised conditions only after a generator start signal is initiated via a redundant path does not meet the intent of this specification.

i. The detection of a compromised start circuit shall initiate and latch the generator start circuit.

j. Each Generator Engine Start Module shall be din-rail mounted and accept up to eight ATS Engine Start. Each channel must have its own dedicated tri-colored status LED.

k. Each Engine Start channel must have its own dedicated switch with ability to enable or disable monitoring function.

l. Engine-start circuit shall be a single pair of typical hardwire used in legacy applications. Additional wiring and components beyond specified herein does not meet the intent of this specification.

m. Coordinate placement of required components within the generator controls with the specified manufacturers.

V. Remote Annunciator Panel: A flush mounted panel shall include a visual signal that battery charger is functioning properly and both audible and visual signals. Annunciator shall meet NFPA 110 Standards.

W. Audible signal shall have a silencing switch. A lamp test button shall be provided.

X. Provide load bank test in the field by a factory certified representative for two hours at 25 percent, 50 percent, 75 percent and 100 percent load for 30 minutes at each stage and provide testing documentation. Also, provide a two hour building load test transferring the ATS switches to generator power. Provide an NFPA 110 test report for Engineer approval.

Y. Provide remote emergency power off button on the generator external to the enclosure.

Z. Provide remote emergency power off button at fire command center integral to the remote annunciator.

AA. Miscellaneous: Necessary lube oil and anti-freeze.

BB. Equipment Testing and Instruction Manual and Drawings:

1. Operating instruction and maintenance manuals shall contain the following information:
   a. Operating Instruction
   b. Replacement Parts
   c. Wiring Diagram
   d. Maintenance
2. Factory test generator for four hours, one hour each at 25 percent, 50 percent, 75 percent and 100 percent load. Take standard readings and submit test reports for approval prior to

shipment.

3. Perform field test with load bank at same ratings for 2 hours, in addition to the 2 hour load test specified below. The field test should be performed at each phase of construction.
4. The entire emergency system shall be field test operated for two hours. A normal power failure shall be simulated. The engine generator unit shall automatically start, come up to speed, and assume full emergency load.
5. Custodians of the equipment shall be present during test. At that time they shall be instructed in operation and maintenance.
6. Upon completion of tests, written reports containing results shall be submitted. Test reports shall contain readings taken at 30 minute intervals along with all other pertinent test information.
   a. Ambient Temperature
   b. Oil Pressure
   c. Battery Charge Rate
   d. AC Volts
   e. AC Amperes All Phases
   f. Frequency
   g. Kilowatts
   h. Power Factor

CC. Coordination of Trades:

1. The following equipment shall be furnished by Electrical Contractor but shall be installed under other sections.
   a. Anchor bolts to be installed by General Contractor based on approved shop drawings.

DD. REMOTE ALARM ANNUNCIATOR PANEL

1. Provide a generator set remote alarm annunciator panel for installation at the location shown on the drawings.
2. Enclose the panel in NEMA 1 enclosure suitable for flush wall mounting and provide audible (A) and/or visual (V) signals for the following:

	Condition	Signal
1.	Generator set operating	V
2.	Failed to start	A/V
3.	Pre-low lube oil pressure	A/V
4.	Pre-high water temperature	A/V
5.	Low water temperature	A/V
6.	Engine overspeed	A/V
7.	Low battery voltage	V
8.	High battery voltage	V
9.	Low fuel supply	A/V
10.	Fuel leak detection	A/V

3. In the panel face, provide a separate lamp for each of the signals listed above, a lamp test pushbutton switch, and an audible alarm signal device with silence switch having ring back

feature.

4. Provide a communication port to interface with the building management system for transmitting the generator set status and alarms data including alarm on a generator set failure to start automatic weekly exercise.
    a. Supports industry-standard Modbus_RTU protocol.
    b. Uses either an RS-232 or RS-485 Network port.
    c. Communicates at baud rates up to 19200.
    d. Allows selection of an access code for remote programming.
    e. Remotely monitors system operation including run times, shutdowns, warnings, and input/output activity.
    f. Allows selection of either metric (SI) or English (IP) units.
    g. Provides more than 100 different Modbus_message codes for system monitoring, including System Ready and Generator Running.
    h. Provides remote programming of most system parameters including time delays, trip points, voltage, frequency, and current.
    i. Provide remote engine start/stop and controller reset and connect to the Johnson Controls Metasys BMS system.

EE. EXECUTION

1. GENERAL
    a. Install, align, set, support, and wire equipment in accordance with the contract drawings, specifications and manufacturer's installation manual..
    b. Provide adequate temporary supports for the equipment during erection or installation.
2. TESTING AND INSPECTION
    a. Provide services of a factory trained field engineer to inspect the installation, service the engine with lube oil, the radiator with rust inhibitors, and supervise start of the engine set and tests for all systems.
    b. Test the equipment and controls after installation, under the supervision of a factory trained engineer, and in the presence of the Architect and the Owner. Certify that the equipment has been tested in accordance with NEMA MG-1 and meets the minimum requirements of that specification.
    c. Verify time delay settings of the automatic transfer switches. ATS serving life safety (emergency) loads shall transfer to emergency without delay. Time delay on transfer for the switches serving standby loads shall be set to satisfy the diesel-generator starting kVA value.
    d. Testing Procedure:
    e. Check all systems to assure compliance with the manufacturer's installation drawings and wiring diagrams..
    f. The load tests shall be with a resistance load bank and shall include:
        1) 1 hour at 25 percent of rated load.
        2) 1 hour at 50 percent of rated load.
        3) 1 hour at 75 percent of rated load.
        4) 1 hour at 100 percent percent of rated load.
    g. Record at the beginning and end of the test the following parameters:
        1) Engine oil pressure.
        2) Engine oil temperature.
        3) Engine exhaust temperature of exhaust manifold.
        4) Jacket water temperature in and out.
        5) AC voltage and amperage (all phases).
        6) Frequency.

h. Simulate a power failure by transferring the entire load to the emergency power system, and operating the fully-loaded emergency power system for a period of 1 hour.

i. Submit all required documentation for registration of generator with the DEP.

j. Provide NFPA 110 equivalent testing and provide test report to engineer for approval.

3. MAINTENANCE SERVICE

a. Instruct the operating personnel in the operation and maintenance of the unit. Provide at least one full day for instructing personnel an explaining the operator's manual.

b. Provide all information for maintenance in an excel spreadsheet for input into owners maintenance software Dude solutions. Coordinate required maintenance info and format and submit to design team for approval.

4. CLEANING AFTER TESTING

a. After completion of testing and adjustment of system, thoroughly clean all exposed surfaces of emergency generator equipment to remove dirt, grease, fingerprints and other contamination. Touch up damaged factory-applied finishes.

FF. Generator Outdoor Housing

1. The engine generating set shall be factory installed in a weatherproof outdoor housing. The housing shall provide year round generating set protection against adverse weather and environmental conditions. The enclosure shall be sound attenuated and meet Federal Specifications.

2. The weatherproof shelter shall be constructed or welded and bolted reinforced aluminum, 14 gauge walls and 14 gauge floor plate. All metal parts shall be prime coated and finished painted.

3. The shelter assembly shall have shuttered air openings on front and sides with mesh screens covering side shutters. The air shutters shall be opened by four 22 volt AC motors when the generating set operates. Motors shall be spring loaded to close shutters when set stops.

4. Hinged double doors on each side and one door in rear of the shelter shall allow easy access to engine generator and controls. All door handles shall be key lock design.

5. Vibration isolators of the open coil spring type, selected for 3 inch (76mm) static deflection, shall be furnished and installed. The number of isolators shall be as recommended by the generator set manufacturer, and complete details shall be included in the Submittals. Anchor bolts, nuts and sleeves shall be supplied with recommended Foundation Plan.

6. Provide an integral 48 hour at 100 percent load reserve base mounted tank, double wall containment with alarms. Include conduit entry provisions for tank. Tank shall be supplied in accordance with the state Fuel Storage Codes for above ground diesel fuel tanks. Provide a full tank of diesel. E.C. shall fill diesel tank after all testing is complete and provide all required diesel fuel for testing.

7. The weatherproof housing shall allow installation of the silencer outside the enclosure. Provide critical type silencer.

8. Provide sound deadening materials, baffles, hoods, to reduce noise levels to 75DBA at 7 meters in any direction.

9. Finish of housing to be selected by Architect include RAL colors.

10. Provide whether proof emergency power off button on the exterior of the enclosure to shut down the prime mover per NEC requirements.

2.25 MANUAL TRANSFER SWITCH

A. Scope:

1. Electrical SubContractor shall furnish, deliver, install and test the manual transfer switches as specified herein and in accordance with the drawings.

B. Quality Assurance:

1. Manual transfer switch shall be UL listed and labeled under the UL 1008 standard.

2. Manual transfer switch manufacturer shall provide a complete factory assembled, wired and

tested manual transfer switch.

3. Manual transfer switch shall be factory Hi-pot tested for a period of not less than 60 seconds.
4. Manual transfer switch installation shall meet all applicable NEC standards.

C. Submittals:
   1. Electrical SubContractor shall submit manufacturer's drawings and data of manual transfer switches for Engineer's approval prior to start of fabrication. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings and wiring diagrams, UL listing information including UL control or file number, component data, mounting provisions, conduit entry locations and installation instructions.
   2. Upon installation of manual transfer switches Electrical SubContractor shall submit manufacturer's Operating and Maintenance Manual which shall include as a minimum:
      a. Certified as-built General Arrangement drawings and Wiring Diagram.
      b. Materials / Component List including part numbers.
      c. Maintenance and service requirements.
      d. Certificate of Compliance and hi-pot test data.

D. Warranty:
   1. Manual transfer switches shall be covered by manufacturer's warranty for a minimum period of one year after shipment from manufacturer.

E. General:
   1. All equipment shall be new.
   2. Manual transfer switch manufacturer shall have produced and sold manual transfer switches as a standard product for a minimum of three years.
   3. Manual transfer switches shall be molded case circuit breaker type; knife switch or fused switches are not acceptable.
   4. Electrical SubContractor shall be responsible for the equipment until it has been installed and is finally inspected, tested and accepted in accordance with the requirements of this Specification.
   5. Manual transfer switches shall be StormSwitch, Model "SSDX-150A-H-150A-H-480-3-1-1-S-C" as manufactured by ESL Power Systems, Inc. or equal.

F. Manual Transfer Switches:
   1. Manual transfer switch shall consist of two mechanically-interlocked molded case circuit breakers, cam-style male connectors, power distribution block and grounding terminals, all housed within a padlockable enclosure.
   2. Manual transfer switch enclosure shall be Type 3R, constructed of continuous seam-welded, powder coated galvanneal steel. The main access shall be through an interlocked, hinged door that extends the full height of the enclosure. Access for portable generator cables with female cam-style plugs shall be via cable entry openings in the bottom of enclosure. A hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be light gray RAL 7038.
   3. Cam-style male connectors (inlets) shall be UL Listed single-pole separable type and rated 400 amps at 600VAC. Cam-style male connectors shall be color coded. Cam-style male connectors shall be provided for each phase and for ground, and shall also be provided for neutral if required. Each of the phase cam-style male connectors within the enclosure shall be factory-wired to a molded case circuit breaker. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. The neutral cam-style male connectors, if required, shall be factory wired to a power distribution block. None of the cam-style male connectors shall be accessible unless both molded case circuit breakers are in the "OFF" position and the main access door is open.
   4. A power distribution block shall be provided for load-side field wiring. The power distribution

block shall be factory wired to the molded case circuit breakers.

5. Molded case circuit breakers shall be UL Listed and the short circuit interrupt rating shall be a minimum of 35kAIC at 480VAC. Trip rating of the molded case circuit breakers shall be as shown on the drawings. One molded case circuit breaker shall be fed from utility power; the other molded case circuit breaker shall be fed from the cam-style male connectors to supply power from a portable generator. Both molded case circuit breakers shall include UL Listed door-mounted operating mechanisms, preventing the opening of the main access door unless both breakers are in the "OFF" position. Both molded case circuit breakers shall be mounted behind a deadfront panel. The load-side of the molded case circuit breakers shall not be energizable unless the main access door is closed and one of the molded case circuit breakers is in the "ON" position. The two molded case circuit breakers shall be safety interlocked by mechanical means to ensure that only one breaker can be closed at any given time.
6. Manual transfer switch shall be suitable for use as service equipment in the USA.

G. Installation:
1. Prior to installation of manual transfer switches, Electrical SubContractor shall examine the areas and conditions under which the manual transfer switch is to be installed and notify the Engineer in writing if unsatisfactory conditions exist.
2. Manual transfer switch shall be installed as shown on the drawings and per the manufacturer's written instructions. In addition, the installation shall meet the requirements of local codes, the National Electrical Code and National Electrical Contractors Association's "Standard of Installation".
3. Conduit entry into the manual transfer switch shall be by Electrical SubContractor; Electrical SubContractor shall furnish and install listed watertight conduit hubs, as manufactured by MYERS or TandB, for each conduit entry on the manual transfer switch. The incoming hub size shall match the conduit size for feeders and ground as shown on the drawings. The outgoing hub size shall match the conduit size for loads and ground as shown on the drawings. Hubs shall be properly installed and tightened to maintain Type 3R integrity of the manual transfer switch enclosure.
4. Electrical SubContractor shall terminate feeder conductors, load conductors and ground per the manufacturer's instructions. Use copper wire only for all conductors and grounds. All field wiring terminations shall be torqued per the instructions on the manual transfer switch's power distribution block, circuit breaker and ground lug.
5. Provide with auxiliary contacts on breakers and connect to fire alarm system to monitor breaker that serves permanent generator. Install fire alarm monitor module to transmit system trouble if breaker to permanent generator is open.

H. Field Testing:
1. Prior to energizing manual transfer switch, the Electrical SubContractor shall perform the following checks and tests as a minimum:
   a. Verify mounting and connections are complete and secure.
   b. Verify internal components and wiring are secure.
   c. Perform continuity check of all circuits.
   d. Perform 1,000 VDC megger test on feeder, load and ground cables.
   e. Verify deadfront is secure.
   f. With the manual transfer switch deadfront in place and the main access door closed and properly latched, actuate both Operator Mechanisms; verify only
   g. One breaker at a time can be turned to the "ON" position.
   h. Confirm operation of the manual transfer switch ground receptacle by attaching a plug to the manual transfer switch ground receptacle and then verify that the plug is grounded to the facility ground.
   i. Once utility power has been applied, confirm operation of manual transfer switch by following directions on main access door.

2.26 TWO WAY COMMUNICATIONS CALL BOXES SYSTEM

A. Summary:
   1. Section Includes: Area of Refuge Base Stations, call boxes and signage.
      a. The Area of Refuge Base Station is to be located at a central control point on the first floor or as determined by local Authority having jurisdiction. Rath Call Boxes are to be located on all floors above and below the first floor.
      b. The Area of Refuge Base Station shall be capable of handling a minimum of 5 Rath Call Boxes. Visual indicators on the base station allow Rescue personnel to know which Area of Rescue Call Box needs assistance. The Base Station shall allow Rescue personnel to speak to all Call Boxes or individual Call Boxes.
      c. The Emergency communication hardware shall comply with the Americans with Disabilities Act (ADA). The phone shall have the ability to be programmed with up to 5 emergency phone numbers. Upon activation of the emergency push button, a call will be automatically placed to the Base Station. If no one answers at the Base Station, the Call Box shall dial a secondary location outside the building to activate two way off-site person to person voice communications.

B. Manufacturers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Rath Area of Refuge
      b. Aiphone
      c. Housing Devices, Inc.
      d. Or Equal.

C. Functional Description of System
   1. Construction
      a. The Area of Refuge Base Station (models 2500) shall have a stainless steel or powder coated steel housing, red coil cord emergency Handset, be 120vac
      b. powered, and maintain back-up power for four hours.
      c. The Area of Refuge Call Boxes (models 2100) shall be in full compliance with Americans with Disabilities ACT (ADA). Call Boxes require a hands-free speakerphone with an LED to indicate status of call.
      d. The Area of Refuge Call Boxes shall allow the programming in of a specific location message of the Call Box. This allows Rescue personnel to know the location of the activated Call Box.
      e. The Area of Refuge Call Boxes are to be located no higher than 48 inch above ground level to ensure conformance with the ADA requirements.
         The Area of Refuge Call Boxes shall have a Braille faceplate located no higher than 48 inch for front reach and 54 inch for side reach above ground level to ensure conformance with the ADA requirements.
         The Area of Refuge Base Station shall provide an audible and visual indicator that a Call Box has been activated.
         The area of Refuge 24vac Power Supply model 2500-PWR24 shall be capable of supplying power to a minimum of 40 Call Boxes. (does not power Base Station)
   2. Mounting
      a. The Area of Refuge Base Station is to be mounted on a wall surface or flush mounted.
      b. Areas of Refuge Call Boxes are to be wall surface or flush mounted.
   3. Electrical
      a. The Base Station is to be powered by 120vac. Call Boxes are to be powered by Rath 24vac Power Supply model 2500-PWR24.
      b. Call Boxes shall have a battery back-up capable of providing up to four hours of electrical back-up in case of building power failure.

c. Base Station shall have a battery back-up capable of providing up to four hours of electrical back-up in case of building power failure.
d. System shall be in compliance with all state and local Electrical Codes.

4. Communications
   a. The Call Boxes shall have an ADA compliant and vandal resistant speakerphone.
   b. The Call Boxes shall be Hands-Free and be a push-button-once to talk system.
   c. Once the button has been pushed, the Call Box will call the Base Station. If no answer at the Base Station, it will automatically call preprogrammed emergency numbers. The Call Box must be capable of being programmed with up to 5 emergency numbers.
   d. Call Box shall have Location Message capability. Call Box shall have a minimum 18 second recordable message capability, programmable to play one or two times. Call Box shall notify called party of the location of the call upon being received at the emergency dispatch center.
   e. Call Box shall be capable of allowing the called party to replay the Location Message if necessary to ensure an understanding of the caller location.
   f. If system is not attended to 2four hours a day, the Call Box shall dial a secondary location outside the building to activate two way off-site person to person voice communications.
   g. Once call has been made (button pushed), the call can only be terminated by thecalled party.
   h. Call Box shall have a red LED that will light up upon push of the button. The light shall be a solid color when the Call Box is activated, and will flash when call has been answered.
   i. The Call Box shall be capable of being programmed and reprogrammed on-site and remotely.
5. Standard Call Box features:
   a. Five number programming.
   b. Operating Temperature of between -40 degrees Fahrenheit to plus150 degrees Fahrenheit (minus 40 degrees to plus 65 degrees Celcius)
   c. Programmable passwords.
   d. On-Site or Remote Programmable.
6. Monitoring
   a. Off-Site monitoring of the system shall be provided as requested by the Owner.
   b. Shall be a UL Listed monitoring service provider
   c. Minimum three year agreement for monitoring of the system.
   d. Call Boxes shall dial the monitoring service.
7. Graphics
   a. Area of Refuge Base Station shall include wording identifying the location of each
   b. Call Box and light an LED when a particular Call Box has been activated.
   c. Call Box wording shall include “Help Phone”, “International Phone symbol” and raised Braille lettering.

D. Startup Service:
   1. Engage a factory-authorized service representative to perform startup service.
      a. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
      b. Complete installation and startup checks according to manufacturer's written instructions.

E. Adjusting:
   1. On-Site Assistance: Engage a factory-authorized service representative to provide onsite assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
   2. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

F. Warranty:
   1. The base station and call boxes shall be warranted for a period of one year.
G. Demonstration:
   1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the system.

2.27 FIRESTOPPING

A. Provide firestopping at all fire-rated construction where penetrated by the Work of this Section.
B. Refer to Section 07 84 00 - Firestopping, for all product requirements for maintaining integrity of fire-rated construction at penetrations.

2.28 ELECTRONIC SCOREBOARDS

A. General
   1. Provide as hereinafter specified, Fair-Play Electronic Scoreboard with shot timers, as Manufactured by Fairtron Corporation and distributed by Hampden Engineering Corporation, East Longmeadow, Massachusetts or equal. Daktronics and Sportable Scoreboards are considered equals. Refer to Drawings for quantities and locations.
   2. Scoreboard shall be ETL listed, and be remotely operated via two-wire shielded cable from control point(s). Scoreboard shall display the following information: Minutes, Seconds and Score for two teams, Period, Bonus indicator for both teams and Possession indicator on the top section; Team Fouls for two teams and Player Number with Personal Fouls on the bottom section. Provide with changeable captions for the sports of basketball, volleyball and wrestling on the bottom section. Equipment to be solid state electronic technology.
B. Scoreboard
   1. Shall be Fair-Play Model BB-1520-4 or approved equal to this specification by the architect. Provide quantities as indicated on plans.
   2. Overall cabinet size shall be five feet six inch in height by seven feet in length by four inch in depth including mounting brackets and constructed of aluminum. Cabinet color shall be as selected from manufacturers standard colors with selected appropriate trim colors. Cabinet to be shipped in two sections and constructed for wall mounting. Approximate weight shall be 118 lbs.
   3. Display digits shall be surface mounted LED (light emitting diode) seven-segment bar type protected by a polycarbonate numeral front. Data display digits shall be colored amber for game clock and red and green for other information. Digit height to be 12 inch for game clock and team score and 10 inch for other display information. Game clock shall have a display capacity up to “99:59”, team scores to “199”, period to “9”, team fouls to “99”, personal fouls to “9”, player number to “99” and bonus with one arrow for each team.
   4. Captions shall be adhesive backed white vinyl permanently attached to the cabinet as follows: Home and Visitor six inch high; Period, Fouls and Player four inch high; Bonus and Possession three inch high. Changeable captions for basketball, volleyball and wrestling shall be the same vinyl on aluminum plaques and shall be four inch high.
   5. Electronics to be packaged in a low voltage, plug-in processor.
   6. Power to be 162 watts maximum 120 VAC, 60 Hz.
   7. Provide a #350 electronic horn rated at 100dB at 10 feet 0 inch.
C. Control Console
   1. Shall be model MP-80 with padded carrying case. Requires 120 VAC power source and draws 5VDC at 1A.
   2. Construction shall be an aluminum case 12¾ inch long by 2¼ inch high by eight inch deep with four rubber slide-resistant ft.
   3. Operating features shall include a two-line LCD readout showing information as sent to the scoreboard display as well as constant display of time remaining or time lapsed; a changeable color coded keypad to allow key identification change by sport, numeric key pad, plus and minus keys for quick sequential data entry, a push-type horn button and a positive action

rocker switch for the “Time In” and “Time Out” function.

4. Electronic features shall include a program mode allowing change in sport controlled or accommodation of a sport rules change, a memory circuit to retain information if power interrupted and electronic foul memory.
5. Furnished with an eight feet. power and 10 feet. data cable cord to connect to power source and control receptacle junction box.

D. Remote Control Cable
   1. Furnish one length of two wire-shielded cable to connect from the control receptacle junction box to the top center of the scoreboard cabinet field confirm actual length.

E. Shot Clocks
   1. Shot clocks shall be ETL listed and be remotely operated via two-wire shielded cable from control point(s). Shot clocks shall display seconds up to 99. Equipment to be solid state electronic technology and shall be Fair-Play Model ST-1410-2 or approved equal to this specification by the architect. Provide quantities as indicated on plans but no less than two.
   2. Overall cabinet size of each display shall be 17 inch in height by 20 inch in length by 6½ inch in depth. Cabinets shall be constructed of aluminum. Cabinet color shall be black. Cabinets to be shipped assembled and constructed for wall mounting (requires optional hangers) or for mounting on basketball backstops (additional supports may be required) or used as portable units to sit on the floor.
   3. Approximate weight shall be 80 lbs. for two displays.
   4. Display digits shall be made up of circuit card mounted LEDs and shall be red in color. Digit height to be 12 in.. Clock shall have a display capacity of “99”.
   5. Electronics to be packaged in a low voltage, plug-in processor.
   6. Power to be 37 watts maximum 120 VAC, 60 Hz for two displays.
   7. Provide a CS2448-10 Edwards electronic horn rated at 100db at 10 feet. Zero inch.

F. Control
   1. No primary control is furnished. An HS-70 Handswitch shall be furnished which plugs into the MP-70 scoreboard control for shot clock operation.

G. Remote Control Cable
   1. Furnish one length of two wire-shielded cable to connect from the control receptacle junction box to each shot clock cabinet field confirm actual length.

H. Limited Warranty
   1. The manufacturer shall provide a limited warranty for a period of five years from the date of invoice against defects in workmanship or material. Defective components shall be repaired or replaced on a factory exchange basis. Exclusions include, but are not limited to accident, neglect, abuse, misuse or natural disasters. Details available on request.

I. The Electrical Subcontractor shall be responsible for structural support including all anchor bolts, hangers, and other associated hardware. Support shall be provided by scoreboard manufacturer.

2.29 UNINTERRUPTIBLE POWER SUPPLY

A. General
   1. This specification describes a continuous duty, three-phase, solid-state, static Uninterruptible Power System (UPS) hereafter referred to as the UPS. The UPS shall contain a full rated input rectifier / boost converter (hereafter referred to as Input Converter), output inverter, and 10 percent battery charging circuit. The system shall also contain a continuous duty bypass static switch, internal mechanical bypass, removable hot swap battery plant, and LCD interface display. All of the above system components are housed in a single enclosure. Maintenance bypass and extended battery is required to meet this specification shall be contained in matching enclosures with all interconnecting cabling included. All programming and miscellaneous components for a fully operational system as described in this specification shall be provided as part of the UPS.

B. Standards
   1. The UPS shall meet the requirements of the following standards:
   2. IEEE 587-1980/ANSI C62.41 1980 Standards for Surge Withstand Ability.
   3. FCC rules and regulations of Part 15, Subpart J, Class A.
   4. UL listed under 1778, Standards for Uninterruptible Power Supply Equipment.
   5. UL Canada (cUL).
   6. NEMA PE 1 (National Electrical Manufacturers Association) - Uninterruptible Power Systems.
   7. NEMA 250 (National Electrical Manufacturers Association) – Enclosures for Electrical Equipment (1000 Volts Maximum).
   8. IEEE 519-1992 Standard Practices and Requirements for Harmonic Control in Electrical Power Systems
   9. NFPA 70 – National Electrical Code.
   10. ISO 9001.
   11. ISO 14001
   12. Occupational Safety and Health Administration (OSHA).

C. Submittals
   1. Submittals shall contain the following documentation:
      a. Installation Drawings: Indicate electrical characteristics and connection requirements. Provide cabinet dimensions; battery type, size, dimensions, and weight; detailed equipment outlines, weight, and dimensions; location of conduit entry and exit; single-line diagram, control, and external wiring requirements; heat rejection, full and part load efficiencies and air flow requirements.
      b. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.

D. Warranty
   1. UPS Module: The UPS shall be covered by a full parts and labor warranty from the manufacturer for a period of thirty-six months from date of installation or acceptance by customer or forty-two months from date of shipment from the manufacturer, whichever occurs first.
   2. Battery: The battery manufacturer’s warranty shall be passed through to the final customer and shall have a minimum period of one year.

E. Maintenance, Accessibility and Self Diagnostics
   1. All UPS subassemblies, as well as the battery, shall be accessible from the front. UPS design shall provide maximum reliability and minimum MTTR (mean time to repair). To that end, the UPS shall be equipped with a self-test function to verify correct system operation. The self-test function shall identify the subassembly-requiring repair in the event of a fault. The electronic UPS control and monitoring assembly shall therefore be fully microprocessor based, thus doing away with all potentiometer settings. This shall allow:
   2. Auto-compensation of component drift;
   3. Self-adjustment of replaced subassemblies;
   4. Extensive acquisition of information vital for computer-aided diagnostics (local or remote);
   5. A socket for connection to a computer-aided diagnostics system.
   6. The UPS shall be repairable by replacing standard subassemblies requiring no adjustments or settings. Communication with a remote maintenance system shall be possible.

F. System Description and Operation
   1. Manufacturer(s): The specified equipment shall be manufactured by American Power Conversion (APC) in compliance with specifications. Liebert or Mitsubishi are approved equals.

2. UPS Design Requirements.
   a. Output Power Continuous Rating: The continuous output power rating of the UPS shall be shall be 24KW/30KVA at a 0.8 lagging power factor.
   b. Input Voltage: 208 VAC – 25 percent / plus15 percent, 3 phase, 4 wire plus ground.
   c. Output voltage: 208 VAC 3 phase, 4 wire plus ground.
   d. Battery Autonomy: The UPS shall have battery strings such that it shall be capable of operating at full load for 7 minutes at 0.8 PF output at a temperature of 25 degrees Celsius on battery power.
   e. Battery Type: Hot swappable valve regulated sealed lead acid (VRLA).
3. AC Input Characteristics.
   a. Input Frequency: 60 Hz (minus 25 percent to plus 15 percent)
   b. Maximum Input Current at Low Line Voltage: rated amps with 125 percent continuous overload.
   c. Input Power Factor: > .98 lagging for loads greater than 50 percent and > .95 for loads greater than 15 percent.
   d. Harmonic Distortion of Input Current Wave Form: less than 5 percent at full load.
   e. Power walk-in: Linear 0 to 100 percent over a 15-second period.
   f. Magnetizing Inrush Current: Less than nominal input current for less than one cycle.
4. AC Output Characteristics.
   a. Voltage Regulation: plus 1.0 percent for balanced load; plus 1.75 for 50 percent unbalanced load; plus 2.5 percent for 100 percent unbalanced load
   b. Frequency: 60 Hz plus 1 percent (or selectable up to 4 percent). 60 Hz plus 0.1 percent when free running.
   c. Voltage Distortion: Maximum two percent total (THD) and one percent any single harmonic on 100 percent linear loads.
   d. Voltage Transient (Step Load) Response:
      plus 3 percent for 50 percent step load change

      plus 5 percent for 100 percent step load change

      plus 1 percent for loss or return of AC input power or manual transfer at full load.
   e. Voltage Recovery Time: Return to within one percent of nominal value within 50 milliseconds.
   f. Phase Angle Displacement: 120 degrees plus one degrees for balanced load; 120 degrees plus .3 degrees degrees for 100 percent unbalanced load
   g. Non-Linear Load Capability: Output voltage total harmonic distortion shall be less than three percent when connected to a 100 percent non-linear load with a crest factor not to exceed 3.0.
   h. Slew Rate: 1 Hz/second maximum (or selectable up to 2.0 Hz/sec).
   i. Power Factor: 0.8 at the rated volt-amperes (VA)
   j. Inverter Overload Capability:
      120 percent of rated load for 1 minute

      145 percent of rated load for 30 seconds
   k. Bypass Overload Capability: > 800 percent for 500 milliseconds, 125 percent continuous.
   l. Overall AC to AC efficiency with fully charged battery 93.5 percent at full load and 92.5 percent at 50 percent load.
5. DC Bus.
   a. Normal DC voltage 192VDC.

b. Maximum DC current at cutoff voltage will be 29 A.

c. End of discharge 152VDC

6. Modes of Operation.
The UPS module shall be designed to operate as a double conversion, on-line reverse transfer system in the following modes.

a. Normal: The input converter and output inverter shall operate in an on-line manner to continuously regulate power to the critical load. The input and output converters shall be capable of full battery recharge while simultaneously providing regulated power to the load for all line and load conditions within the range of the UPS specifications.

b. Battery: Upon failure of the AC input source, the critical load shall continue being supplied by the output inverter, which shall derive its power from the battery system. There shall be no interruption in power to the critical load during both transfers to battery operation and retransfers from battery to normal operation.

c. Recharge: Upon restoration of the AC input source, the input converter and output inverter shall simultaneously recharge the battery and provide regulated power to the critical load.

d. Static Bypass: The static bypass shall be used to provide transfer of critical load from the Inverter output to the bypass source. This transfer, along with its retransfer, shall take place with no power interruption to the critical load. In the event of an emergency, this transfer shall be an automatic function.

e. Internal Mechanical Bypass: As a standard feature, the UPS shall be equipped with an internal, make before break, bypass switch. This switch shall mechanically bypass the UPS for times where maintenance is required.

7. Component Description.

a. Rectifier / Battery Charger
The input power converters of the system shall constantly control the power imported from the mains input of the system, to provide the necessary UPS power for precise regulation of the DC bus voltage, battery charging, and Main Inverter regulated output power.:

1) Soft-Start Operation: As a standard feature, the UPS shall contain soft-start functionality, capable of limiting the input current from 0-100 percent of the nominal input over a default 15 second period, when returning to the AC utility source from battery operation. The change in current over the change in time shall take place in a linear manner throughout the entire operation. (di/dt= constant)

2) Input Current Total Harmonic Distortion: The input current THDI shall be held to 5 percent or less at full system, while providing conditioned power to the critical load bus, and charging the batteries under steady-state operating conditions. This shall be true while supporting loads of both a linear or non-linear type. This shall be accomplished with no additional filters, magnetic devices, or other components.

3) The input converter shall control and limit the input current draw from utility to 150 percent of the UPS output. During conditions where input current limit is active, the UPS shall be able to support 100 percent load, charge batteries at 10 percent of the UPS output rating, and provide voltage regulation with mains deviation of up to +/-15 percent of the nominal input voltage

4) Modular Assembly: The rectifier/battery charger assembly shall be constructed of modular design to facilitate rapid maintenance.

5) Charging Levels: The battery charging shall keep the DC bus float voltage of +/- 220v, +/- 1 percent.

6) Battery Charge Current Limit: The UPS shall be capable of limiting the energy sourced from the mains for purposes of battery charging. As a default setting, the battery charge energy will be set to 100 percent of its nominal value. When signaled by a dry contact, (such as from an emergency generator) the UPS shall be capable of limiting the battery charge energy taken from the mains. This shall take place in user selectable increments of 75 percent, 50 percent, 25 percent, 10 percent and 0 percent of the nominal charge power. The selection shall be made from the UPS front panel display/control unit.

7) Temperature Compensated Charging: The battery charger shall be equipped with a temperature probe to enable temperature compensated charging and adjust the battery float voltage to compensate for the ambient temperature using a negative temperature coefficient of 3 mV per cell per degree Celsius at a nominal temperature of 25 degrees C.
8) Capacity: The rectifier/battery charger shall have sufficient capacity to support a fully loaded inverter and fully recharge the battery to 95 percent of its full capacity within 6-8 hours.

b. Inverter.
The UPS output shall be derived from a Pulse Width Modulated (PWM) IGBT inverter design. The inverter shall be capable of providing the specified precise output power characteristics (specified in section 2.2.C) while operating over the battery voltage range. The inverter assembly shall be constructed as a modular assembly to facilitate rapid maintenance.

c. Static Bypass.
As part of the UPS, a system static bypass switch shall be provided. The system static bypass shall provide no break transfer of the critical load from the Inverter output to the static bypass input source during times where maintenance is required, or the inverter can not support the critical bus. Such times may be due to prolonged or severe overloads, or UPS failure.

8. Uninterrupted Transfer: The static bypass transfer switch shall automatically cause the bypass source to assume the critical load without interruption after the logic senses one of the following conditions:
   a. Inverter overload exceeds unit's rating.
   b. Battery protection period expired and bypass current is available.
   c. Inverter failure.
9. Interrupted Transfer: If the bypass source is beyond the conditions stated below, the UPS will make an interrupted transfer (not less than 500 msec. in duration).
   a. Bypass voltage greater than plus 10 percent, -10 percent from the UPS rated output voltage.
   b. Bypass frequency greater than plus 2 Hz from the UPS rated output frequency.
10. Automatic Uninterrupted Forward Transfer: The static bypass transfer switch shall automatically forward transfer power from the bypass to the rectifier / inverter, without interruption, after the UPS inverter is turned "ON", after an instantaneous overload-induced reverse transfer has occurred and the load current returns the UPSs nominal rating or less.
11. Manual Transfer: A manual static transfer shall be initiated from the UPS Control Panel by turning the UPS inverter off.
12. Overload Ratings: The static bypass transfer switch shall have the following overload characteristics after which time a thermal protection device will engage to protect the static bypass.
    a. 800 percent of UPS output rating for 0.5 seconds (one cycle).
    b. 150 percent for 30 seconds.
    c. 125 percent of UPS output rating continuous.
13. Microprocessor Controlled Logic.

    The full UPS operation shall be provided through the use of microprocessor controlled logic. All operation and parameters are firmware controlled, thus eliminating the need for manual adjustments or potentiometers. The logic shall include a self-test and diagnostic circuitry such that a fault can be isolated down to the printed circuit assembly or plug-in power assembly level. Every printed circuit assembly or plug-in power assembly shall be monitored. Diagnostics shall be performed via a PC through the local diagnostics port on the UPS.

14. Standard Communication Panel.
    The UPS will include a standard easy to use communication panel. Included will be a backlit, color graphic animated LCD display, LED's and audible indicators for UPS On line, UPS fault, UPS on battery and UPS off line. The UPS communication panel will include UPS "ON" and UPS "OFF" pushbuttons that will permit the user to safely command the UPS on or off without risk of load loss.

G. System Controls and Indicators

1. Display Unit: A microprocessor controlled display unit shall be located on the front of the system. The display shall consist of an alphanumeric display with backlight, an alarm LED, and a keypad consisting of pushbutton switches. The following metered data, shall be available on the alphanumeric display:
    a. Measurements, status indications and events.
    b. Bar-graphs and waveforms of the measured values.
    c. Personalization menu protected by a password, used to make specific settings.
    d. Event log with time stamping.
    e. Access to all measurements.
    f. System Parameters Monitored (data displayed): The visual display will display the following system parameters based on true RMS metering:
    g. Measurements:
        1) Year, Month, Day, Hour, Minute, Second of occurring events.
        2) Source Input Voltage
        3) Input Frequency
        4) Output AC voltage
        5) Output AC current
    h. Status indications and events:
        1) Static bypass switch on
        2) EPO Active
        3) Mechanical bypass activated
        4) External bypass switch (Q3) activated
        5) Battery discharged
        6) Return from low battery
        7) Low battery
        8) Load not powered from UPS
        9) UPS in bypass
        10) Runtime calibration aborted
        11) Runtime calibration started
        12) Runtime calibration complete
        13) Battery self test aborted
        14) Battery self test started
        15) Battery self test completed
        16) Number of battery modules decreased
        17) Number of battery modules increased
        18) Fan fault
        19) SBS fault
        20) System not in sync.
        21) Bypass not available, frequency/voltage out of range
        22) Mains voltage/frequency out of range
        23) Site wiring fault
        24) Low battery voltage shut down
        25) Defective battery detected
        26) Runtime is below alarm threshold
        27) Load is above alarm threshold
        28) Battery over-voltage warning
        29) Battery over-temperature warning

30) Emergency power supply fault
31) Output overloaded

i. Display of operating curves: The graphical display shall be capable of displaying curves and bar graphs of the above-mentioned measured values for significant periods.

j. Time-stamped historical events: This function shall time-stamp and store all important status changes, anomalies and faults and make this information available for automatic or user-requested consultation; it shall interpret the events and indicate remedial measures if applicable.

2. Controls: The following controls or programming functions shall be accomplished by use of the display unit. Pushbutton membrane switches shall facilitate these operations.
   a. Silence audible Alarm
   b. Set the alphanumeric display language
   c. Display or set the date and time
   d. Enable or disable the automatic restart feature
   e. Transfer critical load to and from static bypass
   f. Test battery condition on demand
   g. Set intervals for automatic battery tests
   h. Adjust set points for different alarms
   i. Program the parameters for remote shutdown.
3. Front Panel Interface: The following shall make up the UPS front panel user interface.

   Load On — When Green, this LED indicates the load is being supported by the UPS output

   On Battery — When Yellow, this LED indicates the UPS is running from Battery power

   Bypass — When Yellow, this LED indicates the load is being supported by static bypass/mechanical bypass

   Bypass — When Yellow, this LED indicates the load is being supported by static bypass/mechanical bypass
4. Push Button User Controls
   a. Up Arrow
   b. Down Arrow
   c. Help Key
   d. Escape Key
   e. Enter Key
5. Emergency Power Off (EPO): The UPS shall be equipped with a local emergency power off button and dry contact input that can be used to command UPS shut down remotely. Activation of this command shall lead to the following actions:
   a. inverter shutdown
   b. opening of the static bypass switch and the battery circuit breaker
   c. opening of an isolated dry contact on the programmable relay board
6. RJ-45 Interface port for remote communications with a network via web browser or SNMP, or APC InfraStruXure Manager. Provide Communication card and software licenses to perform Advanced power actions including but not limited to Load shedding, shutdown of targeted virtual machines, migrate virtual machines to targeted hosts, Automatic VM group assignment, Shutdown VMware vApp, Automate VMware SRM Recovery plan, Fully virtualized cluster shutdown, and VMware vSAN shutdown.

7. Dry Contacts: The UPS shall be provided standard with a programmable input/output relay board. This board shall have eight dry contacts, i.e. six for input signals and two for output signals. Contacts shall be programmed as:
    a. Low battery
    b. Load on battery power
    c. Load on automatic bypass
    d. Load on UPS
    e. Common Fault
    f. UPS Off
    g. The contacts will be programmable normally open or normally off and will change state to indicate the operating status. The contacts will be rated at 2.0 A (250 VDC / 30 VDC).

H. Mechanical Design and Ventilation
1. Enclosure: The UPS shall be housed in a freestanding enclosure with dead front construction. The mechanical structure of the UPS shall be sufficiently strong and rigid to withstand handling and installation operations without risk. Access to UPS subassemblies shall be through the front or top. The sheet-metal elements in the structure shall be protected against corrosion by a suitable treatment, such as zinc electroplating, bichromating, epoxy paint or an equivalent.
2. Cable Access: The standard UPS shall accommodate top or bottom entry cables.
3. Cabinet Weights and Dimensions: The width of the UPS System is 32.8 (in Inches) and has an approximate weight of 1050 lbs.
4. Ventilation and Heat Rejection: The UPS shall be designed for forced air-cooling. Air inlets shall be provided from the front bottom of the UPS enclosure. Air exhaust shall be from the top rear portion of the unit. Full load heat rejection is 4777 BTU /hour.

I. Battery
1. The UPS battery shall be of modular construction made up of user replaceable, hot swappable, fused, battery modules. Each battery module shall be monitored to determine the highest battery unit temperature for use by the UPS battery diagnostic, and temperature compensated charger circuitry.
2. The battery jars housed within each removable battery module shall be of the Valve Regulated Lead Acid (VRLA) type.
3. The UPS shall incorporate a battery management system to continuously monitor the health of each removable battery module. This system shall notify the user in the event that a failed or weak battery module is found.

J. Accessories
1. External Control and Communications Devices
2. The following control and communications devices shall be provided in the UPS module.
3. Network Adaptor:
   The Ethernet Web/SNMP Adaptor shall allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP network environments. The management information base (MIB) shall be provided in DOS and UNIX "tar" formats. The SNMP interface adaptor shall be connected to the UPS via the RS232 serial port on the standard communication interface board.

   The UPS, in conjunction with a network interface card, shall be capable of gracefully shutting down one or more operating systems during when the UPS is on reserve mode.

   The UPS shall also be capable of using an RS232 port to communicate by means of serial communications to gracefully shut down one or more operating systems during an on battery situation.

4. Remote UPS Monitoring
   The following three methods of remote UPS monitoring shall be available:

   Web Monitoring: Remote monitoring shall be available via a web browser such as Internet Explorer.

   RS232 Monitoring: Remote UPS monitoring shall be possible via either RS232 or contact closure signals from the UPS.

   Simple Network Management Protocol (SNMP): Remote UPS Monitoring shall be possible through a standard MIB II compliant platform.

K. Factory Assisted Start-Up

Factory trained service personnel shall perform the following inspections, test procedures, and on-site training:

1. Visual Inspection:
   Inspect equipment for signs of damage.

   Verify installation per manufacturer's instructions.

   Inspect cabinets for foreign objects.

   Inspect Battery Units.

   Inspect Power Module(s).

2. Mechanical Inspection:
   Check all UPS and external maintenance bypass cabinet internal power wiring connections.

   Check all UPS and external maintenance bypass cabinet terminal screws, nuts, and/or spade lugs for tightness.

3. Electrical Inspection:
   Verify correct input and bypass voltage.

   Verify correct phase rotation of all mains connections.

   Verify correct UPS control wiring and terminations.

   Verify voltage of all battery modules.

   Verify neutral and ground conductors are properly landed.

4. Site Testing:
   Ensure proper system start-up.

   Verify proper firmware control functions.

   Verify proper firmware bypass operation.

   Verify proper maintenance bypass switch operation.

   Verify system set points.

   Verify proper inverter operation and regulation circuits.

   Simulate utility power failure.

   Verify proper charger operation.

   Document, sign, and date all test results.

5. On-Site Operational Training: During the factory assisted start-up, operational training for site personnel shall include key pad operation, LED indicators, start-up and shutdown procedures, maintenance bypass and AC disconnect operation and alarm information.

L. Field Quality Control and Service Organization

1. Field Service Engineer Qualifications

   The manufacturer must employ a Seven by 24 nation wide field service organization with rapid access to all regions of the nation. The responding service professionals must be factory-trained engineers with an accredited and proven competence to service three phase UPS systems.

2. Spare Parts

   Field Engineers must have immediate access to recommended spare parts with additional parts storage located in regional depots. Additional spare parts shall be accessible on a Seven by 24 basis from the national depot and must be expedited on a next available flight basis or via direct courier (whichever mode is quickest).

3. Maintenance Training

   The manufacturer shall make available to the customer various levels of training ranging from basic UPS operation to UPS maintenance.

4. Maintenance and Service Contracts

   The manufacturer shall offer additional preventative maintenance and service contracts covering both the UPS system and the battery bank. Accredited professional service engineers, employed exclusively in the field of critical power systems service shall perform all maintenance and service. The manufacturer shall also offer extended warranty contracts.

2.30 PLATFORM/THEATER EQUIPMENT

A. Definitions of terms:

1. The term Electrical Contractor as used herein, refers to the organization, individuals and their representatives who shall provide the conduit, wire, back boxes, high voltage installation and labor, the stage dimming and control equipment, stage lighting fixtures, accessories provide low voltage wire, termination's and system programming. Division 26 work relating to this specification shall be coordinated through the Electrical Contractor.
2. The term Owner and Architects as used herein refer to the organization(s), Individuals and their representatives as typically defined.
3. Technical terms peculiar to stage, audience, special lighting and related work shall be construed in the following order, in accordance with:
   a. Verification of dimensions and conditions in contract documents prior to equipment installation.
   b. Captions on related drawings.
   c. General recognized theatrical usage.
   d. Relevant usage and definitions of handbooks, guidebooks, or trade-group

B. Scope:

1. Provide Dimming and Control equipment, Stage lighting fixtures, Accessories, Circuit distribution, hang and focus light plots as shown in the plans.
2. Due to the complexity of this project and the specific combination of equipment and services required for a professional installation, equipment in this specification shall be purchased from a qualified Theatre Equipment Contractor.
3. This is a single source specification, one Electrical Contractor shall be responsible for supplying the stage dimming and control equipment, Project management, Stage lighting fixtures, focusing and programming of the system prior to Owner's possession.
4. The Electrical Contractor shall be responsible for supervising the installation of the dimming and control equipment. Specifically; provide a full time Project Manager, to schedule shipments of equipment, coordinate deliveries, answer system inquiries, and generally oversee the installation of the Dimming and Control equipment, and stage lighting.

5. The Manufacturers shall furnish, in conjunction with the Electrical Contractor, the following services:
    a. System rough in wiring and installation shall be made according to Manufacturer's instructions and wiring diagrams.
    b. Verification of dimensions and conditions in contract documents prior to equipment installation.
    c. Schedule coordination and shipping to job site.
    d. Termination of all low voltage control wire.
    e. Inspection and adjustment of completed installation by Factory Authorized personnel.
    f. Programming of House lighting control system.
    g. Two sets of shop drawings, one electronic copy in PDF format.
    h. Turn-on/Energization of the theatrical dimming system, initial programming of house lighting control system and training of all theatrical components.
    i. Installation of dimming modules and house light control faceplates.
    j. Coordination with associated trades in the field.
    k. Submission of recorded drawings, service and operational data, test certificates and warranties. Provide two copies of all operations manuals and two copies on USB.

C. Standards
1. All applicable requirements of The Commonwealth of Massachusetts govern work in this Specification.
2. All Equipment and work shall comply with NEC, NEMA and ANSI codes and standards.
3. All Equipment shall be UL/ETL listed. Proof of listing shall be provided.
4. All Equipment shall be New in the box with full factory warranty. Used or refurbished equipment is not allowed.
5. To insure uniform installation and single responsibility, all stage dimming and control equipment shall be the products of one dimming manufacturer to allow for seamless integration of all components; complete with all required wall plates, control stations, devices or accessories.
6. Catalog designations of ETC are referenced herein to establish standards of design, function and quality. Bidders submitting alternate equipment shall meet or exceed the performance standards as listed by these manufacturers in catalogs and data sheets.
7. The Electrical Contractor’s service technician shall be capable of responding to a service request within eight hours of notification.
8. System apparatus, conduit and wiring shown on drawings are for estimating purposes only. Actual work will depend on furnished product’s Manufacturer’s standards. It is the submitting Electrical Contractor's responsibility to ascertain Manufacturer's requirements prior to bidding. No claim or extra charge will be accepted for any variation from data shown on drawings or descriptions in specifications.
9. System rough in wiring and installation shall be made according to Manufacturer's instructions and wiring diagrams.

D. Description of Work
1. It is the intent of this specification to provide a complete Stage Lighting system as specified and enumerated herein and on the drawings, including delivery F.O.B. job site and installation.
2. All components, consoles, racks and devices, shall be complete and functioning units internally wired, complete to numbered terminal strips to facilitate connection to the building wiring system.
3. Where devices and material are mentioned by name and/or model number, it shall be interpreted as referring to that particular item as completely specified in the manufacturer's published data as though that data and literature were printed herein in their entirety.

4. Any cabinets, racks, or other components which shall be separated from contiguous parts to enable shipment and/or handling at the site shall be furnished complete with all necessary connecting hardware, buss bars and wire jumpers to provide a complete, functioning system when reassembled in the building.
5. Check actual site conditions, ceiling support positions and openings by accurate field measurements before fabrication; show recorded measurements on final shop drawings.
6. The Electrical Contractor shall provide and terminate all low voltage system control devices.
7. The Electrical Contractor shall provide the dimming system energization and two printed copies of all system manuals along with two copies on USB including all system warranties, flame certificates and as-built record drawings.
8. The Electrical Contractor shall set DMX assignments and aim all stage lighting fixtures specified herein, shown on the drawings or on a Light Plot provided by the Architect or Architect's Representative.
9. Demonstrate the stage lighting fixtures in the presence of the Owner or Architect or Architect's Representative, proving them to be operating properly and provide instructions in the use and in the Owner performed maintenance of the fixtures and accessories.
10. Provide one additional, four hour training period separate from the Manufacturer's demonstration and offered at the convenience of the Owner's schedule, for lighting console training, fixture operation and dimming system maintenance procedures. Owner will be permitted to video record training sessions at Owner's expense.

E. Work Included
1. The work of this section shall be contracted to a single firm, referred to as the Electrical Contractor.
2. The Electrical Contractor shall examine the plans and specifications in detail to familiarize him or herself with the scope of work.
3. The Electrical Contractor shall furnish all equipment specified herein and shown on the drawings, including low voltage control wire per the dimming manufacturer. Furnish the stage lighting fixtures and accessories as enumerated in the specifications.
4. The Electrical Contractor shall provide and terminate all low voltage system control devices.
5. The Electrical Contractor shall provide the dimming system energization and two Printed copies of all system manuals along with two copies on USB including all system warranties, flame certificates and as-built record drawings.
6. The Electrical Contractor, set DMX assignments and aim all stage lighting fixtures specified herein, shown on the drawings or on a Light Plot provided by the Architect or Architect's Representative.
7. Demonstrate the stage lighting fixtures in the presence of the Owner or Architect or Architect's Representative, proving them to be operating properly and provide instructions in the use and in the Owner performed maintenance of the fixtures and accessories.
8. Provide one additional, four hour training period separate from the Manufacturer's demonstration and offered at the convenience of the Owner's schedule, for lighting console training, fixture operation and dimming system maintenance procedures. Owner will be permitted to video record training sessions at Owner's expense.
9. Furnish and Install lighting control systems as specified for the Stage and focus of theatre lighting.
10. Provide a full time project manager to coordinate the construction schedule and other services listed in this Section.

F. Products/Manufacturers
1. The Products are specified based on the following equipment criteria:

Manufacturer	Item
ETC	Stage Dimming, Lighting control,

Or equal

ETC Two Circuit Track and stage lighting Fixtures

Or equal

G. Submittals Due
   1. Manufacturer Submit all items as may be required under the General Conditions and this Specification.
   2. Submit within 6-8 week of bid acceptance for review and approval by the Architect or Architect's Representative; one complete electronic set of shop drawings, riser diagrams, detailed parts list, and pin configurations.
   3. Complete product descriptions including any changes required in the wiring schematic shown on the bid drawings to connect the proposed system into the building. Proposals, which do not provide adequate data for product evaluation and installation criteria, shall not be considered.
   4. Catalog Cuts: In lieu of drawings, the Electrical Subcontractor may submit catalog cuts for standard equipment items. These shall contain full information on dimensions, construction, and application to permit proper evaluation. In addition, they shall be properly identified as to their intended use, included accessories, and lamps. Any options or variations shall be clearly noted.
   5. Indicate all variations from these specifications on submittal drawings.
   6. Prior to the commencement of fabrication and delivery, the Electrical Contractor shall submit for approval to the Architect, an outline of a proposed commencement and completion schedule of the project requirements.

H. Workmanship
   1. The fabrication of all equipment shall incorporate only new and unused materials. This includes all metal components in various shapes required such as plate, bar, rod, castings, structural, stampings, forging, clamps, bolts, and all other accessories not mentioned.
   2. The mechanical fabrication and workmanship shall incorporate neat and mechanically acceptable practices such as clean drilled and punched holes without flash; hand smooth finish for all sheared, machined, and cut edges; and proper fit of component and contiguous parts without irregularity where matching is intended. Welding shall meet qualifications of AWS D1, 1-81 and shall be without spatter and other evidence of poor practice. All bolts and rivets shall be sized and located in conformity with minimum acceptable standards as set forth in the Machinery's Handbook and all revisions to date.
   3. All moving parts shall have acceptable tolerances, mountings, connections, and accessories coordinated into the system in a manner approved by the Architect. No wood construction or equipment shall be incorporated into the system excepting as may be set forth in the specifications.
   4. All electrical and electronic parts and components selected and installed shall be consistent with good practice and conservatively rated in their use in the circuit design. Each piece of equipment shall meet accepted basic engineering standards.
   5. All low voltage control wire runs shall be one continuous run. No splices are permitted.

I. Field Engineering Services
   1. Manufacturer shall furnish engineering assistance during delivery and installation to the Electrical Contractor. A factory qualified Field Service Technician shall check the installation prior to initial energization of the system. The Field Service Technician shall supervise initial turn-on and shall make or cooperate with the Electrical Contractor in making any required adjustments or trimming of components to enable the system to function as specified.
   2. The Field Service Technician shall be fully experienced in the programming requirements of both theatrical and architectural controllers and shall assist the Owner with all necessary on-site programming.

3. The Field Service Technician shall demonstrate the system in the presence of the Owner and the Architect or Architect's Representative, proving it to be operating properly. Provide instructions in the use and in the Owner performed maintenance of the system.
4. Provide Instruction in system operation, lighting control console programming and system maintenance on two separate occasions. These instruction sessions shall be a minimum four-hour period separate from the manufacturers training demonstration and offered at the convenience of the Owner's schedule.
5. Provide time and manpower to verify that all stage lighting circuits are properly wired by moving stage lighting fixtures from receptacle to receptacle during the system energization.

J. Testing
1. Manufacturer Standard factory tests of Manufacturer's equipment shall be performed and two typewritten copies submitted to the Architect for record purposes.
2. Provide for final adjustments to systems, the adjustments shall accomplish at least the following:
   a. Provide smooth, continuous light level control from zero percent light output through full light output for both increasing and decreasing light levels.
   b. Limit dimmer output voltage to incandescent circuits of house lighting to between 90 and 95 percent of the rated lamp voltage.
   c. Eliminate all radio frequency interference.
3. During testing and adjustment of the systems it will be necessary to rearrange portable fixtures from circuit to circuit in order to test each dimmer outlet for compliance with operating requirements.

K. Underwriters Laboratories
1. All equipment and components shall be approved and listed by U/L where applicable standards have been established. This approval applies specifically but is not limited to Dimmers, Dimmer and Power Racks, Breaker Panels, Devices, and Fixtures.
2. All equipment and materials shall be manufactured and tested in accordance with the applicable portions of the latest editions of ANSI, NEC, NEMA, U/L, ASA, AIEE, and IPECA standards.

L. Notification
1. Upon notification of completion of work, the Architect or Architect's Representative will run tests on the Lighting and Rigging system. If any problem arises during the tests, the Theatre Equipment Contractor shall correct the problem within 5 working days.

M. Warranty
1. All systems, including all parts and labor, shall be under full warranty for a period of not less than two years from the date of written final acceptance. In the event that any of the equipment should fail to produce capacities or meet design characteristics as specified, it shall be replaced with equipment that will meet requirements without additional cost. After occupancy, any necessary work performed shall be done at the convenience of the Owner's operational schedule, including overtime, if required.
2. Two signed copies of the above are required as a condition for final approval of the work.

N. Network Rack containing 4-Port DMX Gateway and 8-Port Simple Network Switch
1. Mechanical
   a. Equipment Frames (Racks) Low-Profile Wall Mount
      1) Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
         a) Legrand
         b) APC
         c) Cooper B-Line, Inc.
         d) Hubbell Premise Wiring.

e) Panduit
f) Or equal

2) General Frame Requirements:
a) Distribution Frames: wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
b) Module Dimension: Width compatible with EIA 310 standard, 19-inch panel mounting.
c) Finish: Manufacturer's standard, baked-polyester powder coat.
d) Provide Legrand WRS-8 Series low profile vertical equipment rack or equal.

3) EIA compliant 19 inch low-profile wall mount rack shall be Middle Atlantic Products model # WRS-8 (refer to chart). Body and back pan of rack shall be constructed of 18-gauge steel, rack rail shall be 11-gauge steel with threaded 10-32 holes in universal EIA spacing and accommodate eight useable rack spaces, mounting brackets shall be 14-gauge steel, hinged top shall be 16-gauge steel, hinged top and center section shall be locking and separately keyed. Rack shall be phosphate pre-treated and finished in a durable black powder coat. Weight capacity shall be 150 lbs. Electrical knockouts in back pan shall accommodate ½ inch and 1-1/2 inch conduit, laser knockout on back pan shall accommodate larger cable bundles. Rack shall be of fully welded construction. WRS/ WRP Series racks shall be UL Listed in the US and Canada. WRS/WRP Series shall be GREENGUARD Gold Certified. WRS/WRP Series shall be RoHS EU Directive 2011/65/EU compliant. WRS/WRP shall be manufactured by an ISO 9001 and ISO 14001 registered company. WRS/WRP shall be warrantied to be free from defects in material and workmanship under normal use and conditions for the lifetime of this product.

4) Provide optional bonding kit for UL-2416 (NWIN) compliance shall be Middle Atlantic Products PET-K-WRP/S

2. Thermal
a. Ambient room temperature: 0-40 degrees C / 32-104 degrees F
b. Ambient humidity: 10-90 percent non-condensing

O. DMX/RDM Ethernet Gateway – Four Port
1. General
a. The lighting control gateway shall be a microprocessor-based unit specifically designed to provide DMX512 control of lighting systems and transport of RDM configuration and status messages. The gateway shall permit DMX512-A data to be encoded, routed over an Ethernet network and decoded back to DMX512-A. The unit shall be a DMX/RDM 4-port Gateway as provided by ETC, Inc.
b. Gateways shall communicate over Ethernet directly with at least ETC, Inc.’s entertainment and architectural lighting control products and other Ethernet interfaces.
c. Connections shall be made between gateways, consoles, architectural systems, and PCs over standard Ethernet distribution systems using 10/100BaseT.
d. The gateway shall support multiple protocols including:
1) ANSI E1.17 Architecture for Control Networks (ACN)
2) ANSI E1.31 Streaming ACN (sACN)
3) ANSI E1.11 USITT DMX512-A
4) ANSI E1.20 Remote Device Management (RDM)
e. The gateway shall be RoHS Compliant (lead-free).
f. The gateway shall be CE compliant.
g. The gateway shall be tested to UL standards and labeled ETL Listed.
h. The gateway shall have a backlit graphic LCD display for identification (soft-labeling) and status reporting.

1) Labeling shall be user configurable using ANSI E1.17 Architecture for Control Network (ACN), or a purpose built software configuration tool.
2) The LCD display shall show DMX port configuration indication as well as indicate the presence of valid signal.
3) Gateways that do not indicate port configuration (input/output) and valid data shall not be acceptable.

i. Each gateway shall have power and network activity LEDs on the front of the gateway

2. DMX Ports
   a. DMX Ports shall comply with the requirements of ANSI E1.11 USITT DMX512-A standards.
   b. Each DMX port shall be software-configurable for either input or output functionality.
   c. DMX input shall be optically-isolated from the gateway electronics.
   d. DMX output shall be earth-ground referenced.
   e. DMX Port shall be capable of withstanding fault voltages of up to 250vAC without damage.
   f. Each port shall incorporate one DMX512-A Connection
      1) Each DMX port of the portable unit shall be modular and hot swappable
      2) Each DMX port location shall support a single 5-pin male XLR, 5-pin female XLR, EtherCON RJ-45, or terminal strip module for DMX wiring.
   g. Network gateways that do not indicate input/ output port configuration or presence of valid data shall not be accepted
3. Processor
   a. Each gateway shall have sufficient processing power to manage up to 63,999 universes (32,767,488 addresses).
   b. Maximum delay time from input to output shall not be greater than one packet time (approximately 22 mSec.).
   c. A minimum DMX update rate of 40Hz shall be sustained under all conditions unless specifically configured for a slower rate for the sake of compatibility with third party DMX devices.
4. Mechanical
   a. Rack-Mount/Portable
      1) The Gateway shall be fabricated of 16-gauge steel, finished in fine-texture, scratch-resistant, black powder coat (RAL 9004).
      2) Dimensions shall be 22 cm wide by 20 cm deep by five cm high.
      3) The weight of the gateway shall be 3.5 lbs. (1.6 kg) with four DMX modules. An individual module shall weight no more than 0.1 kg).
      4) The gateway shall support table top use
   b. Optional accessories for rack-mount and pipe applications shall be available from the manufacturer. These accessories shall support installation by an end-user
5. Power
   a. Power for the gateway shall be provided over the Category 6a (or better) cable, utilizing IEEE 802.3af compliant Power over Ethernet (PoE). Power consumption using shall not be greater than 5 watts.
   b. An optional low-voltage DC power input shall be available utilizing an isolated in-line power supply capable of an operating range of 8-28vDC. The Power supply shall be provided by the gateway manufacturer.
   c. The gateway electronics shall be electrically isolated from the power supplied over the Category 6a (or better) cable.
6. Configuration
   a. Each gateway on the network shall be individually configurable using freely available software configuration tools. The primary configuration tool shall be Net3 Concert configuration software running on a network connected PC. The PC shall only be required

for configuration, and shall not be required for normal operation of the system.

b. Each DMX gateway shall control up to 512 DMX addresses, within the confines of 63,999 universes.
c. The specific DMX data input or output by the gateway shall be freely configurable by the user.
d. Duplicate outputs of DMX lines (DMX splitter) and discrete outputs shall be fully supported.
e. Multiple DMX universes may be configured with any length up to 512 total addresses. Any range of DMX input addresses shall support selection and routing to the specified sACN output.
f. Multiple sACN sources may be combined with a priority may be assigned to each source sending data to the gateway
g. All relevant routing information shall be stored in non-volatile memory at each gateway. The system shall recover from a power outage without requiring the PC to be online. Gateways that do not support non-volatile storage of data routing shall not be accepted.

7. Network
   a. Communications physical layer shall comply with IEEE 802.3i for 10BASE-T, 802.3u for 100BASE-TX and 802.3af for Power over Ethernet specifications.
   b. All network cabling shall be Category 6a (or better), conforming to TIA-568A/B, and shall be installed by a qualified network installer.
   c. Data transport shall utilize the TCP/IP suite of protocols to transfer the DMX data.
   d. ANSI E1.17 Architecture for Control Networks (ACN) and streaming ACN (sACN) shall be supported. Gateways that do not support ANSI E1.17 shall not be acceptable.
   e. Switches shall comply with power-over-Ethernet IEEE802.3af, unless a separate in-line power supply is provided.
   f. Multiple DMX signal routing patches and multiple facilities shall be supported and limited only by the file storage capacity of the computer with ETC Concert Software, or manufacturer software installed.
   g. Each DMX gateway shall control up to 512 DMX addresses, per DMX port within the confines of up to 64,399 universes (32,767,488 addresses) using Streaming ACN (sACN).
      1) Any range of DMX addresses may be selected for each universe.
      2) Multiple sources shall be supported by prioritized Highest Takes Precedence (HTP with priority). Each source shall support assignment of priority to allow override of default HTP behavior.
      3) Each DMX port shall support its own universe and start address.
   h. Gateways shall have built in DMX merger capability on a universe or channel-by-channel basis.
   i. Gateways shall support built in priority on a per-universe or channel-by-channel basis. Gateways that do not support prioritized merging of multiple network sources at independent priorities shall not be accepted.

8. DMX Connector modules (Rack-Mount/Portable only)
   a. Each gateway shall support up to four connector modules containing a single DMX connector and its associated electronics
   b. Connector module options shall include
      1) 5-pin Male DMX connector for DMX Input
      2) 5-pin female DMX connector for DMX output
      3) RJ-45 EtherCON connector for DMX input or output
      4) Eight position terminal connector for DMX input or output. Terminal connections shall support screw terminals or Insulation displacement (IDC) wire terminations.
   c. Each connector module shall be optically-isolated from the gateway electronics and from other DMX modules in the same gateway.

d. DMX connector modules shall be capable of withstanding fault voltages of up to 250vAC without damage.

9. Environmental
   a. The ambient operating temperature shall be 0 perent to 40 percent Celsius.
   b. The storage temperature shall be -40 degrees to 70 degrees Celsius.
   c. The operating humidity shall be 5 percent - 95 percent non-condensing.
10. Accessories
   a. Hanging bracket kit shall allow unit to be mounted in three orientations.
      1) U-Bolt or C-Clamp mounting hardware shall be available
   b. One E.I.A. rack space mounting bracket kit shall support either one or two complete units and allow for up to eight ports of DMX
   c. Front Access Panel kit shall allow the connectors on the rear of the gateway to be accessed from the front of an equipment rack. Options for 5-pin XLR style connectors that support DMX input or output shall be available
   d. A Universal Power Supply with international plug-set shall be available. Multiple power supplies shall be able to fit in a vertically stacked power strip.
   e. ETC Net3 Concert Configuration and monitoring Software
11. System Requirements
   a. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by Electronic Theatre Controls Inc. of Middleton, WI.
   b. Provide Ethernet switches and power supplies as scheduled and as shown on drawings.
   c. Systems that do not provide the above capabilities shall not be acceptable

P. Dedicated 8-Port Simple Network Switch
1. Manufactures: Subject to compliance with requirements, provide products by one of the following
   a. Cisco Systems
   b. Black Box
   c. Pathway Connectivity Solutions
2. Provide dedicated network switch equipment to support the transmission of Theatrical Lighting control to DMX Gateway with the following functions
   a. Provide the core switch with fiber GBIC cards to support each IDF
   b. Provide each edge switch with a minimum of one fiber GBIC card
   c. RJ-45 10/100/1000Base-T Auto Sensing/Auto negotiating LAN
   d. Connectivity Media: Category 6a Twisted Pair 10/100/1000Base-T
   e. Data Transfer Rate: 10Mbps Ethernet, 100MBPS Fast Ethernet, 1Gbps Gigabit Ethernet
   f. I/O Expansion: Expansion Slots: (two Total) SFP (mini-GBIC)
   g. Performance: 48Gbps Bandwith
   h. Network and Communication: Layer Support: Two
   i. Management and Protocols: SNMP v1, v2, v2c, v3; IEEE 802.1p QoS; IEEE 802.1Q, VLAN; Syslog; RMON
   j. Memory: 3Mb Buffer Memory
   k. Input Voltage: 100 V AC to 240 V AC Power Supply Universal
   l. Power Cord
   m. Rack-Mount Kit
3. Provide an Interface to owners' LAN.

Q. Controls
1. Touchscreen Control Stations
   a. The Touchscreen Control Stations shall be the Unison Echo EchoTouch Controller Mk2 as manufactured by ETC, Inc., or equal.

b. General
    1) The Touchscreen protocols station shall provide control of up to 512 networked addresses or up to 512 local DMX addresses on a maximum of 80 control zones. Addresses may be distributed using DMX512-A or via sACN or Art-Net Ethernet-based lighting.
    2) The Touchscreen station shall operate using graphic buttons, faders and other images on at least seven user programmable control pages.
    3) Touchscreen stations shall support default and fully graphical control pages.
    4) The Touchscreen shall integrate with ETC Unison Echo Controls.
c. Mechanical
    1) Touchscreen stations shall consist of a seven-inch, backlit liquid crystal display (LCD) with a minimum resolution of 800 by 400 pixels with a capacitive multi-touch interface.
    2) Touchscreen bezels shall be constructed of cast aluminum finished in a fine texture powder coat.
        a) Touchscreen shall be available in four standard colors.
            1) Cream (RAL 9001)
            2) Gray (RAL 7001)
            3) Black (RAL 9004)
            4) Signal White (RAL 9003)
        b) The bezel shall have no visible means of attachment
    3) Touchscreen stations shall support surface, flush and rack mounting options.
        a) Flush-mount to industry standard 3-gang back box.
        b) Surface back box dimensions shall be 7.35 in/187 mm wide by 4.88 in/124 mm high by 3.5 in/89 mm deep and available from the manufacturer.
        c) Rack mounting options shall fit in standard 19 inch racks an shall be no taller than 3 EIA rack units.
d. Electrical
    1) The Touchscreen shall have an RJ45 Ethernet port for connection to a lighting system and for Power over Ethernet (PoE).
    2) The Touchscreen shall have an EchoConnect connection terminals.
        a) Control wiring utilizing low-voltage, Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
        b) Control wiring shall be topology free. It may be point-to-point, bus, loop, home run or any combination of these. Control products that require daisy-chain wiring shall not be acceptable.
    3) The Touchscreen shall use two #16 AWG stranded wires for 24 VDC operating power when not utilizing Power over Ethernet (PoE).
    4) The Touchscreen shall have typical power draw of 400mA
    5) The Touchscreen shall have a USB type A connector for firmware maintenance
    6) The Touchscreen shall be cULus Listed and CE Compliant
    7) The Touchscreen shall be FCC Compliant
e. Network
    1) Communications physical layer shall comply with IEEE 802.3i for 10BASE-T, 802.3u for 100BASE-TX and 802.3af for Power over Ethernet specifications.
    2) All network cabling shall be Category 6a (or better), conforming to TIA-568A/B, and shall be installed by a qualified network installer.
    3) Switches shall comply with power-over-Ethernet IEEE802.3af, unless a separate in-line power supply is provided.
f. Functional
    1) System
        a) A maximum of 64 presets shall be contained in non-volatile electronic memory.

b) A maximum of four internal sequences. Sequences shall record user-selected zone levels.
c) The Touchscreen shall be equipped with an on-board help system.
d) The Touchscreen software upgrades shall be made by the user via USB drive. Changing internal components shall not be required.
e) The Touchscreen shall provide a USB port allowing show data to be saved for archival or transfer to other consoles or a personal computer.
f) Systems that do not provide the above capabilities shall not be acceptable.

2) Patching
a) The Touchscreen shall provide patching facilities for dimmers and multi-parameter devices via a built-in library of fixture definitions. The fixture library shall be updated via software based updates. It shall be possible to create custom fixture definitions using an offline application.
b) The Touchscreen shall support patching, address setting, and mode changes using Remote Device Management (RDM) on the local DMX/RDM port.

3) Playback control
a) Customizable zone display using Zone Map. It shall be possible to rearrange the graphical representations for control channels to closely mimic the positions of fixtures in the installation.
b) Seven user customizable interactive pages.
c) Color and white pickers.
d) Touch-based parameter controls with reference-based palettes.
e) Virtual level wheel.

4) Layout and configuration
a) It shall be possible to view and modify the layout of the user pages.
b) It shall be possible to add, remove or edit the following items:
1) Preset Buttons
2) Off Buttons
3) Sequence Buttons
4) Zone and space modifier buttons
5) Space combine buttons
6) Zone Fader
c) There shall be three options for inactivity
1) Dim screen to level
2) Turn screen off
3) Display user chosen inactivity image
d) It shall be possible to have multiple configurations stored within an LCD Station

5) TimeClock
a) The Touchscreen shall have a built-in astronomical and real time event engine allowing the activation of presets and sequences.
1) The system shall support 80 events.
2) The system shall support astronomical, real-time and manual control events in up to 16 control spaces.
b) Timed events shall be programmable via the Touchscreen.
1) TimeClock events shall be assigned to system day types. Standard day types include: everyday, weekday, weekend and day of the week.
2) TimeClock events shall be activated based on sunrise, sunset, time of day, open and closed events and a configurable state based engine.
3) The TimeClock shall automatically compensate for regions using configurable daylight saving time.
4) Presets shall support assignment to events via the TimeClock user interface.
c) Timed events shall resume automatically after power loss.
d) The Touchscreen shall support timed event hold.
1) Timed event hold shall meet California Title 24 requirements.

2. Digital Room Controllers
a. Digital Room Controllers for lighting and pluggable loads shall be the Unison Foundry Mini

Panel by ETC, Inc., or equal

b. Mechanical
   1) Room Controllers shall be constructed from 16AWG steel and finished in a black fine-texture powder paint
   2) The Room Controller shall be no larger than nine inch by 12 inch by 3.5 inch for four zone models or 14 inch by 12 inch by 3.5 inch for eight zone models
   3) Room Controllers shall support wall and ceiling mounting, including installation in Plenum air return spaces
   4) A removable with dead front cover shall be mechanically fastened using by four screws
      a) An optional cover with support for mounting an EchoConnect Time Clock shall also be available
   5) An internal safety cover made of formed 16AWG steel shall prevent access to all line voltage (class1) wiring and components without limiting access to low voltage terminations, changing settings during commissioning, or manual control of relays
   6) Room Controllers shall support onboard configuration without the use of software
      a) A 16 position rotary switch shall assign zones to a space. Spaces one thru 16 shall be available
      b) A 16 position rotary switch shall assign a starting zone number of the room controller. Additional zones will be assigned sequentially thereafter
      c) The Room Controller shall support a contact input for use in UL 924 Emergency Systems
         1) A dry contact input shall provide triggering of an emergency condition
         2) A three position switch shall set the input as Normally Open (NO) Normally Closed (NC), or Off
         3) Load shedding shall be supported via a two position switch per zone, that includes or excludes each zone from the UL924 input
      d) The Room Controller shall support a Demand Response input to automatically reduce overall power consumption
         1) A dry contact input shall be supported to trigger the demand response condition
         2) A single rotary dial shall be available for each to set the maximum trim level when the input is active
      e) The Room Controller shall support a dry contact input to trigger a preset, play back a sequence, trigger room combine, or any other Echo contact input function
         1) A two position switch shall provide selection of momentary or maintained contact functionality
      f) Room Controllers shall provide station bus power for up to six control stations
         1) A two position switch shall allow the internal station bus power supply to be disabled when multiple controllers or external power supplies are used.
      g) All configuration buttons shall be fully accessible when the Room Controller is mounted and the front panel is removed
   7) MicroSD shall be supported for the purpose of software upgrades
   8) Room Controllers shall provide the following LED indicators:
      a) UL924 Active (red)
      b) Demand Response Active (green)
      c) Contact Input Active (green)
      d) Station Power Supply Active (green)

c. Electrical
   1) Power Input shall support 120-277 Volts AC 47-63Hz for control electronics and each independent zone. Daisy Chain of an input to multiple control zones shall be supported
   2) Room Controllers shall provide an optional 20A single-phase normal sense feed input for UL924 Emergency Lighting Control Bypass
      a) The sense feed input is enabled or disabled via a two position switch

b) Digital panels that do not provide an internal normal sense input shall not be acceptable

3) A voltage barrier shall be available to separate normal and emergency circuits or lighting and plug loads when combined in a single controller. The barrier shall be constructed of 94-V-0 plastic.
4) Room Controllers shall provide a 20A, fully rated, latching relay for each output
5) A 0-10V dimming output per zone shall support 0-10V sink control rated for 100mA per output
   a) 0-10V wiring shall be fully isolated from ground within the Room Controller. Controllers without fully isolated 0-10V wiring shall not be acceptable
6) Room Controllers shall support EchoConnect control communications using Class 2 wiring
   a) The control network shall utilize unshielded twisted pair, Belden 8471 or equivalent wire, plus one #14 ESD drain wire (when not installed in grounded metal conduit). Use of Category 6a, or better, control network wiring shall also be supported when utilizing appropriate termination kits available from the manufacturer
   b) The control network shall be topology free supporting wiring in bus, loop, star or any combination of these
7) Room Controllers shall provide 24VDC power output via two 16-26awg screw terminals for power to the optional Timeclock
8) Room Controllers shall provide a three position terminal for power input to the control electronics. The control power input shall accept 6-14AWG wire and be clearly marked Line, Neutral and Earth Ground
9) Each relay shall provide three screw terminals line voltage power connection. Each terminal shall accept 6-14awg wire and be clearly labeled Input, Output and Thru. Controllers that do not support a single power input to multiple discrete relays, in any combination, shall not be deemed acceptable.
10) Room Controllers shall provide wiring connections for a control station bus utilizing 16-26AWG screw terminal connections for signal +, signal-, and ESD ground.
11) Room Controllers shall support 0-10 volt dimming control via terminals 16-26AWG terminals for 0-10V+ and 0-10V common wiring connections
12) Zone Controllers shall support communication with 16 EchoConnect control products and 15 additional Echo output products
13) Room Controllers shall be UL and cUL LISTED and conform to UL 508 and UL 2043 (Plenum rated) standards

d. Functional
   1) Room Controllers shall support automatic configuration to the most energy-efficient control scheme based on other devices installed in the same room or space.
      a) Room Controllers shall support operation in Auto-on/Auto-off, Manual-on/Auto-off and Manual-on/Manual-off modes based on the connected control devices without the need for manual configuration
   2) Upon loss of power, Room Controllers shall return to their last state when power returns
   3) Room Controllers shall be available in 4 or 8 zone configurations with a 20A, fully–rated, relay output and 0-10V dimming output per zone
   4) Room controllers shall support patching of relay and 0-10V dimming outputs to spaces and zones via the EchoAccess mobile app
   5) Room Controllers shall be UL924 LISTED for emergency lighting circuits and shall activate only the selected outputs. Excluded loads shall be shed and not produce output during emergency conditions

6) Room Controllers shall activate a designated Echo control function upon receiving a contact closure on the Contact Input. The Contact Input shall support normally open (NO) maintained, normally closed (NC) maintained or momentary toggle functionality
7) Room Controllers shall support Demand Response input via contact closure. Upon input the controller shall reduce maximum output to 70 percent of peak usage. 0-10V outputs shall support Demand Response maximum level threshold adjustment using a rotary fader, and shall be assignable per circuit while measuring usage
   a) The Room Controller shall support triggering Demand Response of external Echo Power Controllers over the EchoConnect bus
8) Room Controllers shall support commissioning without the use of software or specialty configuration tools. Controllers that require software for configuration shall not be acceptable.

R. Provide the following:

1	ETS-XX	EchoTouch Controller Mk2 7 inch LCD Touch screen with flush mount back box
1	ERMC4-TC-G2	Unison Echo 4-Zone Room Controller
1	C1000-8T-2G-L	Cisco 8-Port Network Switch
1	4260A1113	4-Port DMX Gateway
1		Enclosures for Switch and Gateway

S. Stage Lighting Track and Fixtures
   1. GENERAL REQUIREMENTS
      a. All stage lighting fixtures shall be track mounted, and have two circuit DMX track adapters installed.
      b. Unpack, and focus the stage lighting fixtures in the auditorium according to light plot provided by Architect.

T. Track
   1. General
      a. Track shall be two circuit high quality extruded aluminum with integral data distribution. Track sections shall distribute one 20amp 120 vAC power circuits and shall include integral distribution of DMX-512A control signals to lighting fixtures as manufactured by ETC.
      b. All components of the lighting system shall be UL or ETL listed

U. Fixtures and Accessories
   1. GENERAL
      a. Provide the following Stage Lighting Fixtures with Smart Track Adapter.
   2. PROVIDE THE FOLLOWING;

6	OT12	12 foot surface mount ETC OneTrack
6		12 foot Backbone
3	OT04	4 foot surface mount ETC OneTrack
3		4 foot Backbone
3	OT-EF-KL	OneTrack Left Live end
3	OT-EF-KR	OneTrack Right Live end
9	OT-SC	Straight track coupler
36	OT-2IN-CLIP	OneTrack Mounting clip two inch
10	OT-4IN-CLIP	OneTrack Mounting clip four inch
3	OT-DMXT	DMX terminator
3	OT-CAP	End Cap
15	CSPAR	TL1 - ETC 114 watt LED RGB wash fixture with Track adapter.
6	CSSPOTV	TL2 - ETC 114 watt LED RGB fixture with Track adapter.

Services:

1	Tech Services	DMX addressing and initial programming
		Stage Fixture Accessories
18		Fixture Hanger
12		Pigtail Adapter w/ powercon and 5-pin
6		Pigtail Adapter w/ True1 and 5-pin

a. Hang and focus the Stage lighting fixtures according to light plot provided by the Architect.

V. Installation
1. The electrical contractor shall deliver the lighting equipment and controls to the job site. Coordinate delivery with the General and Electrical Contractor.
2. All Equipment shall be stored in a clean, dry space.
3. The electrical contractor shall furnish, deliver install and terminate all system control wires.
4. The electrical contractor shall provide and install all system control devices.
5. The installation shall conform to the plans and specifications.
6. The electrical contractor shall specifically coordinate the placement and sizes of conduit relating to work of this section and shall specifically review and approve the conduit rough-in.
7. If any conflicts or omissions occur as a result of the electrical contractor's unsuccessful coordination of the above mentioned work, it shall be the theater electrical contractor's responsibility to correct, provide and install any additional material that may be required.

W. Electrical Contractor Services
1. It shall be the responsibility of the Electrical Contractor to receive and store the necessary materials and equipment for installation of the dimmer system. It is the intent of these specifications and plans to include everything required for proper and complete installation and operation of the dimming system, even though every item may not be specifically mentioned.
2. The electrical contractor shall be responsible for field measurements and coordinating physical size of all equipment with the architectural requirements of the spaces into which they are to be installed.
3. The electrical contractor shall install all lighting control and dimming equipment in accordance with manufacturer's approved shop drawings.
4. All branch load circuits shall be live tested before connecting the loads to the dimmer system load terminals.

X. Manufacturer's Services
1. Upon completion of the installation, including testing of load circuits, the Electrical Subcontractor shall notify the dimming system manufacturer that the system is available for formal checkout.
2. Notification shall be provided in writing, two weeks prior to the time factory-trained personnel are needed on the job site.
3. No power is to be applied to the dimming system unless specifically authorized by written instructions from the manufacturer.
4. The purchaser shall be liable for any return visits by the factory engineer as a result of incomplete or incorrect wiring.
5. Upon completion of the formal check-out, the factory engineer shall demonstrate operation and maintenance of the system to the owner's representatives. Training shall not exceed four working hours. Additional training shall be available upon request.

Y. House Light Station Programming
   1. The electrical contractor shall furnish two separate four hour design and programming sessions with the End User to first determine the layout of the LCD master station and second to test and refine the station layout.
      a. LCD stations programming can include control of up to, but not exceeding 12 DMX devices, these can include LED Pars, LED Profile fixtures or LED strips.

Z. Training and Instruction
   1. The electrical Contractor shall furnish one separate on site four hour training sessions in addition to the training provided by the Manufacturers service technician at the time of system turn-on. The first training session shall not take place until the Owner has taken possession of the building and prior to the grand opening of the facility. The first training session shall include;
      a. A review of the lighting console operations
      b. A review of the operation of the Dimming System control processor, and House lighting control processor. Trouble shooting tips and factory 800 service number procedures.
      c. A review of the lighting system, explanation of the light plot and review of focus areas and DMX – out locations and operation.
      d. How to maintain the stage lighting fixtures..
   2. Prepare four identical copies of Owners Manuals. Deliver two to the Owner and two to the Architect.

AA. Warranty
   1. The electrical Contractor in cooperation with the Manufacturers shall warrant products under normal use and service to be free from defects in materials and workmanship for a period of two years from date of delivery.
   2. Warranty shall cover repair or replacement of such parts determined defective upon inspection. Replacement parts are to be furnished and installed by the electrical Contractor within three days.
   3. Warranty does not cover any product or part of a product subject to accident, negligence, alteration, abuse or misuse. Warranty does not cover any accessories or parts not supplied by the manufacturer.
   4. Warranty shall not cover any labor expended or materials used to repair any equipment without manufacturer's prior written authorization.

BB. Final Acceptance
   1. The following conditions shall be met before final billing and final acceptance of the stage lighting and dimming system may be submitted.
      a. Inventory of all equipment both fixed and portable verified by the Architect and Owner.
      b. The Architect or his representative has signed off acceptance of the dimming system.

CC. Satisfactory completion of all punch list items.

2.31 ELECTRICITY METERING

A. SCOPE
   1. This section includes the supply and installation of a complete submetering system as detailed on the drawings and as described in the specifications.

B. SUBMITTALS
   1. The following information shall be submitted to the Engineer and Owner prior to design or installation.
      a. Submit system description including an overview of the system provided with detailed description of suggested communications architecture.
      b. Bill of material including a complete listing of all hardware, software, configuration, training and start-up services being supplied under this contract.

c. Hardware and software description shall be provided in detail.

d. Approved submittal shall be stamped and signed by the contractor prior to start-up.

2. A final closeout submittal shall be provided and include a system operation manual that will include the following information:

a. A system description and as built layout.

b. System field verification and commissioning report.

c. Descriptive bulletins and/or sales aids covering each component.

d. Manuals for all the products.

e. Software data files if software is provided.

f. A complete list of device addresses and ID numbers.

C. RELATED STANDARDS

1. ANSI C12.20
2. The metering unit shall be UL
3. ASHRAE 90.1 para. 8.4.3

D. QUALITY ASSURANCE

1. Manufacturer Qualifications: The manufacturer of this equipment shall have a minimum of 10 years experience producing similar electrical equipment.

a. Comply with requirements of the latest revisions of applicable industry standards.

b. The meter must be made of steel manufactured of steel and metal containment.

E. DELIVERY, STORAGE AND HANDLING

1. Deliver material in manufacturer's original unopened protective packaging unless it is built into new distribution equipment.
2. Securely store materials in original packaging in a manner to prevent soiling, physical damage, incursion of moisture or corrosion prior to installation.
3. Handle in a manner to prevent damage to finished surfaces.

F. Maintain protective coverings until installation is complete and remove such covers as part of final clean-up.

G. MANUFACTURERS

1. SATEC power solutions.
2. DENT Instruments, inc.
3. Or equal

H. COMPONENTS

1. This system shall monitor all the specified locations with time-of-use metering units that will provide kWh readings for monthly tenant billing. 8 tariff changes per day, 4 seasons x 4 types of days.
2. The metering operating system setup shall be ExpertPower cloud based service
3. Metering software shall comply with ASHRAE 90.1 para. 8.4.3 for data intervals and retainment.
4. The metering operating software database shall support reading "interval data" directly from a PAS operating database to execute the database queries and to minimize the query times
5. The metering operating software have a minimum of 4 virtual channel totalization sub-meters, allowing automatic totalization of multiple sub-meters
6. The SATEC Inc. Branch-Feeder-Monitoring II system is defined to include, but not limited to, remote metering devices, pre-wired current transformers in the manufactures panelboard, central display for monitoring the system, web based software, software configuration, ancillary equipment, start-up and training services

7. A kWh total display shall be available as an option at the branch-feeder-monitor unit for energy consumption and in a mechanical numeric digit format for each individual channel
8. A central display shall be available that will display all individual meters consumption readings
9. The branch-feeder-monitor shall be configured in the following: 18 three-phase circuits, 27 split-phase circuits, 54 single-phase circuits, or any combination in this range, modular type design with selection of 18, 24, 30, 36, 42, or 54 channels based on CT inputs.
10. The units may be mounted in single Nema 1, 3, 3R, 4, 4X, 12 enclosures depending on its application and environmental conditions
11. The metering units will provide daily load profile data for up to 150 days (15 min-energy) or 30 min profile for 300 days
12. A minimum of 256MB of non-volatile memory is required
13. A local touchscreen LCD display will view all basic measurement requirements along with on screen vector and phasor monitoring
14. The metering units shall use metering grade current transformers
15. Up to 6kV impulse, isolated for 2.5kV. Voltage output shall not exceed 8 Volts max
16. The current transformers may be installed at the electrical manufacturer's plant or can be field mounted at the job site
17. Front end equipment such as a modem, network controller or computer is not required as part of the metering system
18. Software for reading, logging and printing tenant bills at the remote site (self administered) shall be available by the metering unit hardware manufacturer. Software will run on latest Windows operating system.
19. Remote Web Based software shall be available for managing the tenant bills and monitoring the properties load via the internet

I. COMMUNICATION OVERVIEW

1. The Electronic Branch-Feeder Monitoring II system shall be able to utilize the following standard communications configuration, as a minimum:
   a. Optically isolated RS485 port standard: Modbus RTU/ASCII – COM1
   b. Standard isolated USB 1.1
   c. Standard Ethernet port : Transformer isolated 10/100Base-T port
   d. Direct Application Voltages (For higher voltages, potential transformers are used.): *120 / 240 / 480 – Max 576 L-L.*
   e. Operating Frequency: *60* Hz
   f. Voltage Rating: [120/208V] [120/240V] [277/480V] (plus/minus 15 percent)
   g. Power Factor Range: 0.5 to 1.0 lead/lag
   h. Power Supply Requirements: 3-phase power supply (1,2 or 3-phase operation) 3 by 120/208 – 277/480V AC plus -20 percent
   i. Current Rating: *[100-4000amps]*
   j. Accuracy: plus/minus 0.5 percent of 100 percent registration @ 1.0 pf, 1 percent to 100 percent
   k. Operating Temperature Range: minus 25 degrees to plus 65 degrees Celsius (minus 13 degrees to 149 degrees Fahrenheit)
   l. Power Line Carrier communication will not be accepted
   m. BACnet-IP

J. CURRENT TRANSFORMER

1. Provide revenue class solid or split core current transformers associated within the metering system.

2. CT shall be 40 mA on secondary side. Each CT shall include blocking diodes to prevent harmful operation when not connected to meter base. Mili-voltage driven CT will not be acceptable.
3. Current transformer can be driven 600' without lose of phase accuracy and milliamp driven. The open CT shall not exceed 8 volts max.
4. Each current transformer input channel shall have the ability to adjust the individual transformer correction with phase angle adjustment within minutes to provide precise measurement.

K. POTENTIAL TRANSFORMER

1. The potential transformers, if required, may be mounted in a separate enclosure rated for the size and capacity necessary to feed the number of meters shown as per the drawings and rated by the manufacturer. Potential transformers must be approved for revenue metering.

L. INSTALLATION

1. The contractor shall furnish and install the equipment specified herein. The equipment shall be as shown on the drawings and outlined below.

M. ADJUSTING AND CLEANING

1. The meters shall be adjusted so that accurate readings appear and that the readings are within the meters accuracy range.
2. Clean exposed surfaces using manufacturer recommended materials and methods.

N. TESTING

1. Perform factory and installation tests in accordance with applicable NEC, NEMA and UL requirements.

O. WARRANTY

1. All equipment shall be free from defect in materials and workmanship under normal use and service for the period of ***thirty-six months*** from the date of shipment from factory. The warranty does not apply if equipment has been improperly installed, subjected to misuse, neglect, accident or abnormal conditions of operation.
2. Manufacturer's obligation under this warranty is limited to replacing or repairing any equipment that conforms to the warranty. If failure is due to improper installation, misuse, alteration, or abnormal conditions of operation, repairs will be billed at a nominal cost.

P. STARTUP SERVICES

1. Project management shall be provided for the entire project through a single source of contact. The end-user shall also provide a single source of contract with authority over the project to make decisions on timely bases.
    a. On-Site start-up and training of the Owners personnel is required on the system and shall be included in the project bid.
    b. Start-Up shall consist of complete meter configuration and on-site service testing of the meters & communication to the web-based system.
    c. Training shall include any documentation and hands-on exercises needed by the owner's personnel at the site during the last day of the startup.
    d. Supplier shall have a remote fully functional support facility for support related questions.
    e. Assist ATC sub-contractor with BACnet IP interface for building management system integration.
2. Calibration and Maintenance Service
    a. All meters shall be factory calibrated with precision test equipment and shall remain accurate for the life of the product eliminating the need for in-service calibration or adjustments.
3. Time Of Use (TOU)
    a. All meters are factory configured for "Time of Use" application if or when required.

4. Scope of Services
    a. The Services, to be provided through use of the Application, shall constitute the capturing of data by direct connection, gathering the same and storing the same on a cloud-based database, and providing Customer with the ability to generate detailed, customized and/or automatic reports gathered from such data as well as customized portals for specific site views.
    b. In addition, the Services may also include the following, all of which are features provided on and through the Application:
    c. Data Collection
        1) Automatic data collection from Satec energy meters (i.e. BFM136), Power Quality meters (i.e. PM174), etc.
        2) Complex calculations from two or more devices
        3) Easy configuration of new devices, communication server and Modbus mapping
    d. Presentation
        1) View all data in your browser—no software installation, no employee training
        2) Customized dashboards, single line diagrams with real time data, graphs with status indications (color, icon)
        3) Multi-user, multi-security level
        4) Customizable portals for any level of permissions
        5) End user application for apple or android devices
    e. Historical Information
        1) All data is logged in the database
        2) Graph any parameters
        3) Monitor trends to identify potential problems
    f. Reports
        1) Manual, automatic or scheduled reports
        2) Preconfigured or customized reports
        3) HTML, Export to MS Excel and PDF formats
    g. Alarms and Event
        1) Multi-level thresholds for complex criteria
        2) Messaging, emails and SMS alarms
        3) Log all alarms
        4) Request user acknowledgement
    h. Connectivity and Interoperability
        1) Integrate all energy management, automation system and billing into one web-based system
        2) Built-in data export to different formats (Excel, PDF etc.)
        3) Web interface module allows integration with third party enterprise applications (BMS, SCADA, ERP, CRM, Accounting)
    i. Architecture
        1) Complete web-based design with multi-browser support (Internet Explorer, Firefox, Chrome, Opera, Safari)
        2) Grow as you go architecture – from single device to thousands
    j. End-User Access
        1) End-user access to view current and historical consumption
        2) Individual log in/password protection per user

PART 3 EXECUTION

3.01 WORK COORDINATION AND JOB OPERATIONS

A. Equipment shall not be installed in congested and possible problem areas without first coordinating installation of same with other trades. Relocate electrical equipment installed in congested or problem areas should it interfere with the proper installation of equipment to be installed by other trades.

B. Particular attention shall be directed to coordination of lighting fixtures and other electrically operated equipment requiring access which is to be installed in ceiling areas. Coordinate with other trades, the elevations of equipment in hung ceiling areas to insure adequate space for installation of recessed fixtures before said equipment is installed. Conflicts in mounting heights and clearances above hung ceilings for installation of recessed lighting fixtures or other electrically operated equipment requiring access shall be brought to the attention of Architect for a decision prior to equipment installation.
C. Furnish to General Sub-Contractor and other subcontractors information relative to portions of electrical installation that will affect other trades sufficiently in advance so that they may plan their work and installation.
D. Obtain from other trades information relative to electrical work which he, the Electrical Subcontractor, is to execute in conjunction with installation of other trades' equipment.
E. Lighting fixtures in mechanical spaces or utility/ storage rooms shall only be installed after all mechanical equipment is in place.

3.02 PLANS AND SPECIFICATIONS

A. Plans:
   1. Drawings showing layout of electrical systems indicate approximate location of raceways, outlets, and apparatus. Runs of feeders and branch circuits are schematic and are not intended to show exact routing. Final determination as to routing shall be governed by structural conditions and as indicated on the approved coordination drawings.
B. Specifications:
   1. Specifications supplement drawings and provide specifics pertaining to methods and material to be used.

3.03 IDENTIFICATION

A. Equipment shall be marked for ease of identification as follows:
   1. Provide screw-on nameplates on switchboards, panelboards, F.A. terminal cabinets, starters, and disconnect switches. Nameplates to be of black phenolic with white engraving. For starters and disconnect switches lettering shall be minimum of ¼ inch high. Nameplates on panelboards shall have the following information.
      a. Line 1 - Panel designation in ½ inch high letters.
      b. Line 2 - Utilization voltage in 3/8 inch high letters.
      c. Line 3 - Distribution source "Fed from ¼ inch high letters.
   2. Neatly typed directory cards listing circuit designations shall be fastened inside the cover of panelboards. Spare circuits shall be penciled.
   3. Provide Signage on all rooms that contain Fire alarm control equipment within it. Where a Fire alarm control panel is located within a separate room provide permanent signage that reads " Fire Alarm Control Panel Inside" with minimum 7 inch high by 10 inch width with 2-inch high block letters a 0.5 inch letter stroke - white letters on a contrasting red background. The sign shall be permanently attached, at normal eye level to the door leading to the fire alarm control panel(s).
   4. Color coding schedules. If there is more than a single system voltage, different voltages shall have separate color codes, as previously specified. A copy of the color code schedule shall be affixed to each secondary switchboard and distribution panel and shall be of the phenolic nameplate type as previously specified. A typewritten color code schedule shall also be affixed, under plastic, inside each panelboard door.
   5. Outlet boxes both concealed and exposed shall be identified as to panel origination and circuit number by means of fibre pen on the inside of coverplate.
   6. Special system outlet boxes concealed above hung ceilings shall be identified as to system by spray painting during roughing. The following systems shall be identified.
      a. Fire Alarm - red.
      b. Normal/Emergency - yellow.

c. Security - blue.
d. Sound - green.

7. Wiring device plates on devices connected to normal-emergency circuits shall be red in color.
8. All conductors in boxes larger than standard outlet boxes, in all wireways, and trench headers. shall be grouped logically and be identified.
9. Grounding conductors and neutrals shall be labeled in panels, and wireways. as to circuits associated with.
10. Emergency system wiring shall comply with 700.10(A).
11. Power and raceway identification:
    a. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
    b. Colors for Raceways Carrying Circuits at 600 V or Less:
    c. Black letters on an orange field.
    d. Legend: Indicate voltage and system or service type (Power, Lighting, Emergency, Control).
    e. Colors for Raceways Carrying Circuits at More Than 600 V:
    f. Black letters on an orange field.
    g. Legend: "Danger Concealed High Voltage Wiring" with three inch high letters.
    h. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
    i. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: four inch wide black stripes on 10-inch centers diagonally over orange background that extends full length of raceway. Stop stripes at legends.
    j. Metal Tags: Brass or aluminum, two by two by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
    k. Write-On Tags: Polyester tag, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
12. Armored metal clad cable identification:
    a. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
    b. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; two inch wide; compounded for outdoor use.
13. Power and Control Cable identification:
    a. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
    b. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
    c. Metal Tags: Brass or aluminum, two by two x 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
    d. Write-On Tags: Polyester tag, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
    e. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

14. Conductor Identification materials:
    a. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than three mils thick by one to two inch wide.
    b. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
    c. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
    d. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
    e. Write-On Tags: Polyester tag, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
15. Underground warning tape:
    a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines but not less than 4 mils thick and six inch wide.
    b. Printing on tape shall be permanent and shall not be damaged by direct-burial service.
    c. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
    d. Color and Printing:
        1) Comply with ANSI Z535.1 through ANSI Z535.5.
        2) Inscriptions for Red-Colored Tapes: Electric Line, High Voltage.
        3) Inscriptions for Orange-Colored Tapes: Telephone Cable, CATV Cable, Communications Cable, Optical Fiber Cable.
16. Warning labels and signs:
    a. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
    b. Baked-Enamel Warning Signs:
    c. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. Nominal size, seven by 10 inch.
    d. Metal-Backed, Butyrate Warning Signs:
    e. Weather-resistant signs, non-fading, preprinted, cellulose-acetate butyrate signs with galvanized-steel backing; and with colors, legend, and size required for application. Nominal size 10 by14 inch.
    f. Safety signs shall warn of potential electrical hazard and shall include, but are not limited to, the following legends:
    g. Multiple power source warning.
    h. Workspace clearance warning.
    i. Potential electric arc flash hazard.
17. Equipment identification labels:
    a. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.
    b. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch Overlay shall provide a weatherproof and UV-resistant seal for label.
    c. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

18. Cable ties:
    a. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
    b. Minimum Width: 3/16 inch,
    c. Color: Black except where used for color-coding.
    d. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
    e. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking. UL 94 Flame Rated.
19. Verify identity of each item before installing identification products. Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors approved in submittals and required by code.
20. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
21. Apply identification devices to surfaces that require finish after completing finish work.
22. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
23. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
24. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
25. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
26. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
27. Outdoors: UV-stabilized nylon.
28. In Spaces Handling Environmental Air: Plenum rated.
29. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at six to eight inch below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inch overall.
30. Renovation Projects: For alterations and additions to existing facilities, use existing identification system. Where systems have not been standardized, use the identifying and marking system specified in this standard.
31. Distribution Equipment: Identify major components of the distribution system (such as circuit breakers, switches, transformers, switchboards, panelboards, motor control centers) with nameplates. Nameplates on disconnect switches and control stations shall identify the equipment served.
32. Identification Schedule:
    a. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for service, feeder, and branch circuits more than 30A and 120V to ground: Identify with self-adhesive vinyl label applied at 10-foot maximum intervals.
    b. Power-Circuit Conductor Identification, 600 V or Less: Identify conductors in the panels, pull and junction boxes, manholes, handholes.
        1) Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors for ungrounded service, feeder and branch-circuit conductors as specified in Division 26 Section “Low-Voltage Power Conductors”.
            a) Factory applied continuous color coding for conductors No.8 AWG and smaller.

b) Field-applied, color coding conductor tape: For conductors No.6 AWG and larger. Apply in half-lapped turns for a minimum distance of six inch from terminal points and in boxes where splices or taps are made.

2) Lighting and Receptacle Outlet Boxes: Identify with the panel and circuit number.

c. Power-Circuit Conductor Identification, above 600 V: For conductors in the vaults, pull and junction boxes, manholes and handholes, use write-on tags.

d. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

e. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

f. Terminal Blocks: Attach numbered nameplates to terminal blocks which require identification numbers; use the designations shown on the wiring diagrams. Install nameplate at the top of vertically mounted terminal blocks and at the end of horizontally mounted terminal blocks. Indicate the individual terminal point designation shown on the wiring diagrams.

g. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

h. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be per by NFPA 70 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in the finished spaces.

i. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Apply warning, caution, and instruction signs where required by the referenced Electrical code, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install self-adhesive warning labels or baked-enamel warning signs with approved legend where instructions or explanations are needed for system or equipment operation. Install metal-backed, butyrate warning signs for outdoor items.

j. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer, load shedding and other emergency operations.

k. Safety sign for the switchboards and panelboards: Provide a sign to warn qualified persons of potential electric arc flash hazard.

l. All electrical distribution equipment and mechanical/plumbing/fire protection equipment fed from the electrical distribution system shall contain in addition to the identification requirements listed in this section shall be labelled where they are fed from. For example Distribution panel 4DP1A is fed from MSB-1A, its label shall be “4DP1A fed from MSB-1A” submit full labeling scheme for review and approval.

m. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to the disconnect switches and protection equipment, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1) Labeling Instructions:

a) Indoor Equipment: Self-adhesive, laminated acrylic or melamine label.

b) Outdoor Equipment: Engraved, laminated acrylic.

c) Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2) Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved laminated acrylic. Panelboard directories shall identify the load name and location (i.e. AHU-1, Room #, FCU-1, Room #).

3.04 PROTECTION AND CLEANUP

A. Protection:
   1. Materials and equipment shall be suitably stored and protected from weather.
   2. During progress of work, pipe and equipment openings shall be temporarily closed so as to prevent obstruction and damage.
   3. Be responsible for maintenance and protection of material and equipment until final acceptance.

B. Cleanup:
   1. Keep job site free from accumulation of waste material and rubbish. Remove all rubbish, construction equipment, and surplus materials from site and leave premises in a clean condition.
   2. At completion, equipment with factory finished surfaces shall be cleaned and damaged spots touched up with the same type paint applied at factory.
   3. Particular attention is called to Section 110-12(c) of the NEC, which requires that internal parts of electrical equipment not be contaminated by construction operations.

3.05 PORTABLE OR DETACHABLE PARTS

A. Retain possession of and be responsible for spare parts, portable and detachable parts, and other removable portions of installation including fuses, keys, locks, blocking clips, inserts, lamps, instructions, drawings, and other devices or materials that are relative to and necessary for proper operation and maintenance of the system until final acceptance, at which time such parts shall be installed or turned over to the Owner, as the case may be.

3.06 SAFETY PRECAUTIONS

A. Provide proper guards, signage, and other necessary construction required for prevention of accidents and to insure safety of life and property. Remove any temporary safety precautions at completion.

3.07 MOUNTING HEIGHTS

A. All electrical equipment shall be mounted at the following heights unless noted or detailed otherwise on drawings. Notes on architectural drawings shall supersede those noted below or detailed on the electrical drawings. If mounting height of an electrical component is questionable, obtain clarification from Architect before installation.
   1. Duplex convenience outlets, microphone outlets, and telephone outlets - 18 inch.
   2. Light switches, pushbutton stations, HOA switches, and all other toggle or control switches for the operation of heating, ventilating, and air conditioning, plumbing, and general service - 48 inch.
   3. Clock outlets - 84 inch.
   4. Fire alarm pull stations - 48 inch.
   5. Fire alarm audio visual signals - 80 inch or six inch below ceiling, whichever is lower.
   6. Panelboards for lighting, power, telephone, and other auxiliary systems - 78 inch to top.
   7. Equipment located in lobbies shall be located as detailed on architectural drawings or per the Architect's instructions.
   8. All receptacles, light switches, fire alarm signals, and clocks sharing a common location shall be symmetrically arranged.
   9. Exterior and interior wall brackets shall be as detailed on architectural drawings or per the Architect's instructions.

B. Mounting heights given are from finished floor to centerline. In the case of a raised floor, surface of raised floor is the finished floor.

3.08 WORKMANSHIP AND INSTALLATION METHODS

A. Work shall be installed in first-class manner consistent with best current trade practices. Equipment shall be securely installed plumb and/or level. Flush-mounted outlet boxes shall have front edge flush with finished wall surface. No electrical equipment shall be supported by work of other trades. Cable systems shall be supported and not draped over ducts and piping or laid on ceiling suspension members. Lighting fixtures shall be installed to agree with Architects reflected ceiling plans.

B. Supports:
   1. Support work in accordance with best industry practice and by use of standard fittings.
   2. In general, walls and partitions will not be suitable for supporting weight of panelboards, dry type transformers and the like. Provide supporting frames or racks extending from floor slab to structure above.
   3. Provide supporting frames or racks for equipment, intended for vertical surface mounting in free standing position where no walls exist.
   4. Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members, rigidly bolted or welded together and adequately braced to form a substantial structure. Racks shall be of ample size to assure a workmanlike arrangement of equipment.
   5. Provide 3/4 inch thick painted plywood mounting surfaces in all electric and telephone areas and for all equipment on free standing racks. All plywood shall be fire retardant and painted both sides and edges with two coats of white paint.
   6. No work for exposed installations in damp locations shall be mounted directly on any building surface. In such locations, flat bar members or spacers shall be used to create a minimum of 1/4 inch air space between building surfaces and work.
   7. Nothing (including outlet, pull and junction boxes and fittings) shall depend on electric raceways or cables for support. All outlet, pull, and junction boxes shall be independently supported.
   8. Nothing shall rest on, or depend for support on, suspended ceiling or its mounting members.
   9. Support surface or pendant mounted lighting fixtures:
      a. From outlet box by means of an interposed metal strap, where weight is less than five pounds.
      b. From outlet box by means of a hickey or other direct threaded connection, where weight is from five to 50 pounds.
      c. Directly from structural slab, floor deck or framing member, where weight exceeds 50 pounds. Support from roof deck is not permitted.
      d. Pendant lighting fixtures shall be supported by threaded rods in non-public areas and by manufacturer's standard tube hangers with swivel aligner and canopy in public areas. Provide non-standard pendant lengths where required to mount fixtures at elevations either called for on drawings or as shown in architectural elevations.
      e. Support recessed lighting fixtures directly from structural slabs, floor decks or framing members, by means of jack chain or air craft cable, one at each end of fixture at opposite corners. Support from roof deck is not permitted.
   10. Where support members penetrate air ducts, provide airtight sealing provisions which allow for a relative movement between the support members and the duct walls.
   11. Provide channel sills or skids for leveling and support of all floor mounted electrical equipment.
   12. Where permitted loading is exceeded by direct application of electrical equipment to a slab or floor deck, provide proper dunnage to distribute the weight in a safe manner. Support from roof deck is not permitted.
   13. Support metallic raceways by either running within steel frame or hung from the building frame. Anything hung from building frame shall be attached with metallic fasteners.

C. Fastenings:
   1. Fasten electric work to building structure in accordance with the best industry practice.
   2. Where weight applied to attachment points is 100 pounds or less, fasten to building elements of:
      a. Wood -- with wood screws.
      b. Concrete and solid masonry -- with bolts and expansion shields.
      c. Hollow construction -- with toggle bolts.
      d. Solid metal -- with machine screws in tapped holes or with welded studs.
   3. Where weight applied to attachment points exceeds 100 pounds, fasten as follows:
      a. At field poured concrete slabs, provide inserts with 18 inch minimum length slip-through steel rods, set transverse to reinforcing steel.
      b. Where building is steel framed, utilize suitable auxiliary channel or angle iron bridging between structural steel elements to establish fastening points. Bridging members shall be suitably welded or clamped to building steel. Provide threaded rods or bolts to attach to bridging members.
   4. Floor mounted equipment shall not be held in place solely by its own dead weight. Provide floor anchor fastenings. Floor mounted equipment over 72 inch in height shall also be braced to nearest wall or overhead structural elements.
   5. For items which are shown as being mounted at locations where fastenings to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging to building structural elements.
   6. Fastenings for metallic raceways using the fastening as support shall be of the metallic type. Fastenings to hold raceways or cables in place may be via traps.

D. General Raceway Installation:
   1. Install the various types of raceways in permitted locations as previously specified. All raceways shall be run concealed. Consult Architect for instruction for raceways which must be exposed in public spaces.
   2. Raceways for normal-emergency or emergency only wiring cannot contain other conductors.
   3. Raceways shall be properly aligned, grouped, and supported in accordance with code. Exposed raceways shall be installed at right angles to or parallel with structural members. Concealed raceways may take most direct route between outlets.
   4. Raceways run on trapeze hangers shall be secured to the trapeze.
   5. Raceways shall be continuous and shall enter and be secured to all boxes in such a manner that each system shall be electrically continuous from service to all outlets. Provide grounding bushings and bonding jumpers where raceways attach to painted enclosures or terminate below equipment.
   6. Where raceways enter boxes, cabinets, tap boxes, other than those having threaded hubs, a standard locknut shall be used on the outside and locknut and bushing on the inside.
   7. Where raceways terminate below equipment and there is no direct metal to metal continuity, provide grounding bushings on raceways and interconnect with equipment grounding conductor.
   8. All empty raceways shall be provided with a pull wire.
   9. All raceway sleeves, stub-ups, or stub-outs, where not connected to a box or cabinet, shall be terminated with a bushing.
   10. All raceway joints shall be made up tight and no running threads will be permitted.
   11. Where raceways are cut, the inside edge shall be reamed smooth to prevent injury to conductors.
   12. All vertical raceways passing through floor slabs shall be supported.
   13. Raceways shall not be installed in concrete slabs above grade or below waterproofed slabs.

14. Electric raceways and/or sleeves passing through floors or walls shall be of such size and in such location as not to impair strength of construction. Where raceways alter structural strength or the installation is questionable, the structural engineer shall be contacted for approval.
15. Raceways shall not run directly above or below heat producing apparatus such as boilers, nor shall raceways run parallel within six inch of heated pipes. Raceways crossing heated pipes shall maintain at least a one inch space from them.
16. Raceways shall be installed in such a manner as to prevent collection of trapped condensates, and all runs shall be arranged to drain.
17. Raceways passing between refrigerated and non-refrigerated spaces and those penetrating enclosures with air movement shall be provided with seals.
18. Raceways feeding fire and jockey pumps shall be rigid metal conduit either run below slab or inside 2 hour rated enclosure. Final connections to motors shall be liquidtite flexible conduit.
19. Where two alternate wiring methods interconnect such as EMT to flexible metal conduit, an outlet box shall be provided.
20. All empty raceways entering building and all sleeves or core drilled openings through floors shall be sealed.
21. Each exterior raceway or assembly in a ductbank shall be provided with continuous warning tape installed 12 inch above raceway or ductbank.
22. Underground rigid non-metallic raceways where allowed and run as a ductbank encased in concrete shall be installed with plastic spacers to ensure a separation of three inch between raceways. Top of ductbanks shall be 30 inch below grade, unless otherwise detailed.
23. Elbows and extensions of rigid non-metallic raceway systems which penetrate slabs shall be rigid or intermediate metal conduit.
24. Raceways used for transformer connections shall be flexible type and shall contain a grounding conductor.
25. Raceways entering building through foundation wall into a basement area shall be provided with wall entrance seals or with other acceptable waterproofing method.
26. Underground non-metallic raceways shall be fully surrounded by a selected backfill to prevent more than the desired deflection and, in power raceways is needed to provide room for heat dissipation and good compaction of backfill. Separation Between Direct-Buried, Non-encased Ducts: three inch minimum for like services, and 12 inch minimum between power and signal ducts, unless shown otherwise on the drawings. Raceways formation for non-encased ducts shall be built up layer by layer. After each layer is placed, the selected backfill shall be placed over it to the specified depth. This fill should be spread evenly and compacted to provide continuous support for the next tier of raceways. Any temporary spacers used should be removed from each layer of raceway as soon as backfill is completed in that layer. A maximum of 9 conduits shall be grouped in the same trench unless otherwise noted on the drawings.
27. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
28. Run conduit concealed in finished areas above suspended ceilings, in wall spaces. Exposed conduit runs in finished areas require Architect's approval. Properly group conduit runs. Install conduit parallel to walls, structure and ceilings, and support with proper hangers and clamps. Running conduits at the bottom of structural members in exposed conditions is not allowed. Check door swings before installing back boxes for switches and receptacles.
29. Where conduit passes through a building expansion joint, use weatherproof, telescopic type expansion fittings which permit at least four inch of movement.
30. Form bends in conduit by means of a conduit bending machine or by an approved hickey. To fasten conduit to outlet boxes, cabinets, use locknuts and insulated throat bushings of compatible material.

31. Cut conduit ends square, thread conduit, and ream to remove burrs and sharp edges. Field threads shall be of the same type and have the same effective length as factory cut threads. Turns, wherever required in exposed conduit runs, shall be made by the use of factory-made bends, or field-made bends that meet the requirements of this Section and Electric Code. In the event of a multiplicity of conduits making the same turn, a steel junction box with a removable steel cover may be used. Offsets and bends for changes in elevation of exposed conduit runs shall be made at walls or beams and not in open spaces between walls or beams. Rout conduits required to avoid interfere with the operation or maintenance of equipment.
32. Plug or cap conduit ends as soon as conduit is installed, to prevent entrance of moisture or other debris during construction. Do not pull wire into any conduit until the conduit system is complete.
33. Drawings, in relation to the routing of conduits, are diagrammatic. Except where additional conduits may be required to avoid derating of branch circuits, elsewhere within this Section, the number and size of conduits and wire shall be furnished and installed as indicated by the drawings. Coordinate routing of conduits in the field with the building structure. Run conduit in straight lines parallel and perpendicular to walls, beams, and columns and with right angle bends and threaded conduit fittings. Maintain 12 inch clearance between conduit and surface with temperatures exceeding 104 degrees Fahrenheit.
34. Conduits passing through floors, walls and beams shall be of such size, number, and in such locations so as not to impair the strength of the construction.
35. Rout raceways in ceiling spaces in an orderly and organized manner, and to eliminate or minimize the number of junction boxes required. Support and secure conduits by means of rods, clamps and other conduit support devices approved by the Architect. Do not use wire to support conduits.
36. Where rigid metal conduit is threaded in the field, use a standard conduit cutting die providing 3/4 inch taper per foot.
37. Conduit and EMT runs shall be mechanically and electrically continuous from service entrance to outlets. Secure conduit to cabinet, junction box, pull box or outlet box with locknut outside and bushing inside, or with liquid-tight, threaded, self-locking, cold-weld wedge adapter. Locknuts and bushings or self-locking adapters will not be required where conduits are screwed into tapped connections. Before installing conductions, protect vertical conduit runs that terminate in bottoms of wall boxes or cabinets from entrance of foreign material.
38. Size rigid steel conduit, EMT and flexible metallic conduit required by the referenced Electrical Code, except as otherwise specified or shown on the drawings. Check raceway sizes to determine that equipment grounding conductor fits in same raceway with phase and neutral conductors to meet Massachusetts Electrical Code percentage of fill requirements.
39. Where conduit is secured rigidly on opposite sides of building expansion joints, and where runs of exposed conduit are long and subject to stress, provide expansion fittings capable of safely deflecting and expanding to twice the distance of structural movement. Provide separate external copper bonding jumper secured with grounding straps on each end of fitting.
40. Install a pull or junction box every 100 feet. of straight conduit run, and wherever there is an equivalent of four 90 degree elbows or a total of 360 degree bend. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
41. Install sealing fittings at following points, and elsewhere as shown:
    a. Where conduits enter or leave hazardous areas equipped with explosion proof lighting fixtures, switches, receptacles, and other electrical devices.
    b. Where conduits pass from warm to cold locations.
42. Pull cords: In each empty raceway, provide nylon fishing line having tensile strength not less than 200 lbs, or provide No. 14 AWG steel wire. Label each end of each line or wire with a securely attached tag which indicates the location of the other end.

43. Liquid-tight type flexible conduits installed in the air-handling plenum space shall be with a plenum-rated outer jacket.
44. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

E. General Outlet Box Installation:
1. Boxes shall be set flush with finish surface and provided with proper type extension rings or plaster covers. Thru the wall boxes are not permitted. Check device or fixture to be mounted to box to ensure box orientation is proper.
2. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operation.
3. Remove knockouts only at locations for proper installation of wires and cables, and plug unused openings.
4. Where required for horizontal and vertical alignment of boxes in stud partitions, bar hangers spanning two studs shall be used. Device boxes for insertion type receptacles shall be provided with far side box supports where there are less than two entering nonflexible raceways and where bar rangers are not provided.
5. Boxes flush mounted in fire rated partitions and on opposite sides of the partition shall be separated by a distance of 24 inch in accordance with UL listing for the box.
6. Locations of outlets indicated on drawings are approximate. For items exposed to view, refer to architectural drawings and coordinate locations with masonry joints, panel joints, ceiling grids, and structural members.
7. In case of conflict with standard mounting heights and device alignment, consult Architect prior to roughing.
8. Check all door swings on architectural drawings to ensure lighting switches are installed on strike side of door.
9. The right to make any reasonable change in location of outlets prior to roughing is reserved by Architect. "Reasonable change" shall be interpreted as movement within 10 feet. of location shown.
10. Obtain dimensioned plan from Architect for floor outlets.
11. Outlet boxes for use where surface metal raceways are allowed shall be of a type specifically designed to be used with such surface metal raceway systems.

F. Conductor Installation:
1. No conductors shall be pulled into individual raceways until such raceway system is complete and free of debris. No harmful lubricants shall be used to ease pulling.
2. All conductors shall be wired so that grounded conductor is unbroken; switches in all cases being connected in ungrounded conductor.
3. Connections throughout the entire job shall be made with solderless type devices of approved design satisfactory to Inspector of Wires.
4. All taps and splices shall be insulated equal to that of conductor insulation.
5. All conductors of each feeder in pull boxes shall be grouped, tied together, supported, and identified.
6. All conductors in panelboards and other wiring enclosures shall be neatly formed and grouped.
7. All conductors of emergency only and/or normal/emergency shall be run in separate raceway systems to final outlet box.
8. Provide support for conductors in vertical raceways in accordance with Article 300-19.
9. Strip insulation from conductors with approved tools and only of sufficient length for proper termination. Cutting of conductor stranding is unacceptable.
10. Taps from paralleled conductors shall be of a type which tap each conductor, such as ILSCO "PTA" series.
11. Grounding conductors are to be identified as to associated power circuits.

G. Type MC Cable Installation:
   1. Where cable is permitted under the products section, the installation of same shall be done in accordance with code and the following:
      a. Cable shall be supported in accordance with code. Tie wire is not an acceptable means of support. Horizontally run cable supports such as Caddy WMX-6, and clamps on vertical runs such as Caddy CJ6 shall be used. Where cables are supported by the structure and only need securing in place, then ty-raps will also be acceptable. Ty-raps are not acceptable as a means of support. All fittings, hangers, and clamps for support and termination of cables shall be of types specifically designed for use with cable, i.e., romex connectors not acceptable.
      b. Armor of cable shall be removed with rotary cutter device equal to roto-split by Seatek Co., not with hacksaw.
      c. Use split "insuliner" sleeves at terminations.
      d. Any cable system used in conjunction with isolated ground circuits shall have both an isolated ground conductor and an equipment ground conductor.

H. Stranded Conductor Installation:
   1. If Sub-Contractor selects stranded conductors for # 10 AWG and smaller, terminate such conductors as follows:
      a. No stranded conductor may be terminated under a screwhead. Provide insulated terminal lugs for all screw connections equal to Thomas and Betts "STA-KON" type RC with forked tongue and turned up toes. Installation of lugs shall be done with compression tool such as TandB WT-145C which prevents opening of tool until full compression action is completed.
      b. Backwired wiring devices shall be of clamp type; screw tightened. Force fit connections not allowed.
   2. Stranded conductors will not be allowed for fire alarm work.

I. Accessibility:
   1. Electrical equipment requiring service or manual operation shall be accessible.
   2. Work switches for equipment within accessible hung ceiling spaces, such as fan powered terminal boxes, shall be located at terminal box, and so located so as to be accessible.

J. Vibration Elimination: All equipment connections to rotating equipment or equipment capable of vibration shall be made up by flexible raceways.

K. Wiring Device Gaskets: Provide wiring device gaskets at coverplates where device is mounted in wall separating conditioned and non-conditioned spaces.

3.09 FEEDER CIRCUITS

A. Provide feeders as called for on the drawings.

B. Feeders shall be defined as any circuit originating from the main building switchboard and/or distribution panels.

C. All feeder conductors shall be continuous from origin to panel or equipment termination without splicing.

D. All feeders shall be conductors pulled into raceways. Cable systems are not allowed for feeders unless specifically indicated.

3.10 BRANCH CIRCUITS

A. Provide all branch circuit wiring and outlets for a complete and operating system. The system shall consist of insulated conductors connected to the panelboards and run in raceways or as cable systems if permitted under products section, to the final outlet and shall include outlet boxes, supports, fittings, receptacles, plates, and fuses.

B. Provide dedicated neutrals for all fluorescent lighting circuits and all circuits originating from panelboards fed from K-rated transformers.

C. Physical arrangement of branch circuit wiring shall correspond to circuit numbering on drawings. Combining of circuits and raceways will be allowed up to a 3 phase, 4 wire circuit or 3 phase 6 wire (dedicated neutrals) in a single raceway. Any combination of homeruns such as this, however, shall be indicated on record drawings. When a common grounded conductor is used for more than one circuit, the arrangement shall be such that a receptacle, fixture, or other device may be removed or disconnected without disconnecting the grounded conductor for other circuits. Ground fault circuit breakers and isolated ground outlets shall be wired with separate neutrals and separate grounding conductors per circuit. A consistent phase orientation shall be adhered to throughout project at terminations.

D. Circuits feeding three phase equipment shall not be combined into common raceways, unless specifically indicated.

E. All wiring in panelboards and cabinets shall be neatly formed and grouped.

3.11 FIREPROOFING AND WATERPROOFING

A. Fireproof and waterproof all openings in slabs and walls.

3.12 CUTTING, CORE DRILLING, AND PATCHING

A. Sequence the installation of the work and project schedule to avoid cutting and patching of new work.

B. Perform all cutting and core drilling operations that are outlined in Part 1 of this SECTION.

C. Throughout the performance of the cutting and coring work, ensure that the structural integrity of the walls, floors, overhead structure, and other structural components is maintained until permanent work is installed.

D. All cutting or coring of structural elements must be identified by submittal to the Architect and receive acceptance of the Architect and Structural Engineer prior to proceeding.

E. Cutting, coring, or drilling of holes larger than eight inch in any direction shall be coordinated through the Electrical Sub-Sub-Contractor, and shall be performed by Sub-Contractor who originally provided (or would traditionally be responsible for, in the case of existing materials indicated to remain) the material or surface being cut. Costs for cutting such openings shall be paid by Electrical Sub-Sub-Contractor.

F. Patching of surfaces cut or damaged by this subcontractor shall be performed by the subcontractor who originally provided (or would traditionally be responsible for, in the case of existing materials indicated to remain) the material or surface that was cut or damaged. Costs for patching “new work” surfaces shall be paid by this subcontractor. Costs for patching holes in existing surfaces where existing piping or equipment is demolished as part of the work shall be paid by the General Sub-Contractor.

G. No additional compensation to this subcontractor shall be authorized for cutting and patching work that is necessitated by ill-timed, defective, or non-conforming installations.

H. Prior to any coring or cutting, verify all locations of same with the General Sub-Contractor.

I. All cutting and coring is to be performed in accordance with approved Coordination Drawings.

J. Cut all masonry and concrete with an approved diamond blade concrete saw in a neat straight direction, perpendicular to the plane of the wall or floor.

K. Use a core drilling process which produces clean, sharp edges and the minimum hole size which will accommodate the size of pipe sleeve specified.

3.13 ELEVATOR COORDINATION

A. Elevator Electrical Work:

1. Several items pertaining to elevator electrical system shall be provided by Electrical Subcontractor as follows:
    a. Power source to elevator machine room including fused disconnect switch and wiring between disconnect switch and controller for each elevator.
    b. Power source to elevator machine room including fused disconnect switch (120 volt) for elevator signal system and cab light for each cab.
    c. Light, switch, and GFCI receptacle in each pit.

d. Light, switch, and GFCI receptacle in machine room.
e. Junction box in machine room with five control modules from fire alarm system for elevator recall to prevent cab opening on a fire floor.
f. Junction box in machine room for cab telephone with one one inch conduit with two CAT 6 telephone cables to main telephone demarcation backboard.
g. Power to automatic damper in hoistway penthouse louver.
h. Power wiring to elevator sump pump.

3.14 MECHANICAL SYSTEM COORDINATION

A. The Mechanical System Subcontractor shall be providing various items of mechanical services equipment and control apparatus. Electrical Subcontractor shall furnish disconnect switches and starters and connect up power wiring to this equipment.
B. The Mechanical and Electrical Subcontractor shall closely coordinate their respective portions of work.
C. If, due to local regulations, electric heating equipment furnished by the mechanical systems subcontractor is required to be installed by licensed electricians in order to allow connection by Electrical Subcontractor's licensed electricians, it shall then be Mechanical Subcontractor's responsibility to engage and pay for services of such licensed electricians.
D. Power wiring to be provided by Electrical Subcontractor is the line voltage power supply wiring. Control wiring is responsibility of Mechanical System Subcontractor unless specifically indicated on electrical drawings, or in this Division of the specifications. Temperature Control Subcontractor shall refer to electrical drawings for location of all magnetic starters.
E. 120 volt control wiring source to the main BMS temperature control panel is the responsibility of Electrical Subcontractor.

3.15 DISTRIBUTION EQUIPMENT TESTING

A. All dry-type transformers, individual motor starters, switchboard and main distribution panels, motor controls, motor control centers, feeder conductors, and emergency systems shall be tested in accordance with the following. In general, all tests shall be done in accordance with the 1995 Acceptance Testing Specifications of the International Electrical Testing Association.
B. The Testing Subcontractor may be an independent Sub-Contractor or a manufacturer of the equipment, which is to be tested.
C. Test report forms, delineating tests to be made, and method of recording same shall be submitted prior to commencing work. Test reports when submitted shall include interpretation of results and recommendation for any corrective work required.
D. Switchboard and Main Distribution Panels:
    1. Visual Inspection:
        a. Check for foreign material within bus enclosure.
        b. Check for missing hardware.
        c. Inspect entire assemblies for transit damage or factory defects.
        d. Check for all bus dimensions and bracing per specifications.
        e. Check ratings of current transformers and potential transformers.
        f. Check ratings of all protective relays per drawings.
    2. Physical Inspection:
        a. Torque all bus hardware to proper tension.
        b. Circuit breaker interlocks all work properly.
        c. All doors and hinged panels open and close properly.
        d. Relay blocking removed from all control and protective relays.
        e. All circuit breakers operate, close and trip mechanically.
        f. Torque all feeder conductors to terminal manufacturers' recommendations.

3. Electrical Testing:
    a. Breakers operated electrically trip and close from local and remote positions.
    b. All circuit breakers calibrated to manufacturer's respective time current curves as specified.
        1) Long time pick-up amps.
        2) Long time delay tripping at 300 percent of current setting.
        3) Resets okay at 80 percent of pick-up value.
        4) Short time pick-up current.
        5) Short time delay trip time at 105 percent of setting.
        6) Instantaneous minimum pick-up current.
    c. All protective relays calibrated to manufacturer's characteristic time curves for pick-up, drop-out, instantaneous and time delay.
    d. All instruments calibrated for accuracy.
    e. Protective relay schemes to be electrically tested by primary injection of current through current transformers and the tripping of associated circuit breakers.
    f. Insulation resistance tests made on all circuit breakers, line to load breaker open, line to ground breaker closed, 3 poses tested individually. Switchgear bus to be tested phase to phase and phase to ground with Megohometer type instrument. Relays also to be insulation resistance tested.

E. Transformers:
1. Visual inspection for transit damage such as broken porcelain, brazed connections broken off, core shifted on frame, and winding damage.
2. Insulation resistance tests in accordance with U.S.A.S.I. Standard C571222 and NEMA TRI-2.055.
3. D.C. over-potential test procedures and A.C. voltage values for factory proof testing of C57.12968 and NEMA TRI-2.055. The ratio applied for converting A.C. test potential to equivalent D.C. value is 1.6.
4. Acceptance test voltage for new transformers at D.C. value will be 75 percent of equivalent A.C. voltage used for factor proof testing the value will be 65 percent.
5. Transformers shall be subjected to a ratio and polarity test to prove the polarity and winding ratio as in accordance with nameplate specifications.
6. Torque all connections to terminal manufacturers' recommendations.

F. Starters:
1. Visual inspection to determine:
    a. Shipping damage.
    b. Proper bussing and contactor sizes.
    c. Correct overload relay heater ratings. Any incorrectly sized overloads shall be replaced by the Sub-Contractor who originally provided same.
2. Electrical Testing:
    a. Electrical operation of control relays, timing relay, and contactor coils.
    b. Insulation resistance test on all current carrying bus to ground and between phases.
    c. Calibration check of overload heater to ascertain tripping point and time delay at 300 percent of heater rating.

G. Conductors: All secondary service conductors and all feeder conductors from switchboards and distribution panels shall be tested.
1. Visual and mechanical inspection: Conductors to be inspected for physical damage and proper connection and sizing in accordance with single line diagram.
    Conductor connections shall be torque tested to manufacturer's recommended values.
2. Electrical Tests: Perform insulation resistance test on each conductor with respect to ground and adjacent conductor.
    Perform continuity test to insure proper conductor connection.

H. Emergency Systems:
   1. Engine Generator - Prior to the emergency generator test specified under the emergency generator specification, the testing Sub-Contractor shall perform the following:
      a. Visual and Mechanical Inspection:
         1) Inspect for physical damage.
         2) Compare nameplate rating and connection with specifications and single line diagram.
         3) Inspect for proper anchorage and grounding. Verify engine cooling and fuel system integrity.
      b. Electrical and Mechanical Tests:
         1) Perform a dielectric absorption test on generator winding with respect to ground. Determine polarization index.
         2) Perform phase rotation test to determine compatibility with load requirements.
         3) Test protective relay devices in accordance with applicable sections of these specifications.
         4) Perform dc over potential test between winding and ground.
   2. Automatic Transfer Switches:
      a. Visual and Mechanical Inspection:
         1) Inspect for physical damage.
         2) Verify that the short circuit withstand rating exceeds the available short circuit duty.
         3) Compare equipment nameplate information and connections with single line diagram and report any discrepancies.
         4) Check switch to ensure positive interlock between normal and alternate sources. (Mechanical and Electrical).
         5) Check tightness of all control and power connections.
         6) Perform manual transfer operation.
         7) Ensure manual transfer warnings are attached and visible to operator.
      b. Electrical Tests:
         1) Perform insulation resistance tests phase-to-phase and phase-to-ground with switch in both source positions.
         2) Measure contact resistance in normal and alternate source position.
         3) Set and calibrate in accordance with the project electrical engineer's specifications.
            a) Voltage and frequency sensing relays.
            b) All time delay relays.
            c) Engine start and shutdown relay.
         4) Perform automatic transfer by tests.
            a) Simulating loss of normal power.
            b) Return to normal power.
            c) Simulating loss of emergency power on return to normal.
            d) Simulate all forms of single phase conditions.
         5) Monitor and verify correct operation and timing.
            a) Normal voltage sensing relays.
            b) Engine start sequence.
            c) Time delay upon transfer.
            d) Alternate voltage sensing relays.
            e) Automatic transfer operation.
            f) Interlocks and limit switch function.
            g) Timing delay and retransfer upon normal power restoration.
            h) Engine cooldown and shutdown feature.

I. Grounding Grids or Electrodes: Measurement of resistance from ground grids or electrodes to earth to determine adequacy of grounding system in building and compliance with specifications and/or electrical code.

J. Settings of Adjustable Devices: Using the result of the fault current and coordination study specified hereinafter, the Testing Sub-Contractor shall set all adjustable devices.

K. In addition to the testing requirements of this section, Division 01 for additional requirements.

3.16 FAULT CURRENT, ARC FLASH AND COORDINATION STUDY

A. Sub-Contract:
   1. Work of this Section is part of the Electrical sub-contract. Refer to Section 26 00 10 for additional information about this work.

B. Related Documents:
   1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

C. Scope:
   1. The Electrical SubContractor shall furnish short-circuit and protective device coordination studies as prepared by the manufacturer of the switchgear provided for the project.
   2. The Electrical SubContractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in the current version of NFPA 70E -Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE Standard 1584 – 2002, the IEEE Guide for Performing Arc-Flash Calculations.
   3. The scope of the studies shall include new distribution equipment supplied by switchgear manufacturer furnishing the electrical distribution equipment for this project.

D. References:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
      b. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
      c. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
      d. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
      e. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
      f. IEEE 1584 -Guide for Performing Arc-Flash Hazard Calculations
   2. American National Standards Institute (ANSI):
      a. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
      b. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
      c. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
      d. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.
   3. The National Fire Protection Association (NFPA)
      a. NFPA 70 -National Electrical Code, latest edition
      b. NFPA 70E – Standard for Electrical Safety in the Workplace

E. Submittals For Review/Approval:
   1. The studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the study may cause delays in equipment shipments, approval from the Engineer may be obtained for a preliminary submittal of data to ensure that the selection of device ratings and characteristics will be satisfactory to properly select the distribution equipment. The formal study will be provided to verify preliminary findings.

F. Submittals For Construction:
   1. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. A minimum of five bound copies of the complete final report shall be submitted. For large system studies,
   2. requiring more than five copies of the report will be provided without the section containing the computer printout of the short- circuit input and output data. Electronic PDF copies of the report shall be provided upon request.
   3. The report shall include the following sections:
      a. Executive Summary including Introduction, Scope of Work and Results/Recommendations.
      b. Short-Circuit Methodology Analysis Results and Recommendations
      c. Short-Circuit Device Evaluation Table
      d. Protective Device Coordination Methodology Analysis Results and Recommendations
      e. Protective Device Settings Table
      f. Time-Current Coordination Graphs and Recommendations
      g. Arc Flash Hazard Methodology Analysis Results and Recommendations including the details of the incident energy and flash protection boundary calculations, along with Arc Flash boundary distances, working distances, Incident Energy levels and Personal Protection Equipment levels.
      h. Arc Flash Labeling section showing types of labels to be provided. Section shall contain descriptive information as well as typical label images.
      i. One-line system diagram that shall be computer generated and shall clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location, device numbers used in the time-current coordination analysis, and other information pertinent to the computer analysis.

G. Qualifications:
   1. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the responsible charge and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.
   2. The Registered Professional Electrical Engineer shall be an employee of the equipment manufacturer.
   3. The approved engineering firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analyses it has performed in the past year.

H. Computer Analysis Software:
   1. The studies shall be performed using SKM Systems Analysis Power*Tools for Windows (PTW) software program.

I. Studies:
   1. The Electrical SubContractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D. This study shall also include short-circuit and protective device coordination studies.

J. Data:
   1. Electrical SubContractor shall furnish all data for the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Sub-Contractor with a listing of required data immediately after award of the contract. The Electrical SubContractor shall expedite collection of the data to assure completion of the studies for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.
   2. Source combination may include present and future motors and generators.

3. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner, or General Sub-Contractor.
4. If applicable, include fault contribution of existing motors in the study. The Electrical SubContractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

K. Short-Circuit Analysis:
1. Transformer design impedances shall be used when test impedances are not available.
2. Provide the following:
   a. Calculation methods and assumptions
   b. Selected base per unit quantities
   c. One-line diagram of the system being evaluated that clearly identifies individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis
   d. The study shall include input circuit data including electric utility system characteristics, source impedance data, conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.
   e. Tabulations of calculated quantities including short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings and notes regarding adequacy or inadequacy of the equipment rating.
   f. Results, conclusions, and recommendations. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.
3. For solidly-grounded systems, provide a bolted line-to-ground fault current study for applicable buses as determined by the engineer performing the study.
4. Protective Device Evaluation:
   a. Evaluate equipment and protective devices and compare to short circuit ratings
   b. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
   c. Switchgear Manufacturer shall notify Owner in writing, of any circuit protective devices improperly rated for the calculated available fault current.

L. Protective Device Time-Current Coordination Analysis:
1. Protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.
2. Include on each TCC graph, a complete title with descriptive device names.
3. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
4. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
5. Plot the following characteristics on the TCC graphs, where applicable:
   a. Electric utility's overcurrent protective device
   b. Medium voltage equipment overcurrent relays
   c. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
   d. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
   e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
   f. Medium voltage conductor damage curves
   g. Ground fault protective devices, as applicable

h. Pertinent motor starting characteristics and motor damage points, where applicable
i. Pertinent generator short-circuit decrement curve and generator damage point
j. The largest feeder circuit breaker in each motor control center and applicable panelboard.

6. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.
   a. Provide the following:
      1) A One-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.
      2) A sufficient number of log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.
      3) Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
      4) The study shall include a separate, tabular printout containing the recommended settings of all
      5) adjustable overcurrent protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system one-line diagram
      6) A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations for addressing system protection or device coordination deficiencies.
      7) Switchgear Manufacturer shall notify Owner in writing of any significant deficiencies in protection and/or coordination. Provide recommendations for improvements.

M. Arc Flash Hazard Analysis:
   1. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2009, Annex D. The arc flash hazard analysis shall be performed in conjunction with the short-circuit analysis (Section 2.03) and the protective device time-current coordination analysis (Section 2.04).
   2. The flash protection boundary and the incident energy shall be calculated at significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.
   3. Circuits 240V or less fed by single transformer rated less than 125 kVA may be omitted from the computer model and will be assumed to have a hazard risk category 0 per NFPA 70E.
   4. Working distances shall be based on IEEE 1584. The calculated arc flash protection boundary shall be determined using those working distances.
   5. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations
   6. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios shall be compared and the greatest incident energy shall be uniquely reported for each equipment location in a single table. Calculations shall be performed to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.

The Arc-Flash Hazard Analysis shall be performed utilizing mutually agreed upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.

7. The incident energy calculations shall consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:
    a. Fault contribution from induction motors should not be considered beyond 5 cycles.
    b. For each piece of ANSI rated equipment with an enclosed main device, two calculations shall be made. A calculation shall be made for the main cubicle, sides, or rear; and shall be based on a device located upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment's main device to clear the arcing fault. For all other non-ANSI rated equipment, only one calculation shall be required and it shall be based on a device located upstream of the equipment to clear the arcing fault.
8. When performing incident energy calculations on the line side of a main breaker, the line side and load side contributions shall be included in the fault calculation.
9. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
10. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. A maximum clearing time of two seconds will be used based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than two seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.
11. Provide the following:
    a. Results of the Arc-Flash Hazard Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, personal-protective equipment classes and AFIE (Arc Flash Incident Energy) levels.
    b. The Arc-Flash Hazard Analysis shall report incident energy values based on recommended device settings for equipment within the scope of the study.
    c. The Arc-Flash Hazard Analysis may include recommendations to reduce AFIE levels and enhance worker safety.

N. Field Adjustment:
1. Electrical SubContractor shall adjust relay and protective device settings according to the recommended settings table provided by the coordination study.
2. Electrical SubContractor shall make minor modifications to equipment to accomplish conformance with short circuit and protective device coordination studies.
3. Switchgear manufacturer shall notify the design engineer in writing of any required major equipment modifications.

O. Arc Flash Labels:
1. Electrical SubContractor shall provide a four inch by four inch Brady thermal transfer type label of high adhesion polyester for each work location analyzed.
2. The labels shall be designed according to the following standards:
    a. UL969 – Standard for Marking and Labeling Systems
    b. ANSI Z535.4 – Product Safety Signs and Labels
    c. NFPA 70 (National Electric Code) – Article 110.16
3. The label shall include the following information:
    a. System Voltage
    b. Flash protection boundary

c. Personal Protective Equipment category
d. Arc Flash Incident energy value (cal/cm²)
e. Limited, restricted, and prohibited Approach Boundaries
f. Study report number and issue date

4. Labels shall be printed by a thermal transfer type printer, with no field markings.
5. Arc flash labels shall be provided for equipment as identified in the study and the respective equipment access areas per the following:
   a. Floor Standing Equipment - Labels shall be provided on the front of each individual section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area. Equipment line-ups containing sections with multiple incident energy and flash protection boundaries shall be labeled as identified in the Arc Flash Analysis table.
   b. Wall Mounted Equipment – Labels shall be provided on the front cover or a nearby adjacent surface, depending upon equipment configuration.

P. General Use Safety labels shall be installed on equipment in coordination with the Arc Flash labels. The General Use Safety labels shall warn of general electrical hazards associated with shock, arc flash, and explosions, and instruct workers to turn off power prior to work.

3.17 INSTALLATION OF FIRESTOP SYSTEMS

A. General: Install firestop systems at all fire-rated construction where penetrated by the Work of this Section.
B. Refer to Section 07 84 00 - Firestopping, for all installation requirements for maintaining integrity of fire-rated construction at penetrations.

3.18 STORAGE AND INSTALLATION OF EQUIPMENT

A. The electrical subcontractor shall store and install electrical equipment and wiring listed for dry locations only after the building is watertight.

3.19 CONSTRUCTION WASTE MANAGEMENT

A. Comply with Division 01 requirements for construction waste management and recycling. Refer to Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.

3.20 TRAINING

A. All training shall be scheduled with the user. Training shall be professionally videotaped and a USB Thumb Drive delivered to the Owner. Refer to each specific system for amount of training required. Refer to Section 01 79 00 - DEMONSTRATION AND TRAINING for additional requirements.

3.21 SPARE PARTS/ATTIC STOCK:

A. Requirements:
   1. Provide attic stock of the following quantities and parts for each piece of equipment as follows:

Equipment/Unit	Parts Description	Quantity
Lighting Fixtures	LED Source Packages	Five for each fixture type
	LED Drivers	10 percent of each type not fewer than 5
	Single faced exit signs	10 percent of total signs not less than 10
	Double faced exit signs	10 percent of total signs not less than 10
	Louvers, Lenses, Baffles	1 percent of each type not fewer than 5
	MC Cable	100 feet for each exit sign owned in the extra material section.
Fire Alarm	Smoke detectors of each type (Duct, ceiling, fire detectors)	Provide three for attic stock
	Detector	Provide three for attic stock.

Equipment/Unit	Parts Description	Quantity
	Pull stations	Provide three for attic stock.
	Speaker/Strobe device	Provide three for attic stock.
	Strobe only device	Provide three for attic stock.
	Mass Notification Strobe	Provide three for attic stock.
	Spare printer ribbon	Provide one for attic stock
	Extra set of keys and tools for access to locked and tamperproof components	Provide three for attic stock
Lighting Controls	Occupancy Sensors	Five percent of total quantity per floor not less than five
	Photo-Sensors	Five percent of total quantity per floor but not less than five
	Luminaire Control Modules	One percent of total quantity per floor but not less than five
	Three Zone Controller	Provide five for attic stock.
	Single Zone Controller	Provide five for attic stock.

END OF SECTION

SECTION 27 01 00
STRUCTURED CABLING SYSTEM

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section to be included in Sub-Bid for Section 26 00 10 ELECTRICAL.

B. Filed Sub-Sub Bid Requirements:

1. Sub-sub-bid requiring a paragraph “E” listing on the form for sub-bid required per M.G.L. Chapter 149 Section 44F, as amended to date. The Electrical Subcontractor shall be responsible for all related building preparation and coordination. See specification for additional Paragraph “E” listing requirements and coordination responsibilities. Failure to meet or exceed the requirements as detailed in this specification, shall be grounds to reject the applicable bidder.
2. It is the sole intent of this Paragraph "E" listing to ensure to the end-user, single source responsibility from a single qualified Structured Cabling System installer listed as the Paragraph E sub-sub bidder for this Class of Work.
3. The Structured Cabling System installer shall be DCAM Certified by the State of Massachusetts Division of Capital Asset Management in the Category of Telecommunications Systems.
4. Paragraph E sub-subcontractors for the work of this section shall be factory authorized to install the specified products. Filed Sub-Bidders shall be factory-authorized to install the systems specified in order to list themselves as Paragraph E subcontractors.

C. Drawing and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

A. This Section includes, but is not limited to the following:

1. Data and Voice Communications Systems cabling, including but not limited to:
   a. Category 6A Data and Voice Station Cabling to all equipment requiring data and voice connectivity, including but not limited to data outlets, voice outlets, video surveillance cameras, access control network connections, and other equipment specified in related sections
   b. Indoor distribution fiber optic cabling - multimode and singlemode
   c. Fiber Optic Cabling for Pole Mounted Security Cameras
   d. Category 5 Voice Riser Backbone Cabling
   e. Category 6A RJ-45 Style Data Jacks
   f. Category 6A RJ-45 Style Voice Jacks
   g. Category 6A RJ-45/110 Style Voice and Data Patch Panels
   h. Category 6A Patch Cords
   i. Technology Outlet Faceplates
   j. Category 5e 110-style Voice Termination Blocks
   k. Equipment Racks
   l. Vertical and Horizontal Cable Managers
   m. Cabling Distribution Support

B. Work to be done under this SECTION is shown on the following technology drawings and related details: T0.10, T0.11, T1.11, T1.12, T1.13, T1.14, T0.20, T1.21, T1.22, T1.23, T1.24, T0.30, T1.31, T1.32, T1.33, T1.34, T1.41, T2.01, T2.02, T2.03, T2.04, T2.05, T2.06, T2.07, T2.08, T2.09, T2.10, T2.11, T2.12.

1.03 RELATED REQUIREMENTS

A. Section 01 91 13 General Commissioning Requirements
B. Section 07 84 00 Firestopping
C. Section 08 71 00 Door Hardware
D. Section 26 00 10 Electrical
E. Section 27 08 00 Communications Systems Commissioning
F. Section 27 40 00 Audio-Video Communication Systems
G. Section 27 50 00 Distributed Communication System
H. Section 28 10 00 Integrated Security System
I. Section 01 25 00 Substitution Procedures
J. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.
K. Technology workboxes, back boxes, floor boxes, conduits, sleeves, cable tray, corridor cable support and grounding systems are per Electrical Sections 26 05 29 and 26 05 33.

1.04 TECHNICAL REFERENCES

A. The product specifications, design considerations, and installation guidelines provided in this document are in part derived from recommendations found in recognized telecommunications industry standards. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed below, the more stringent requirements will apply. The bidder is responsible for determining and referencing the most recent releases of all specifications during bidding and installation. Design, manufacture, test, and install all structured cabling systems per manufacturer's requirements and in accordance with NFPA 70 (National Electric Code), state codes, local codes, Underwriters Laboratories (U.L.), requirements of authorities having jurisdiction, ADA requirements, and most current version of the following specifications:
   1. TIA-568.0-D, Generic Telecommunications Cabling for Customer Premises.
   2. TIA-568.1-D, Commercial Building Telecommunications Cabling Standard.
   3. TIA-568-C.2, August 2009, Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
   4. TIA-568.3-D, Optical Fiber Cabling and Components Standard.
   5. TIA-568-C.4, Broadband Coaxial Cabling and Components Standard.
   6. TIA-569-D–2015, Telecommunications Pathways and Spaces.
   7. TIA-526-7 (OFSTP-7), Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.
   8. TIA-526-14-B (OFSTP-14), Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant; IEC 61280-4-1 Edition 2, Fibre-Optic Communications Subsystem Test Procedure- Part 4-1: Installed Cable Plant-Multimode Attenuation Measurement.
   9. TIA-455-C General Requirements for Standard Test Procedures for Optical Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components.
   10. Building Industries Consulting Services International (BICSI) Telecommunications Distribution Methods Manual (TDMM)
   11. BICSI Information Transport Systems Installation Manual (ITSIM)

12. ISO/IEC 18010, Pathways and Spaces for Customer Premises Cabling
13. TIA-942-A-1, Telecommunications Infrastructure Standard for Data Centers
14. TIA-607-C, Generic Telecommunications Bonding and Grounding (Earthling) for Customer Premises.
15. ISO/IEC 11801, Information Technology – Generic cabling for Customer Premises
16. TIA-862, Building Automation Systems Cabling Standard for Commercial Buildings
17. ISO/IEC 14763, Implementation and Operation of Customer Premises Cabling
18. TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure
19. TIA-607-C Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
20. IEEE Standard 802.3an – 10GBASE-T over copper twisted pair cable.

B. In cases where product specifications, design considerations, and installation guidelines provided in this document conflict with the references listed above, the more stringent requirements will apply. The bidder is responsible for referencing the most recent releases of all references when developing bid proposals.
C. This document does not take precedence over any code, either partially or wholly.

1.05 SUBMITTALS

A. General: Submit shop drawings, samples, and related submittals all together, at the same time, for coordinated review. Isolated items submitted will not be reviewed until all items have been submitted for review.
B. Equipment List: Provide a detailed Equipment List showing quantities by manufacturer and model number of all major items of equipment and installation material to be used in the system as specified herein.
C. Product Data: Include complete sets of indexed cut sheets, in quantity as dictated by the project, of all major pieces of equipment, cable and connectors being supplied. Arrange these sheets in the order the equipment appears in the Specification. Clearly highlight information showing compliance with this and/or all applicable Specifications. In the event that the manufacturer or representatives' cut sheet contains more than one item, clearly indicate which items of the cut sheet are intended for installation.
D. Firestop: Include cut sheets on all firestopping materials.
E. Shop Drawings: Submit a set of complete Shop Drawings, by system, showing equipment to be installed, including but not limited to:
    1. System configuration block diagrams of all equipment, indicating equipment type and model numbers. Show each and every component, system and subsystem, as well as all proposed connections between system components, and cable types connecting components.
    2. After consulting with the Owner and technology consultant, provide proposed layouts and elevations of all equipment racks and cabinets showing all equipment specified and spaced accordingly. Indicate spaces in racks for Owner's network switch equipment. Proposed layouts will be reviewed by the Owner with revised layouts issued back to the Structured Cabling System installer prior to installation as may be necessary to accommodate Owner's final requirements and equipment.
    3. Provide scaled room layout drawings of the main network room (MDF) and IDF closets showing rack positions in relation to all other equipment.

F. Samples: Provide one complete sample of each Technology Outlet plate type with connectors, cable, and labels installed. Faceplates shall be fully assembled with voice, data and video cables terminated onto the jacks. Unassembled faceplates will be returned for resubmittal. These samples shall be submitted for approval prior to ordering and installation, at the Structured Cabling Systems installer's expense. Failure to submit Technology Outlet faceplate samples can result in Outlet plates being rejected and all previously installed Outlets to be replaced at Structured Cabling Systems installer's expense. Upon approval of the faceplate submittals, all materials will be returned.

G. Provide a plan for labeling of all structured cabling. Meet with the Owner prior to submittal to coordinate Owner requirements and reflect on the plan.

H. Quality Assurance Submittals:
   1. Include certification from the manufacturer that the installer and/or its systems integrator is qualified to install systems as specified in accordance with the specific requirements set forth herein.
   2. Include names, qualifications, and certifications of installation personnel including Structured Cabling Systems installer's site Supervisor/Foreman who shall be in charge of, and responsible for, all activities at the job site for the duration of the Project. The job Supervisor/Foreman shall not be changed during the Project without notification and approval from the Owner.
   3. Complete warranty information including sample Registration Certificate.

I. Close-Out Submittals:
   1. Technical Manual: Submit for approval a draft of the complete Technical Manual at least two weeks prior to the time of final system check out. When the final drafts are approved, provide five copies of detailed technical manuals. The manuals shall include the following:
      a. Table of contents.
      b. Structured Cabling System installer’s name; contact name; address, telephone number, fax number, and email address.
      c. Manufacturer's Registration Certificate of Warranty for Structured Cabling system.
      d. Product Information: Include original copies of manufacturer's installation and operating instructions, and service manuals, arranged alphabetically. All service manuals shall be originals; there shall be no Xerox copies of the service manuals and schematic supplied. Warranty information shall be filled out in the Owner's name.
      e. Detailed Description of the complete system and all subsystems.
      f. Maintenance Documentation: Include the following:
         1) Information necessary to perform routine and corrective maintenance by the Owner's technical staff, or other qualified technicians.
      g. List of all equipment by manufacturer, model or part number, and serial number.
      h. List of spare parts.
   2. Test Data: Submit for approval in writing the test results including numerical values for all measurements as specified in the Cable Schedules of this Section. Reports shall be titled and submitted in three ring binders. Once approved, provide one set for the main network room (MDF). Also submit written certifications that the installation conforms to Specification, is complete and operable, and ready for approval by the Architect.

3. Technical Diagrams and Drawings:
    a. Simplified single line block diagrams showing the interconnection of all equipment and functional relationships for all systems specified. Show all equipment, patch panels, cables and jacks, and all other hardware, whether connected or not. These drawings shall be on Engineering size E, 30 by 42 inch sheets. The intent of these diagrams is to provide sufficient clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.
    b. Provide record architectural quality plan drawings at 1/8 inch = 1 foot scale showing data jack locations and numbers. These drawings shall be on Engineering size E, 30 by 42 inch sheets. Also provide all plans on thumb drive in AutoCAD 2010 or later .dwg format and in PDF format.
    c. All technical diagrams and drawings shall be mounted on the wall behind a clear plastic cover for protection. There shall be one set of the above drawings and diagrams provided for the MDF room.

J. Cable Schedules: Prior to substantial completion, prepare and submit cable schedules for each cable installed under this section describing the as-built condition of the systems. Prepare cabling schedules in tabular form. Include the following information in each schedule:
    1. Structured Cabling System Schedule:
        a. MDF and IDF where the cable originates.
        b. Patch panel port number or block and position where each cable is terminated.
        c. Destination room number or locations at which the cables is installed.
        d. Outlet jack number in the room where the cable is terminated.
        e. In those cases where more than one cable is installed at a specific outlet or locations, clearly identify each cable; e.g. Data 1, Data 2, Voice 1, Voice 2, CCTV 1, CCTV 2.
        f. Test results.

K. Modified Close-Out Submittals: Modified Close-Out Submittals shall include full test reports of all cabling installed and required under this section for all areas completed prior to the completion of the Project. It shall also include “As Built” architectural quality plans drawings at 1/8 inch = 1’-0” inch scale showing Outlet locations and corresponding Outlet numbers. These drawings shall be engineering size E, 30 by 42 inch sheets. Modified Close-Out Submittals shall not eliminate or diminish the requirement for a full set of Close-Out Submittals for the entire Project once all phases of construction are compete.

L. Modified Close-Out Submittals are required at the conclusion of the project.

1.06 QUALITY ASSURANCE

A. Structured Cabling Product Requirements: The products that shall best support the needs of the project and provide the highest level of system performance over the life of the facility, shall be a cabling system that is made up of system components designed, manufactured and installed as a total system solution. Therefore, it is the intent of the Specification that one manufacturer, not a combination of different manufacturer's components, be selected for the voice and data cabling system as specified to ensure that the final system performance and warranty are the responsibility of a single manufacturer. This requirement also applies to data patch cords specified in this section.

B. The onsite Job Supervisor/Foreman shall have at least five years’ experience in

designing, installing, and testing systems specified as described herein. The onsite Job Supervisor/Foreman shall have a current and valid RCDD certification. The onsite Job Supervisor/Foreman shall carry an active cellular telephone or other two-way device, so that he/she may be reached when circumstances require. Additionally:

1. The Structured Cabling System installer shall own and maintain tools and equipment necessary for successful installation and testing of all systems specified.
2. The Structured Cabling System installer shall have personnel who are adequately trained and certified by the Manufacturers providing final system warranties.
3. The Structured Cabling System installer shall hold certifications from the Manufacturer who is providing the final System Warranty and Performance Assurance.

C. Installation Procedures: Adhere to the engineering, installation and testing procedures of the Manufacturer of the components specified, and use only the cabling, components and methods of provisioning the Project authorized by the Manufacturer.

1.07 DELIVERIES, STORAGE AND HANDLING

A. Perform all tasks necessary to properly coordinate with all involved parties/trades for: Shipment, arrivals, loading dock, elevators (as applicable), acceptance, storage, and security of equipment and materials. Do not, during these tasks, interfere with other trades or the progress of this Project.

B. Assure that all deliveries are in correct quantities, within the appropriate times, and in compliance with all manufacturers' shipping instructions.

C. Protect all materials according to manufacturer's Specifications and/or instructions.

1.08 SYSTEM WARRANTY, SERVICE AGREEMENT AND PERFORMANCE ASSURANCE

A. Voice and Data Cabling Warranty: Provide a Manufacturer's Extended Product Warranty that covers product defects for all passive components of the Voice and Data Cabling Systems. Passive components are defined as those exhibiting no gain or contributing no energy to the Cabling System and include but are not limited to cabling, connectors, outlets, patch panels, patch cords, racks as outlined in PART 2 of this Specification.

B. The requirement of this section is that a single warranty shall cover all components of the Voice and Data networks, regardless of which manufacturer actually manufactures the device(s). Provide clear identification of who is certifying the installation, who is providing the warranty, and what the warranty covers.

1. The following shall be covered by the Manufacturer's Extended Product Warranty:
    a. All passive components that comprise the Voice and Data Cabling Systems shall be free from manufacturing defects in material of workmanship under normal and proper use.
    b. All passive components that comprise the Voice and Data Cabling Systems shall exceed the Specifications set for the herein, and exceed ISO/IEC 11801 standards, including all subsequent changes to these standards that are in effect at the time of installation, and shall meet or exceed the performance Specifications as outlined in PART 2 of this Specification.
    c. The installation shall exceed the insertion and return loss, attenuation and near end crosstalk (NEXT) requirements set forth herein and the ISO/IEC

11801 standards for cabling links/channel configurations specified in these standards including all subsequent changes to these standards that are in effect at the time of installation.

d. Each Voice and Data Channel shall be capable of delivering data at ten plus Gbps between active network electronics and end user device. A Data Channel is comprised of all passive components including cabling, connectors, patch panel port, and patch cords, with up to a total of four connections.

2. Upon successful completion of the Voice and Data Cabling Systems installation by the Structured Cabling Systems installer, and subsequent inspection by an authorized representative of the Manufacturer of the passive components, the Owner will be provided with Registration Certificate from the Manufacturer, registering the Installation, in its entirety.
3. Duration of Warranty: The warranty shall run for 20 years from the Date of final project completion, unless the Registration Certificate is issued by the Manufacturer at a later date, in which case the warranty shall run for 20 years from the date that the Registration Certificate is issued.
4. The Extended Product Warranty is applicable to the Voice and Data Cabling Systems passive components at the original site of installation. Under the Extended Product Warranty, the Manufacturer of the passive components shall either repair or replace the defective product(s) at the Manufacturers cost. This includes the replacement or repair cost of defective materials and the cost of labor to repair or replace all defective products.
5. The Structured Cabling Systems installer shall be able to provide a Manufacturer's warranty that the Voice and Data Cabling Systems shall be free from failures which prevent operation of the specific applications for which the original Data System was designed to support.

C. The Warranties required by this section shall not be diminished by other warranties in the Contract Documents, equipment manufacturer's warranties, and all other rights and remedies available to the Owner under this Contract and public law. In addition, this Warranty shall not diminish the terms of individual manufacturer's warranties.
D. The Warranties required by this section shall be for the benefit of the Owner to whom Registration Certificate is issued and any successor in interest to the site.
E. Any repair or replacement of Cabling or Equipment resulting from this warranty shall be warranted for either (a) 90 days or (b) the remainder of the original warranty period, whichever is longer.
F. Service Agreement: The Structured Cabling System installer shall respond to all requests for service during the warranty period. During this period, the installer replace defective material and repair items of faulty workmanship at no charge to the Owner. All requests for service shall be responded to by telephone within two business hours, and technicians shall be dispatched within twenty-four 24 hours. Only certified technicians shall be dispatched.

1.09 SEQUENCING AND SCHEDULING

A. A set of “as-built” Technology Outlet Plans shall be provided to the Owner by the Structured Cabling System installer showing the unique label (based on actual final room numbering) for each outlet installed prior to substantial completion.
B. Where cables are to be installed in Wiremold, or other raceway, the Structured Cabling Systems installer shall closely coordinate cable, equipment and faceplate installation with the Electrical Contractor.

1.10 SYSTEM START UP AND COMMISSIONING

A. During the installation of owner technology equipment not covered by this Specification, provide a full-time technician who is knowledgeable of the installation and configuration of the structured cabling system to assist the Owner and Owner's technology vendor(s) with the installation of technology hardware and coordination with the structured cabling system. The technician shall provide no less than 40 hours of assistance and shall be dedicated to the Owner for this purpose.

1.11 TRAINING OF OWNER'S PERSONNEL

A. Conduct a Training Program for the Owner's staff. The Training Program shall include a demonstration of the configuration of all structured cabling systems. Schedule the Training Program at the convenience of the Owner, after the Technical Manual has been submitted and approved. All materials in the Technical Manual shall be reviewed during the training program. All training sessions shall be videotaped with five copies provided to the Owner with closeout submittals.

1.12 EXTRA INSTALLATION PROVISIONS, MATERIALS AND SPARE PARTS

A. Provide and/or install the following. All "provide and install" outlets shall be installed around the time of substantial completion of each phase with the assumption that ceiling grids shall be installed at the time of installation. Spare parts shall be delivered to the Owner with closeout documentation/submittals.
   1. Provide and install up to 20 additional single data outlets, including box and conduit stub not currently shown on plans in locations provided by the Owner. Assume cable runs of 290 feet.
   2. Provide ten Spare Single gang two port Technology Outlet Faceplates with blank inserts.
   3. Provide ten data jack inserts of each type/color specified.
   3. Provide two spare 48 Port Patch Panels.
   4. Provide four spare fiber connectors of each type.
   5. Provide 2000 feet of spare data Cat 6A Cable.
   6. Provide 1000 feet of 12 strand multi-mode and 12 strand single-mode fiber optic cabling.

PART 2 PRODUCTS

2.01 GENERAL

A. It is the intent of the Specification that one manufacturer, not a combination, be selected for each particular class of material. A combination of manufactures for cabling and connectivity is acceptable, as long as the solution provides for a certified, warranted cable plant as described herein.

B. Certain equipment is listed by manufacturer and model number. This is to define and establish a level of quality and functionality. The words, "or equal", are understood to follow all names of these specified products, trade names, catalog numbers, and detailed descriptions. It shall be interpreted to apply to any material, article, assembly or system, which in the opinion of the Owner is at least equal in quality, durability, appearance, strength and design to the material specified, and shall perform at least equally the functions imposed by the general design. The words, "or equal", shall not be construed to permit departure from the detailed requirements of the Specification. Other manufacturers' products accepted by the Awarding Authority shall be equal to the specified products in terms of construction, quality, durability, performance, and appearance. Refer to Section 01 25 00 regarding product substitutions.

C. All materials and equipment shall be new and unused.

D. All part numbers and manufacturers shall be according to this Specification unless otherwise noted on the construction Drawings.
E. Provide all mounting hardware, shelving, bracketing, bracing, support members and other hardware required to support all cabling and equipment specified.

2.02 MANUFACTURERS

A. Acceptable “or equal” manufacturers for the Structured Cabling System include:
   1. AMP/Tyco
   2. APC
   3. Belden
   4. Berk-Tek
   5. Carlon
   6. Chatsworth
   7. CommScope
   8. Corning
   9. Eaton
   10. Legrand
   11. Leviton
   12. Hubbell
   13. Mohawk/CDT
   14. Superior Essex

2.03 VOICE AND DATA CABLING SYSTEMS

A. Voice and Data Channel Performance Specifications: Voice and Data Cabling System channels shall exhibit Category 6A performance capabilities. The data channel shall be comprised of the passive components including cabling, connectors, patch panel port, and patch cords, providing up to a total of four connections between network electronics. The Category 6A channel shall be component compliant, capable of supporting ten Gigabit per Second networking. System shall be Belden 10GX series channel solution.
B. Faceplates:
   1. Outlet faceplates shall consist of single or double gang utility outlet faceplates, as specified. All faceplates shall match those of corresponding electrical in color, material and finish. All faceplates shall have labeling windows.
   2. Faceplates without clear plastic labeling windows are not acceptable, and shall be replaced by the Systems installer at no expense to the Owner.
   3. Unused ports at each faceplate shall be provided with blank module inserts.
   4. Wall mounted telephone locations shall have faceplates appropriate for the wall mounted telephones.
   5. Provide blank faceplates on all empty boxes.
C. Category 6A Jacks
   1. All voice and data jacks shall meet or exceed Category 6A transmission requirements for connecting hardware, as specified in referenced TIA 568 Standards, and be part of the UL LAN Certification and Follow-up Program. Category 6A jacks shall contribute to the overall Channel Performance Specifications. Jacks shall be snap-in, 110 style, 8-pin insulation displacement contact (IDC), modular (RJ-45) jacks as specified herein and indicated on the Technology Outlet Plans.
   2. Cat 6A Jacks shall be Belden 10 GX Modules Part #AX104156 (blue) for Data, Part #AX104155 (green) for Voice, Part #AX 10415X (white) for WAP cabling,

and Part # AX102286 (Yellow) for Security Camera Cabling. Confirm colors with Owner.

3. Cat6A Jacks above Ceilings for Wireless APs and security cameras shall be single gang surface mount boxes with appropriate Belden faceplate and Category 6A jacks. Wireless AP Jacks shall be gray.

D. Category 6A Voice/Data Patch Panel:
   1. Category 6A RJ45/110 Type modular jack panels shall be 48 ports. One wire management-retaining trough shall be installed above every patch panel. Modular Jack Panels shall accommodate both T568A/T568B configurations.
   2. The patch panel shall support the appropriate Category 6A applications and contribute to the overall Channel Performance specification. The patch panel shall facilitate cross connection and inter connection using modular patch cords.
   3. Provide rear cable management strain relief brackets, one for each row of patch panel terminations.
   4. Category 6A Voice/Data Patch Panels shall be Belden 10 GX Part # AX1032643. Provide rear cable management strain relief brackets, one for each row of patch panel terminations.

E. Category 6A UTP, 4 Pair Station Cable
   1. Voice and Data horizontal station cables shall be extended between the station location and the MDF/IDF, and consist of 4 pair, 24AWG, UTP, and shall be terminated on the 8 pin modular jacks provided at each Outlet. Cable jacket shall comply with Article 800 NEC for use as a plenum cable. The 4-pair UTP cable shall be UL® and c (UL®) Listed Type CMP (plenum).
   2. All voice and data station cables shall conform to the referenced TIA-568 Standards, and be part of the UL® LAN Certification and Follow-up Program. These cables shall be capable of supporting evolving high-end applications, including but not limited to: 10GbE, 1000Base-T; 100 Base-T; 100Mbps TP-PMD; 155 Mb/s ATM; and 622Mbps ATM using parallel transmission schemes.
   3. Cabling color for data shall be blue. Cabling color for voice shall be green. Cabling Color for WAP's shall be white. Cabling Color for security shall be Yellow. Confirm colors with Owner.
   4. Category 6A cabling shall be Belden 10 GX Part # 10GX13. Cable colors shall be Blue for data cabling (Part # 10GX13D151000), Green for voice cabling (Part # 10GX130051000), White for WAP cabling Part # 10GX130091000), and yellow for Security cabling (Part # 10GX130041000.
   5. All cabling shall be plenum rated. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.

F. Category 6A Data Patch Cords:
   1. Patch cords shall be Belden 10 GX Category 6A 24 AWG copper, stranded conductors. Provide two modular patch cords for each wired port on the patch panels. Patch cord one shall be of sufficient length for neat connection from the data patch panels to the network switch electronics utilizing cable management in the MDF and IDFs. Coordinate these lengths with the Owner prior to and during network switch installation. For bidding purposes, assume all cords shall be 15 feet. Provide the second data patch cord to the Owner for connection of owner equipment at the user end. Coordinate these lengths with the Owner prior to and during technology equipment installation. For bidding purposes, assume all cords shall be ten feet. Patch Cords shall be hand delivered to, and signed for, by the Owner or Owner's representative. It is the Systems Cabling System

installer's responsibility to verify the exact quantity and lengths of patch cords and deliver and obtain signature receipt for the same.

2. Provide all patch cables required to neatly connect systems specified in this and other related sections.
3. Patch cords shall be provided in the same colors as the station cabling furnished and installed between the outlets and the patch panels, Blue for data, Green for Voice, White for WAP, and Yellow for security cabling.
4. Only patch cords from the Structured Cabling System manufacturer that is providing the overall system warranty shall be accepted. No third-party patch cords shall be accepted.

G. Multi-Mode Fiber Optic Cabling:
   1. Multimode Fiber optic cabling shall be provided between the MDF and IDF rooms. Cabling shall be furnished with the quantity of fibers as designated on the Technology Drawings.
   2. All fiber optic cables shall be from the same manufacturer and shall be the same type. A mix of fibers from different manufacturers may not be used without written permission.
   3. Multimode Fiber Specifications:
      a. All multimode fiber optic cables within the premises shall use multimode, graded-index fibers with 50-micron cores only. Fiber shall be laser-enhanced and guaranteed for transmission distances in ten Gigabit Ethernet of up to 500 Meters.
      b. Fiber shall be Belden FI4D012P9 12 Strand and FI4D024P9 24 Strand plenum indoor distribution OM4 ten gig 50 micron fiber.
   4. All cabling shall be plenum rated. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.

H. Single Mode Fiber Optic Cabling:
   1. Single Mode Fiber optic cabling shall be provided between the MDF and IDF rooms. Cabling shall be furnished with the quantity of fibers as designated on the Technology Drawings.
   2. All fiber optic cables shall be from the same manufacturer and shall be the same type. A mix of fibers from different manufacturers may not be used without written permission.
   3. Single Mode Fiber Specifications:
      a. All singlemode fiber optic cables within the premises shall use singlemode, graded-index fibers.
      b. All cables shall be of tight buffered, distribution style construction, or riser type construction, all dielectric.
      c. Fibers shall be Belden FISD006P9 6 strand and FISD012P9 12 strand plenum indoor outdoor distribution OS2 Single-mode Fiber.
   4. All cabling shall be plenum rated. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.

I. Exterior Light Pole Camera Cabling
   1. Furnish and Install 6 strand OM4 multimode indoor/outdoor rated cable from each pole mounted camera and the nearest IDF room.
   2. Specification:
      a. Belden FD4006R9 6 strand indoor/outdoor riser rated distribution cable or approved equal for fiber optic cabling in continuous pipe and FD4006P9 6 strand indoor/outdoor plenum rated distribution cable or approved equal for

fiber optic cabling not in continuous pipe

3. Terminate all pairs of each fiber optic cable in a rack mount fiber optic enclosure in IDF. Clearly label all fibers supporting pole cameras.
4. Coordinate with the installer of the surveillance cameras for terminating fibers at the poles and enclosing terminations in either the approved pole cabinet, or directly in the camera mount to be furnished and installed by Section 28 10 00 INTEGRATED SECURITY SYSTEM. The installation of cabling shall be done in accordance with the requirements of the light pole manufacturer
5. Terminate and test all fiber optic pairs at the pole end, even though they will not be used. Provide manufacturer recommended dust caps to protect the unconnected fibers.
6. Coordinate with Electrical Contractor for pathways, grounding of equipment and for the power receptacle required in the pole mount surveillance cabinet.
7. Provide and install all necessary mounting hardware and accessories for a neat, professional and permanent installation.

J. Fiber Distribution Patch Panels: The Fiber Patch Panel is the termination and administration point for the fiber optic backbone between the MDF and IDF rooms. These devices shall protect the connectorized fiber from mechanical stress, macro-bending loss at the connection point, tampering with the circuits, and provide circuit identification. The patch panels shall provide cross-connect and inter-connect capabilities and include support hardware to properly terminate cables, route the fibers and jumpers in a rack mount field. In addition, panels shall:
   1. Have connector panels to accommodate LC connectors;
   2. Be UL approved;
   3. Be from a manufacturer that is ISO 9001 certified.
   4. Be Hubbell FCR3U12SP for MDF room and FCR1U3SPL for IDF's and Pole Cameras.

K. Multimode Fiber Optic Connectors: Provide multimode LC type connectors to terminate fiber optic cables for cable-to-cable, cable-to-equipment, and equipment-to-equipment, and to make jumpers. The connectors shall be Hubbell OM4 compatible LC fiber Connectors.

L. Singlemode Fiber Optic Connectors: Provide Singlemode LC type connectors to terminate fiber optic cables for cable-to-cable, cable-to-equipment or equipment-to-equipment, and to make jumpers. The connectors shall be Hubbell Single-mode OS2 Fiber Connectors.

M. Fiber Optic Cabling Raceway: All fiber optic cables withing the buildings shall be enclosed in non-metallic corrugated flexible raceway for protection, ease of identification, and general organization of fiber optic cable installation.
   1. Corrugated Flexible Raceway (Inner-duct) shall be plenum rated Carlon p/n CG4X1C or approved equal with pull string. The Inner-duct shall begin no more than 24 inches from the termination point and run continuously end-to-end with the appropriate number and size pull boxes according to the referenced TIA-568 Standards. The use of conduit sleeves shall not negate the requirement for use of innerduct for fiber optic cables.

N. Patch Panel and Switch Equipment Racks
   1. Equipment racks shall be 19-inch floor mount racks with wide floor mounting flanges, Hubbell HPW84RR19.
   2. Four post racks shall be Hubbell SF841929.
   3. Vertical cable guides shall be Hubbell VS76 with covers. Provide on both sides

of all racks.

4. Horizontal cable managers shall be Hubbell HS23C with covers. Provide above and below all patch panels.
5. 6 position surge protected power strips shall be Chatsworth p/n 12816-708 modified to connect to receptacle mounted overhead on the underside of the cable tray.

O. Security System Server Cabinet
1. APC NetShelter shall be P/N AR3107.
2. 19 Inch Rack LCD console shall be APC P/N: AP5719.
3. Sliding Shelf shall be APC P/N AR8123BLK.
4. Two Horizontal cable managers shall be AR8600A.
5. Vertical Cable manager shall be AR7723.
6. USB2 Keyboard, Mouse.
7. KVM Switch shall be APC KVM0108A with 8 KVM-USB modules.
8. UPS to be furnished and installed by Section 281000

P. Owner Server Cabinet
1. APC NetShelter shall be P/N AR3107.
2. 19 Inch Rack LCD console shall be APC P/N: AP5719.
3. Sliding Shelf shall be APC P/N AR8123BLK.
5. Two Horizontal cable managers shall be AR8600A.
5. Vertical Cable manager shall be AR7723.
7. USB2 Keyboard, Mouse.
8. KVM Switch shall be APC KVM0108A with 8 KVM-USB modules.
9. UPS to be furnished and installed by Owner.

Q. Multi-pair voice backbone cable:
1. Shall be 24 AWG, sized as shown on drawings. (25 pair shall consist of be 6 Cat6A cables. 50 pair shall be 12 Cat 6A cables).
2. Shall conform to the referenced TIA-569 standards.
3. ULÒ and c (ULÒ) Listed for Fire Safety
4. ISO 9001 Certified Manufacturer
5. All cabling shall be plenum rated. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.

R. MDF and , IDF Voice Termination Frame Wiring Blocks.
1. Shall be Category 5e
2. Shall be from the same manufacturer as the data jacks and patch panels.
3. Shall be fire retardant, molded plastic consisting of horizontal index strips for terminating 25 pairs of conductors each.
4. Index strips shall be marked with five colors on the high teeth, separating tip and ring .
5. Fanning strips shall be located on each side of the block for dressing cable pairs terminated on the adjacent index strips.
6. The blocks shall accommodate 22 through 26 AWG conductors.
7. The blocks shall have mounting legs.
8. Separate termination fields shall be created for vertical backbone and horizontal station cable terminations.

S. Wall phones jacks shall support wall phone mounting without any additional hardware.

2.04 UNSPECIFIED EQUIPMENT AND MATERIAL

A. Any item of equipment or material not specifically addressed on the Drawings or in

this document and required to provide a complete and functional installation shall be provided in a level of quality consistent with specified items.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Prior to commencing Work of this Section or ordering equipment, examine site and conditions under which work shall be performed. Determine exact locations of items shown diagrammatically on Drawings. Determine dimensions needed to move in racks and any custom items. Notify the Architect of any conflicts or special requirements needed to provide for free access to doorways, corridors, stairs, and similar areas, required to move in the specified equipment. If the Structured Cabling System installer fails to provide such notification, any additional cost to remove and reinstall any building members shall be back charged to the installer.

B. Prior to commencing Work of this Section, inspect drawings and verify that voice and/or data horizontal station cabling, when fully installed shall not exceed a maximum length of 295 feet (90 meters) end to end. Notify the Architect in writing of any cable runs that may exceed this requirement. If the Structured Cabling System installer fails to provide such notification, any additional cost to remove and reinstall any cabling to satisfy this requirement shall be the responsibility of the installer.

C. The Technology Drawings designate the MDF, IDF rooms, Service Entrance Room, and related equipment spaces.

D. Technology Drawings designate Communication System Outlet locations. Install quantity and type of Technology Outlets according to the Technology Outlet Plans and as specified herein. Provide all required adapters and/or accessories for a complete installation in all raceways, and other locations.

E. Commencement of Work of this Section indicates acceptance of existing site conditions.

3.02 WORKMANSHIP

A. Structured cabling system shall be installed in a neat, workmanlike manner. Workboxes, equipment, and enclosures are to be plumb and square. Install the system elements in cooperation with all trades to achieve coordinated progress and desired results. Watch for conflicts with Work being performed by other trades that have impact on the installation of the system components. Make moderate moves or changes in equipment locations as are necessary to accommodate other equipment, without a claim for additional payment.

3.03 INSTALLATION, GENERAL

A. Pre-installation: Meet with the Construction Manager, Project manager, and any other appropriate parties for coordination meeting prior to beginning work and to coordinate requirements.

B. Coordinate Work with adjacent Work of other trades to facilitate installation and prevent conflicts.

C. Staff job appropriately to keep pace with the Project schedule.

D. Abide by the decision of the Architect to case of conflict or interference of the other trades.

E. Work under this Section shall be performed in accordance with associated local, state, and national building codes.

F. Coordinate requirements of ceiling and floor mounted outlets with the Electrical Contractor.

G. Coordinate the type of floor boxes and associated hardware with Electrical Contractor to ensure compatibility of Technology Outlet requirements with floor mount boxes

being supplied by the Electrical Contractor. Supply and install all required floor box Technology hardware including bezels, inserts, connectors, and covers for Technology Outlets.

H. If the Structured Cabling System installer must re-enter an area of a previously completed phase of Work, the installer shall be responsible for returning that area back to the condition it was in before the installer re-entered the area. This includes re-installing ceiling tiles, cover plates, cleaning floors, and other areas. Coordinate the cutting and patching of holes with the Construction Manager and comply with the Cutting and Patching Section.

I. Every effort shall be made to schedule the Work under this Specification in such a manner so as to complete all above ceiling Work prior to ceiling panel installation. If the Structured Cabling System installer is required to remove ceiling panels, such Work shall not break or disturb the existing ceiling grid or panels and shall be coordinated with the Construction Manager and Ceiling Contractor.

J. Cabling used throughout this Project shall comply with the requirements as outlined in the National Electric Code (NEC®) Article 725, 760, 770, 800, and 820, and all appropriate local codes. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.

K. All cabling shall bear the appropriate CMP or ONFR markings, as applicable, on the cable jacket. Cable not appropriately marked is not acceptable and if installed, shall be removed at the installer's expense.

L. The Structured Cabling System installer is responsible for furnishing and installing cross-connections between the riser and station cabling in the Telephone Service Entrance Room and MDF, IDF rooms and other technology rooms to each other and to TELCO lines. All pairs presented at the Telephone Service Demarcation (Service Entrance) shall be cross-wired to the multi-pair risers between the telephone demarcation and the MDF room and IDF rooms. Provide cabling and direct connections to phone lines for all systems and equipment requiring such connections.

M. Spare pull strings shall be left in all EMT, Conduits, and Innerduct.

N. Furnish and install all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware required to ensure that all equipment and cabling is properly installed and supported according to the manufacturer's recommendations.

O. Take precautions to prevent and guard against electromagnetic and electrostatic interference. Avoid potential sources of EMI in all aspects of installation. If interference is experienced, the Structured Cabling System installer shall provide all required testing to identify the source of interference and provide a remedy including but not limited to re-routing and/or replacing cables.

3.04 CABLE SUPPORTS AND ROUTING

A. Install all cabling shall be installed in accordance with the manufacturer's guidelines and according to all applicable building codes at the time of installation, including but not limited to the NEC and the TIA Telecommunications Building Wiring Standards.

B. Route all cables in large groupings, through main hallways, until cable can be distributed directly to the communication Outlet. Route individual cables to the appropriate Outlet locations in accordance with all standards described herein.

C. Install cables in cable tray, Snake Tray, J-hooks, pipe and/or sleeves specified in this and other sections.

D. In suspended ceilings where cable trays or conduit are not available, and it is not possible to install corridor cable support, bundle cables in bundles of 50 or less, with

Velcro cable tie wraps pulled snug, but not deforming the cable geometry. Support the cable bundles with approved "J" style hooks attached to the building structure at a maximum of three-foot intervals.

E. The Structured Cabling System installer shall adhere to the manufacturers' requirements for bending radius and pulling tension of all communication cables.
F. Install cables in such a manner to minimize tension and stress on cables, which can lead to changes in the physical and/or electrical characteristics of the cables over time. This applies to, but is not limited to, horizontal cable support methods, vertical cable support methods, tie wraps, or similar types of cable support methods.
G. Cables exiting floor conduits and sleeves shall be neatly dressed, and securely supported from the floor up to the ceiling so that the cables are not stressed or stretched by the weight of the cables. Cables shall be arranged in bundles of not more than 50 cables or less, and secured with Velcro cable tie wraps pulled snug, but not deforming the cable geometry. Acceptable support structures include but are not limited to: Cable tray runway radius dropout, vertical ladder tray, J-hooks, unistrut, or similar types of support structures. The intent is that cables shall not be supported by the weight of the cables themselves but are supported so that the weight of the cables is assumed by the support structure(s).
H. Route station cables at right angles to electrical power circuits and supported only from the building structure when not in cable tray or conduit.
I. Do not support cabling from ceiling tiles, grid or hanger wires.
J. Do not install random or diagonal cable runs. Cable turns and bends shall be made at 90 degrees angles whenever possible, but maintaining manufacturers' requirements for bending radius at all times.
K. Install cables at Technology Outlets, regardless of how routed to the Outlet, with a 5 foot service loop of cable secured above the ceiling where the cable enters the pathway to the Outlet. Install service loops so as not to exceed cable bend radius, or 295 feet.
L. In the MDF and IDF rooms, a ten foot service loop of cable shall be provided in the cable tray above the data patch panels for data cables. Service loops shall be installed in either a figure “8” or “U” pattern and shall be installed so as not to exceed cable bend radius, or 295 feet. Service loops shall not be installed as tight circular coiled loops.
M. Cables which penetrate a steel stud or steel wall cap shall be protected from damage with a "stud liner".
N. Cables entering power poles, surface mounted raceway, or other cable management systems shall be protected from damage.
O. Extend cabling between floors utilizing inter-floor sleeves and conduit as shown. All necessary conduits shall be provided by Division 26.
P. Conduit and sleeves provided as a means of routing cables between various rooms and floors shall be used according to the following requirements: Install cabling through separate conduits and/or sleeves for each system. In each group of conduits and/or sleeves, one four inch conduit and/or sleeve shall remain empty as a spare conduit or sleeve for future cabling. It is imperative that the cables for each system remain separate from the other systems. Cables routed in violation of this requirement shall be pulled back and rerouted, even if already terminated, at no additional cost to the Owner.
Q. Conduit and sleeves provided as a means of routing cables between various rooms and floors, and those which remain empty as spare, shall be sealed with an approved

fireproof, removable safing material. Sleeves which pass vertically from floor to floor shall be sealed in a similar manner using an approved re-enterable system. Additional penetrations through rated assemblies necessary for passage of wiring shall be made using an approved method, coordinated with the Construction Manager, and permanently sealed after installation of cables.

R. Meet all requirements regarding use of cable in return air plenums and in raised floor systems. Provide wiring that complies with all applicable state, local building codes, and the National Electrical Code. All cables run in raised floor systems with forced air-cooling shall meet the requirements of NEC Article 645, "Electronic Computer Data Processing Equipment".

S. Cables installed partially or fully within the MDF and IDF rooms shall be routed through and secured in the cable tray wherever possible. Cables placed in the cable tray are to be laced or tie wrapped with Velcro tie wraps frequently to keep them neatly bundled and not permitted to shift from one side of the tray to the other as they are routed in the tray.

T. Color of cable jacket for each system shall be unique and distinguishable from other system cabling

U. Cables routed in main corridors shall be installed in corridor cable support as specified in this Section. The Structured Cabling System installer shall size and select the correct product so that no more than 75 percent of the manufacturer's loading capacity is achieved in any given corridor area. The installer shall use the manufacturers' recommended attachment hardware for hanging the corridor cable support. Corridor cable support shall be suspended from integrated mounting hardware every four feet along the center spine.

3.05 EQUIPMENT RACKS

A. Mount Equipment Racks an isolation pad and utilize non-conductive washers to secure the rack to the floor. Provide a minimum of four anchors per rack.

B. Insulate conduits and sleeves from the equipment racks, equipment cabinets and overhead cable tray.

C. Ground equipment racks and cabinets to the Telecommunications Grounding Busbars within the MDF and IDF rooms using a standard ground lug and #6 jacketed green cable. Grounding shall be accomplished per TIA-607-C.

D. Mount power strips in each equipment rack as shown on the Technology Drawings. Each power strip shall be provided with a power cord long enough to be neatly run from the power strip, at its furthest mounting location, through the equipment racks to the electrical outlets mounted on the bottom of the cable tray. Each power cord shall be equipped with a twist lock type NEMA L5-20P to connect to the electrical receptacles on the underside of the cable tray.

E. Coordinate with the installer of Section 27 20 00 DATA COMMUNICATION SYSTEM and for the installation of network switches, UPS's, and PDU's, and; Section 28 10 00 INTEGRATED SEURITY STYSTEM for the installation of camera, NVR, Video Intercom, Access Control, and any other security system requiring rack space and/or structured cabling.

F. Provide blank and vent steel panels on all data equipment racks. Aluminum panels are not acceptable. Fill all unused rack spaces. All panels shall be the same finish, color and manufacturer.

G. Proposed layout of all racks and cabinets including location of racks in rooms as well as proposed equipment in racks and cabinets, which are submitted by the Structured Cabling System installer as part of the Submittal requirements shall be reviewed by

the Owner. The Installation of racks, cabinets, cable tray, cabling and equipment shall not proceed until the Owner has reviewed and commented on proposed layouts. Revisions to proposed layouts may be issued back to Structured Cabling System installer to be incorporated into the final installation in order to accommodate Owner's final requirements and equipment needs.

3.06 VOICE AND DATA CABLING

A. Provide, install, terminate and test one Category 6A, 4 pair cable from each voice and each data modular insert in each technology outlet shown.

B. The voice and data system station cables shall be run using a star topology format from the technology outlet to the nearest MDF or IDF room as indicated on the Technology Drawings.

C. The length of each individual cable run between data patch panels in the MDF and IDF rooms to each data or voice Technology Outlet shall not exceed 295-ft (90m), including service loops. Cables may be routed through rooms and other spaces in the event that cable routing through main hallways negatively affects the requirement that the length of each individual cable run not exceed 295-ft (90m) (terminated end to terminated end). Cabling which deviates from the main pathways shall be clearly identified on the as-built floor plans and brought to the attention of the Owner or his representative.

D. Observe the bending radius and pulling strength requirements of all the voice and data cable during handling and installation.

E. Each run of cable between the patch panel to the technology outlet shall be continuous without any splices. All cables shall be terminated at each end.

F. Terminate cables using the TIA 568B wiring configuration.

G. Wiring color codes shall be strictly observed, and terminations shall be uniform throughout the system. Identification markings and systems shall be uniform.

H. All data station cables shall be terminated in the MDF room and IDF rooms utilizing only approved Category 6A, 110 style IDC termination patch panels. All voice riser cables shall be terminated in the MDF room and IDF rooms utilizing only approved Category 5e, 110 style IDC termination blocks. Data patch panels and 110 voice termination blocks shall be sized to allow for 20% percent spare future expansion in the MDF and IDF rooms.

I. No data patch panel shall exceed 48 ports.

J. All voice, data, security and wireless access point Cat6A cables shall be terminated onto separate Cat6A patch panels in increasing numerical order, left to right, and from the upper left to bottom right of the patch panel, or termination block in the case of voice risers. All patch panels shall be labeled with the corresponding station jack location number.

K. In the MDF room and/or IDF rooms, where the rooms are serving two floors, all voice, data, security and wireless access point Cat6A cabling shall be separated by floor and the cabling serving the first floor shall be terminated onto separate patch panels in the two-post rack to the left of the four-post rack. Cat6A cabling serving the second-floor outlets and devices shall be terminated onto separate patch panels in the two-post rack to the right of the four post rack. All other rooms should have the Cat6A cabling serving outlets and devices corresponding to that floor terminated on separate patch panels in the two-post rack to the left of the four post rack, leaving the two post rack to the right empty.

L. Voice riser cable shall be routed through sleeves and/or conduit provided, and down behind plywood termination walls. The Structured Cabling System installer shall

provide holes in the plywood wallboards. Ensure that cables are protected from sharp edges and other areas that could cause potential damage.

M. Install multi-pair Category 5 voice riser cable between the MDF riser field and the local exchange carrier telephone demarcation wallboard and between the MDF riser field and each IDF/DAT riser field. Terminate all pairs onto 110-style termination blocks in the demarc, and onto 110-style terminations blocks at the MDF and IDFs. Voice riser 110-style termination blocks shall use C5 connecting blocks. Provide a 5-foot service loop of cabling installed in cable tray and at each end. Provide all cross connections necessary between pairs and TELCO lines.

N. Install multi-pair Category 5 voice riser cable between the voice riser wall field 110 termination blocks in the MDF and IDF rooms, to the equipment racks in each room. Terminate one end of each cable onto 110 termination blocks at the wall field and the other end onto approved category 6, 110 style IDC termination patch panels. Terminate one pair of the 50 pair cable to one 8 position connector on the patch panel, using pins 4 and 5 or the white-blue termination position on each connector.

O. Provide one voice station cable to each elevator equipment room for installer of the elevator to interface with. Terminate, label and crosswire cable serving elevator phone location to the local telephone line provided by the service provider for the elevator phone.

P. Provide one voice station cable to each system requiring direct connection to an outside POTS line. Terminate, label and crosswire and connect cable to the line(s) provided by Local Exchange Carrier.

Q. Pull boxes shall be installed according to the TIA 568-C series Telecommunications Building Wiring Standards.

R. Spare pull strings shall be left in all conduits and inner duct.

S. Category 6A cabling shall be separated, grouped, and terminated according to color onto separate patch panels in MDF and IDF's according to the technology that the station cabling supports (data, voice, WAP and security).

T. Data outlets supporting wall mount wireless access points and wall mounted security cameras shall be coordinated with the architect and the installer of equipment in Sections 27 20 00 and 28 10 00, respectively. Data outlets shall be mounted above the nearest accessible ceiling to the wireless access point and camera using a ten foot patch cord from the outlet to the wall mounted device. At data outlets supporting wall mounted wireless access points and/or security cameras where suspended ceiling is not accessible, the data cabling shall be terminated in such a way as to allow for wireless access devices and/or cameras to be installed over the data outlet workbox to conceal the data cabling, patch cable, and jack behind the device being mounted.

3.07 CONDUITS, SLEEVES, CABLE TRAY AND WALL/FLOOR PENETRATIONS

A. Conduits, Sleeves, Cable Tray and Wall/Floor Penetrations between the MDF/IDF's rooms and main corridors shall be provided by Division 26 for cabling under this section.

B. The Structured Cabling System installer shall be responsible for coordinating room and/or space for cabling within all conduits, sleeves, cable tray and wall/floor penetrations between MDF/IDF's and main corridors provided by Division 26.

C. Conduit sleeves between all main corridors and hallways into all rooms, offices, and spaces showing communications devices, and through all fire rated walls shall be provided by Division 26.

3.08 FIRESTOPPING

A. Seal all horizontal and vertical openings between floors, through fire rated fire and smoke walls, used or created by the Structured Cabling System installer.

B. Refer to Section 07 84 00 - Firestopping, for all product requirements for maintaining integrity of fire-rated construction at penetrations.

3.09 LABELING

A. Meet with the Owner prior to the final labeling of all installed jacks, blocks, patch panels and related equipment to verify and confirm the exact requirements of the labeling scheme for the project.

B. Data cabling supporting Data jacks, Voice Jacks, Wireless Access jacks, and Security System jacks shall be terminated onto separate data patch panels in MDF and IDF rooms.

C. Clearly label and identify all components. Logically and permanently mark all cable, jacks, connectors, patch panels, racks, electronic equipment, and all wall plates.

D. Use a letter quality printer or other mechanically produced lettering for patch panel and outlet labels. Insert patch panel and outlet labels behind clear plastic designation strips. Labels which are surface mounted directly onto the patch panel or faceplate are not acceptable and shall be replaced by the Structured Cabling Systems installer at no expense to the Owner.

E. Place permanent cable markers three inches from all connectors to allow easy identification. Use Brady Markers with clear plastic ends. Acceptable markers are, Brady B-320, B-292, SL-292, or Brady machine embossed labels with clear vinyl ends. Machine generated markers are required. Place cable markers on cables so that they can be easily seen.

F. Handwritten labels shall not be accepted, even if written with a permanent marker. Temporary handwritten labels may be used only during the “rough-in” stages; they must be replaced with permanent labels prior to Project completion.

G. Labeling of communication jack wall plates and patch panels shall be confirmed and communicated by the Owner prior to final labeling.

H. All labeling of Technology Outlets, patch panels, cross connect blocks, or similar types of items, shall be based on the finished project room numbers and not the architectural room numbers.

I. The Structured Cabling System installer shall be responsible to contact the Architect, GC and/or Owner Representative for obtaining the final room numbers.

J. Voice station blocks, riser termination blocks, and data patch panels shall be color coded as per TIA-606-B.

3.10 BONDING AND GROUNDING

A. Bonding and grounding shall be in accordance with TIA 607-C, the NEC® and NFPA. Horizontal cables shall be grounded in compliance with NFPA 70 and local requirements and practices. Horizontal equipment includes cross connect frames, patch panels and racks, active telecommunications equipment and test apparatus and equipment.

B. Telecommunications Bonding Backbone utilizing #6-AWG or larger bonding conductor shall be provided by Division 26. This is part of the grounding and bonding infrastructure (part of the telecommunications pathways and spaces in the building structure) and is independent of equipment or cable.

C. For all systems, provide equipment grounding connections. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

D. For all systems, provide conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.
E. For all systems, provide transient protection on the AC power feed and on station lines leaving or entering the building.
F. Note in the system Drawings, the type and location of these protection devices as well as all wiring information.
G. Furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground bus bar.
H. Provide any necessary screws, anchors, clamps, tie wraps, distribution rings, and miscellaneous grounding support hardware to complete the installation of the grounding system.
I. Grounding busbars shall be installed in the MDF, IDF rooms and the Service Entrance room by Division 26.
J. All non-current carrying telecommunications components (passive) shall be bonded to the grounding busbar utilizing two-hole lugs for all bonding connections.
K. All grounding conductors shall be affixed with permanent labels in a visible location at each end of the conductor, and as close as practicable to the bonding point at each end of the conductor. The labels shall clearly identify both the source and destination of the bonding conductors. Handwritten labels are not acceptable.

3.11 TESTING

A. Voice and Data Cabling Testing:
   1. All terminated cabling runs shall be 100 percent tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements found in the referenced TIA-568 Standards. All pairs in each installed cable shall be verified prior to system acceptance. Any defect in the cabling system installation, including (but not limited to) cables, connectors, patch panels, and cordage shall be repaired or replaced in order to ensure 100 percent usability of all installed runs.
   2. Copper Channel Testing - All balanced twisted-pair cable links shall be tested for basic continuity and length, as indicated below. Additional testing shall be performed to verify compliance with Category 6A performance. The extent of testing shall be in accordance with the end-customer's testing requirements. Provide 100 percent testing of permanent links for Insertion Loss, Return Loss, NEXT, PSNEXT and PSACRF. These tests shall be performed at the same time as the Continuity test using an automated tester, such as the Fluke DTX1800.
   3. Continuity – Each pair in every installed cabling run shall be tested using a test set that detects and identifies opens, shorts, polarity and pair reversals, crossed pairs, and split pairs. The results shall be recorded as Pass/Fail (as indicated by the test set) and referenced to the appropriate cable identification number and circuit/pair number. Any fault shall be corrected and the run re-tested prior to final acceptance.
   4. Length – Every installed cabling run shall be tested for installed length using a time domain reflectometer (TDR) device. The cable length shall not exceed 90 m (295 ft). The cable length shall be recorded, referencing the cable identification number and circuit/pair number.

5. Category 6A performance testing shall be done according to the published standards.
6. Bring cables and/or pairs not meeting the requirements of the standard into full compliance, at no additional cost to the Owner.
7. Document cable testing in accordance with Submittal paragraph. Provide a table of test results in a three-ring binder submitted with the as-built Drawings.
8. Provide an electronic version of test results and any cable test software required to read and evaluate results.

B. Multi-pair Voice Riser Tests:
1. Test each pair of multi-pair voice riser cable for proper polarity; no reversals; no transpositions; continuity; no shorts; no AC voltages; no DC voltages; no opens; and proper numbering at each termination.
2. Bring cables and/or pairs not meeting the requirements of the standard into full compliance, at no additional cost to the Owner.
3. Document cable testing in accordance with Submittal paragraph. Provide a table of test results in a three-ring binder submitted with the as-built Drawings.
4. Provide an electronic version of test results and any cable test software required to read and evaluate results.

C. Fiber Optic Cable Testing.
1. Fiber testing shall be performed on all fibers in the completed end-to-end system. Testing shall consist of a bi-directional end to end OTDR trace, or a bi-directional end to end power meter test performed per TIA-455-C. The system loss measurement shall be provided at 850 and 1310 nanometers.
2. Pre-installation cable testing: Test all fiber optic cable prior to the installation of the cable. Assume all liability for the replacement of the cable should it be found defective after the installation.
3. Loss Budget: Fiber links shall have a Maximum Loss of:
   a) Maximum Loss = (allowable loss per km) (km of fiber in link) plus (.4dB) (number of connectors) Note: A mated connector-to-connector interface is defined as a Single connector.
   b) Loss numbers for the installed link shall be calculated by taking the sum of the bi-directional measurements and dividing that sum by two. Any link not meeting the requirements of the Maximum Loss shall be brought into compliance at no additional charge to the Owner.
4. Prepare a certification report listing the test results and both the calculated and measure loss for each fiber. Submit this report with the test results as called for in Article 1.5 SUBMITTALS.
5. The Structured Cabling Systems installer shall bring cables and/or strands not meeting the requirements of the standard into full compliance, at no additional cost to the Owner.
6. Document cable testing in accordance with Submittal paragraph. Provide a table of test results in a 3-ring binder submitted with the as-built Drawings.
7. Provide an electronic version of test results and any cable test software required to read and evaluate results.

3.12 TRAINING

A. Train systems administrative and/or maintenance personnel in procedures involved in operating, troubleshooting, servicing and preventative maintenance of each system specified. Provide no less than 20 hours of training, including:
1. Review of the physical configuration and interrelationship of the system

components.

2. Labeling and interconnection techniques used in the installation.
3. Applications of systems including any unique connections or interfaces required in the use of systems on site.
4. A review of warranty documents for the system.
5. A review of the Technical Manual prepared per "Closeout Submittals."
6. A Review of operation manuals and users guides for the system.
7. System operation and maintenance procedures.
8. Review of all user programmable options and how to modify options.

B. For each session, provide two thumb drive copies of recorded training. The Owner will not accept “train the trainer” models. Provide owner with complete user instructions used for training purpose as well as training log of all users who attended training classes.

3.13 CLEANING

A. Clean all equipment and work areas under this Section, prior to scheduling Owner training. Include wiping of Work areas and surfaces, and the removal of dust, streaks, stains, and all other contaminants from all equipment specified. Leave installed systems and components clean and undamaged.

END OF SECTION

SECTION 27 20 00
DATA COMMUNICATION SYSTEM

1.01 **GENERAL REQUIREMENTS**

A. This Section to be included in Sub-Bid for Section 26 00 10 ELECTRICAL.

B. Filed Sub-Sub Bid Requirements:

1. Sub-sub-bid requiring a paragraph “E” listing on the form for sub-bid required per M.G.L. Chapter 149 Section 44F, as amended to date. The Electrical Subcontractor shall be responsible for all related building preparation and coordination. See specification for additional Paragraph “E” listing requirements and coordination of responsibilities. Failure to meet or exceed these, as detailed in this specification, shall be grounds to reject the applicable bidder.
2. It is the sole intent of this Paragraph E listing to ensure to the end user, single source responsibility from a single qualified Data Communication System Provider listed as the Paragraph “E” sub-sub bidder for this Class of Work.

3. Paragraph E sub-subcontractors for the work of this section shall be factory authorized to provide the specified products. Trade Bidders shall be factory-authorized to provide the systems specified in order to list themselves as Paragraph E subcontractors.

B. Drawing and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 **SECTION INCLUDES**

A. Section includes Network Switch Electronics to support all building wide network needs including but not limited to local area network, voice communication systems, wireless network, building management systems, HVAC, Lighting Controls, and shall include but not be limited to.

1. Stackable Switches
2. Stackable Switches Power Supplies
5. Fiber Patch Cables
6. Uninterruptable Power Supply to support switches in NETWORK (MDF) and IDF rooms
7. Power Distribution Units
7. Installation, Configuration, Programing, Training, and Support
8. Wireless Access Points.

B. Work to be done under this SECTION is shown on the following technology drawings and related details: T0.10, T0.11, T1.11, T1.12, T1.13, T1.14, T0.20, T1.21, T1.22, T1.23, T1.24, T0.30, T1.31, T1.32, T1.33, T1.34, T1.41, T2.01, T2.02, T2.03, T2.04, T2.05, T2.06, T2.07, T2.08, T2.09, T2.10, T2.11, T2.12.

1.03 **RELATED WORK IN OTHER SECTIONS**

A. Section 01 91 13 General Commissioning Requirements
B. Section 07 84 00 Firestopping
C. Section 08 71 00 Door Hardware
D. Section 26 00 01 Electrical
E. Section 27 01 00 Structured Cabling System
F. Section 27 08 00 Communications Systems Commissioning
G. Section 27 30 00 Voice Communications System
H. Section 27 40 00 Audio-Video Communication Systems
I. Section 27 50 00 Distributed Communications System
J. Section 28 10 00 Integrated Security System

K. Section 01 30 00 – Administrative Requirements
L. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.
M. Technology workboxes, back boxes, floor boxes, conduits, sleeves, cable tray, corridor cable support and grounding systems are per Electrical Sections 26 05 29 and 26 05 33.

1.04 **TECHNICAL REFERENCES**

A. The product specifications, design considerations, and installation guidelines provided in this document are in part derived from recommendations found in recognized telecommunications industry standards. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed below, the more stringent requirements shall apply. The bidder is responsible for determining and referencing the most recent releases of all specifications during bidding and installation. Design, manufacture, test, and install all structured cabling systems per manufacturer's requirements and in accordance with NFPA 70 (National Electric Code), state codes, local codes, Underwriters Laboratories (U.L.), requirements of authorities having jurisdiction, ADA requirements, and the following specifications:
   1. Building Industries Consulting Services International (BICSI) Telecommunications Distribution Methods Manual (TDMM)
   2. BICSI Information Transport Systems Installation Manual (ITSIM)
   3. BICSI Network Systems and Commissioning (NSC) reference
B. In cases where product specifications, design considerations, and installation guidelines provided in this document conflict with the references listed above, the more stringent requirements shall apply. All references listed above were current during the development of this specification. The bidder is responsible for referencing the most recent releases when developing bid proposals.
C. This document does not take precedence over any code, either partially or wholly.

1.05 **QUALITY ASSURANCE**

A. The Data Communication System Installer shall have at least five years' experience in designing, installing, and testing Data Communication Systems similar to the system specified and described herein. Additionally:
   1. The Data Communication System Installer shall be fully certified by the manufacturer(s) of the systems specified and shall be in good standing with the manufacturer, having satisfied all training and product certification requirements of the Manufacturer.
   2. The Data Communication System Installer shall be at least an authorized dealer or value-added reseller of the system specified to be furnished and installed.
   3. The Data Communication System Installer shall utilize personnel who are fully trained and certified by the Manufacturer providing final system warranties on all equipment. The onsite supervisor/foreman shall have satisfied all training and product certification requirements of the Manufacturer specified and being installed.
   4. The Data Communication System Installer shall own and maintain tools and equipment necessary for successful installation and testing of all systems specified.
B. Installation Procedures: Adhere to the engineering, installation and testing procedures of the Manufacturer of the components specified, and use only the

cabling, components and methods of provisioning the Project authorized by the Manufacturer.

1.06 **SUBMITTALS**

A. General: Submit shop drawings, samples, and related submittals all together, at the same time, for coordinated review. Isolated items submitted shall not be reviewed until all items have been submitted for review.

B. Equipment List: Provide a detailed Equipment List showing quantities by manufacturer and model number of all major items of equipment and installation material to be used in the system as specified herein.

C. Product Data: Include complete sets of indexed cut sheets, in quantity as dictated by the project, of all major pieces of equipment, cable and connectors being supplied. Arrange these sheets in the order the equipment appears in the Specification. Clearly highlight information showing compliance with this and/or all applicable Specifications. In the event that the manufacturer or representatives' cut sheet contains more than one item, clearly indicate which items of the cut sheet are intended for installation.

D. Shop Drawings: Submit a set of complete Shop Drawings, by system, showing equipment to be installed, including but not limited to:

1. System configuration block diagrams of all equipment, indicating equipment type and model numbers. Show each and every component, system and subsystem, as well as all proposed connections between system components, and cable types connecting components.
2. Proposed layouts and elevations of equipment racks.
3. Wireless Heat Map based on wireless access point cabling provided under Section 27 01 00 STRUCTURED CABLING SYSTEM.

E. Quality Assurance Submittals:

1. Include certification from the manufacturer(s) that the Bidder is factory-authorized representative of all systems provided.
2. Include certification from the manufacturer that the Bidder is at least a Gold level dealer or value-added reseller with the manufacturer.
3. Include names, qualifications, and certifications of installation personnel including site Supervisor/Foreman who shall be in charge of, and responsible for, all activities at the job site for the duration of the Project. The job Supervisor/Foreman shall not be changed during the Project without notification and approval from the Owner.
4. References: Include a brief description of three projects of similar size and scope that the Bidder has completed within the last two years. Included the contact information of the primary awarding individual, including the address, telephone number and email address.
5. Complete description of the Warranty for the proposed system.

1.06 **DELIVERIES, STORAGE AND HANDLING**

A. Perform all tasks necessary to properly coordinate with all involved parties/trades for: Shipment, arrivals, loading dock, elevators (as applicable), acceptance, storage, and security of equipment and materials. Do not, during these tasks, interfere with other trades or the progress of this Project.

B. Assure that all deliveries are in correct quantities, within the appropriate times, and in compliance with all manufacturers' shipping instructions.

C. Protect all materials according to manufacturer's Specifications and/or instructions.

1.07 **SUBMITTALS AT PROJECT CLOSEOUT**

A. Technical Manual: Submit for approval a draft of the complete Technical Manual at least two weeks prior to the time of final system check out. When the final drafts are accepted, provide four copies of detailed technical manuals. The manuals shall include the following:
   1. Table of contents.
   2. Installer Name; contact name; address, telephone number, fax number, and email address.
   3. Product Information: Include original copies of manufacturer's installation and operating instructions, and service manuals, arranged alphabetically. All service manuals shall be originals; there shall be no Xerox copies of the service manuals and schematic supplied. Warranty information shall be filled out in the Owner's name.
   4. Detailed Description of the complete system and all subsystems.
   5. Maintenance Documentation: Include the following:
      a. Information necessary to perform routine and corrective maintenance by the Owner's technical staff, or other qualified technicians.
      b. List of all equipment by manufacturer, model or part number, and serial number.
      c. List of spare parts.
      d. Labeling info, asset database
   6. Submit written certifications that the installation conforms to Specification, is complete and operable, and ready for use by the Owner.

B. Technical Diagrams and Drawings:
   1. Simplified single line block diagrams showing the interconnection of all equipment and functional relationships for all systems specified. Show all equipment, patch panels, cables and jacks, and all other hardware, whether connected or not. The intent of these diagrams is to provide sufficient clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.

1.08 **SYSTEM WARRANTY, SERVICE AGREEMENT AND PERFORMANCE ASSURANCE**

A. Warranty all systems to be free of faulty workmanship and defects, and from damage due to contamination from the site for a period of five years from the date of final project completion.

B. The Warranties required by this section shall not be diminished by other warranties in the Contract Documents, equipment manufacturer's warranties, and all other rights and remedies available to the Owner under this Contract and public law. In addition, this Warranty shall not diminish the terms of individual manufacturer's warranties.

C. The Warranties required by this section shall be for the benefit of the Owner to whom Registration Certificate is issued and any successor in interest to the site.

D. Any repair or replacement of Cabling or Equipment resulting from this warranty shall be warranted for either (a) 90 days or (b) the remainder of the original warranty period, whichever is longer.

E. Service Agreement: The Data Communication System Installer shall respond to all requests for service during the warranty period. During this period, the Data Communication System Installer shall replace defective material and repair items of faulty workmanship at no charge to the Owner. All requests for service shall be responded to by telephone within two business hours, and technicians shall be dispatched within twenty-four hours. Only certified technicians shall be dispatched.

F. All software Assurance or equivalent is to be for 5 years.

1.09 **TRAINING OF OWNER'S PERSONNEL**

A. Conduct Training Program for the Owner's Administration Staff and other Users (See Article 3.5 Training in this Section). The Training Programs shall include detailed training on the use of Data Communication System equipment. Administrative training shall also include training of personnel responsible for managing the system. Schedule the Training Program at the convenience of the Owner, after the Technical Manual has been submitted and accepted. All materials in the Technical Manual shall be reviewed during the training program. All training sessions shall be videotaped with two copies provided to the Owner with closeout submittals.

1.10 **SYSTEM START UP AND COMMISSIONING**

A. During the installation of owner technology equipment not covered by this Specification, provide a full-time technician who is knowledgeable of the installation and configuration of the system to assist the Owner and Owner's technology vendor(s) with the configuration of network switches, troubleshooting, networking of Owner related equipment, and for general coordination purposes. The technician shall provide no less than eight hours per week during the six weeks of the installation and start up of Owner related equipment and two hours per day for the first four weeks of school, of the first full year of operation.

PART 2 PRODUCTS

2.01 **GENERAL**

A. It is the intent of the Specification that one manufacturer, not a combination, be selected for each particular class of material. A combination of manufactures for cabling and connectivity is acceptable, as long as the solution provides for a certified, warranted cable

B. Equipment specified is standard equipment that is used throughout the other schools, and the awarding authority has voted for this equipment to be specified as proprietary, which means that no substitutes shall be accepted. The only substitutions shall be those recommended by the manufacturer of the listed proprietary equipment, in the case that any of the specified equipment are superseded with newer versions of the same equipment or if any of the specified equipment is scheduled to reach end of life within 12 months of the completion of the project.

C. Other equipment, which is not listed as proprietary is specified as the basis of design because it is installed throughout the Owner's other public school facilities. It is the desire of the Owner for the same equipment to be installed on this project to assist the Owner with the daily maintenance, ongoing management, and support of their district wide security systems. The words, "or equal", are understood to follow all names of these specified products, trade names, catalog numbers, and detailed descriptions. "or equal" shall be interpreted to apply to any material, article, assembly or system, which in the opinion of the Owner is at least equal in quality, durability, appearance, strength and design to the materials specified, and shall perform at least equally in all aspects with the functions of the equipment specified, and installed in other schools. The words, "or equal", shall not be construed to permit departure from the detailed requirements of the Specification. The "or equal" provision of G.L. c.30, §39M(b) is hereby incorporated by reference. Other manufacturers' products accepted by the Awarding Authority shall be equal to the

specified products in terms of construction, quality, durability, performance, and appearance. Refer to Section 01 25 00 regarding product substitutions.

D. All materials and equipment shall be new and unused.

E. All part numbers and manufacturers shall be according to this Specification unless otherwise noted on the construction Drawings.

F. Provide all mounting hardware, shelving, bracketing, bracing, support members, required to support all cabling and equipment specified.

2.02 **MANUFACTURERS**

A. Acceptable manufacturers for the Data Communication System include:
   1. Networks Switches (Proprietary)
   2. Wireless Networks (Proprietary)
   3. UPS – APC, Eaton or accepted equal meeting the APC basis of design.

2.03 **NETWORK SWITCH ELECTRONICS**

A. Provide all equipment specified and shown on the plans. In cases of a discrepancy between the specification and the plans, provide the higher quantity and quantity product(s) specified/shown. All warranty and professional services start date shall be the date of Owner occupancy.

B. Provide network switches according to the following parts list:
   1. NETWORK ROOM (MDF): 149

1.0	2	MS450-32	48x 25G/10G/1G SFP28/SFP+/SFP ports and (two) 10G/1G SFP+/SFP ports and (eight) 100G/40G QSFP28/QSFP+ ports
1.1	3	MS355-48X2	Cisco Meraki layer 3 managed switch with (32) 10/100/1000/2.5G, (16) 100/1000/2.5G/5G, (eight) 10G/25G SFP+/SFP28, (two) 1200W power suuplies (redundant hot swappable), front to back airflow, rack mountable, PoE ++ (1800W).
1.2	3	LIC-MS355-ENT-1YR	Cisco Meraki 24 by seven Comprehensive Support extended service agreement (renewal), advance parts replacement, one year, shipment, reposne time
1.3	10	MA-SFP-10GB-LR	Cisco Meraki Transceiver. Connect transceiver modules at the top and bottom of the IDF the stack for maximum redundancy. Review topology with Owner prior to installation
1.4	38	MA-SFP-1GB-SX	Meraki transceiver module - 1GbE for exterior pole-mounted cameras
1.5	2	MA-CBL-40G-1M	Meraki 40GE Direct Attach Cable- SFP28 (M) to SFP28 (M) – 1m

1.6	1	MA-CBL-40G-3M	Meraki 40GE Direct Attach Cable- SFP28 (M) to SFP28 (M) – 3m
1.7			Meraki limited lifetime warranty on all switches and accessories
1.8	1		Eaton PDUMH20 PDU, or equal
1.9	1		APC SRT3000RMXLT-5KTF UPS with transformer, appropriate rail kit, AP9641 Management Card, AP9335TH Temp and Humidity Sensor, or equal
1.10			Three year repair or replace warranty on UPS. Two year repair or replace warranty on battery
1.11			Two year warranty on PDU

2. IDF 229:

2.1	10	MS355-48X2	Cisco Meraki layer 3 managed switch with (32) 10/100/1000/2.5G, (16) 100/1000/2.5G/5G, (eight) 10G/25G SFP+/SFP28, (two) 1200W power suuplies (redundant hot swappable), front to back airflow, rack mountable, PoE ++ (1800W).
2.2	10	LIC-MS355-ENT-1YR	Cisco Meraki 24 by seven Comprehensive Support extended service agreement (renewal), advance parts replacement, one year, shipment, reposne time NBD for FS-648F-FPOE.
2.3	2	MA-SFP-10GB-LR	Cisco Meraki Transceiver. Connect transceiver modules at the top and bottom of the IDF the stack for maximum redundancy. Review topology with Owner prior to installation
2.4	9	MA-SFP-1GB-SX	Meraki 40GE Direct Attach Cable- SFP28 (M) to SFP28 (M) – 1m
2.5	1	MA-CBL-40G-1M	Meraki 40GE Direct Attach Cable- SFP28 (M) to SFP28 (M) – 3m
2.6			Meraki limited lifetime warranty on all switches and accessories
2.7	2		Eaton PDUMH20 PDU, or equal
2.8	1		APC SRT3000RMXLT-5KTF UPS with transformer, appropriate rail kit, AP9641

			Management Card, AP9335TH Temp and Humidity Sensor, or equal
2.9			Three year repair or replace warranty on UPS. Two year repair or replace warranty on battery
2.10			Two year warranty on PDU

3. IDF 203:

3.1	8	MS355-48X2	Cisco Meraki layer 3 managed switch with (32) 10/100/1000/2.5G, (16) 100/1000/2.5G/5G, (eight) 10G/25G SFP+/SFP28, (two) 1200W power suuplies (redundant hot swappable), front to back airflow, rack mountable, PoE ++ (1800W).
3.2	8	LIC-MS355-ENT-1YR	Cisco Meraki 24 by seven Comprehensive Support extended service agreement (renewal), advance parts replacement, one year, shipment, reposne time NBD for FS-648F-FPOE.
3.3	2	MA-SFP-10GB-LR	Cisco Meraki Transceiver. Connect transceiver modules at the top and bottom of the IDF the stack for maximum redundancy. Review topology with Owner prior to installation
3.4	7	MA-SFP-1GB-SX	Meraki 40GE Direct Attach Cable- SFP28 (M) to SFP28 (M) – 1m
3.5	1	MA-CBL-40G-1M	Meraki 40GE Direct Attach Cable- SFP28 (M) to SFP28 (M) – 3m
3.6			Meraki limited lifetime warranty on all switches and accessories
3.7	2		Eaton PDUMH20 PDU, or equal
3.8	1		APC SRT3000RMXLT-5KTF UPS with transformer, appropriate rail kit, AP9641 Management Card, AP9335TH Temp and Humidity Sensor, or equal
3.9			Three year repair or replace warranty on UPS. Two year repair or replace warranty on battery
3.10			Two year warranty on PDU

4. Spare Equipment:

4.1	1	MS355-48X2	Cisco Meraki layer 3 managed switch with (32) 10/100/1000/2.5G, (16) 100/1000/2.5G/5G, (eight) 10G/25G SFP+/SFP28, (two) 1200W power suuplies (redundant hot swappable), front to back airflow, rack mountable, PoE ++ (1800W).
4.2	1	LIC-MS355-ENT-1YR	Cisco Meraki 24 by seven Comprehensive Support extended service agreement (renewal), advance parts replacement, one year, shipment, reposne time NBD for FS-648F-FPOE.
4.3	2	MA-SFP-10GB-LR	Cisco Meraki Transceiver. Connect transceiver modules at the top and bottom of the IDF the stack for maximum redundancy. Review topology with Owner prior to installation
4.4	4	MA-SFP-1GB-SX	Meraki transceiver module - 1GbE for exterior pole-mounted cameras
4.5	4	MA-CBL-40G-1M	Meraki 40GE Direct Attach Cable- SFP28 (M) to SFP28 (M) – 1m
4.6	4	MA-CBL-40G-3M	Meraki 40GE Direct Attach Cable- SFP28 (M) to SFP28 (M) – 3m

C. Network Switch Accessories:
   1. Multimode OM4 Fiber Patch Cables (one meter) for connecting switches in MDF and IDF rooms to multimode mode fiber between rooms and between school and WAN. (Quanty 20, which includes spares)
   2. Single Mode Fiber Patch Cables (one meter) for connecting switches in the MDF room to the Wide Area School Network (Quantity four)
   3. All cables and software necessary for connectivity.

D. Uninterruptible Power Supplies (UPS) as specified, shall provide battery backup in each IDF and MDF room to carry all switch loads between a power failure and emergency generator power. Provide SRTRK4 APC Smart-UPS 19 Inch Rail Kit for each UPS for mounting in either four-post or two-post racks. Final determination of where the UPS will be mounted will be made by the Owner. Include enough power cable to reach power receptacle outlets above racks. Provide products that fit in specified racks in Section 270100 STRUCTURED CABLING SYSTEM and connect to power receptacles provided and shown by Division 26.

E. AP9641 UPS Network Management Card with Environmental Monitoring Card per UPS.
F. The Power supply of each network switch shall be directly connected to separate UPS's.

2.04 **WIRELESS ELECTRONICS**

A. Wireless Network Hardware
   1. Indoor General Access Points: Meraki R770
   2. Exterior Access Points: Meraki T750
   3. Protective covers for Gymnasium access points
   4. Ceiling and Wall mounting brackets
   5. Mounting Bracket for exterior Locations
   6. Wireless Access Point Licensing (Three Years)
   7. Manufacturer Heat Map (provide with Section Submittals)

2.05 **UNSPECIFIED EQUIPMENT AND MATERIAL**

A. Any item of equipment or material not specifically addressed on the Drawings or in this document and required to provide a complete and functional installation shall be provided in a level of quality consistent with specified items.

PART 3 EXECUTION

3.01 **INSTALLATION, GENERAL**

A. Pre-installation: Meet with the Construction Manager, Project manager, and any other appropriate parties for coordination meeting prior to beginning work and to coordinate requirements.
B. Coordinate Work with adjacent Work of other trades to facilitate installation and prevent conflicts.
C. Staff job appropriately to keep pace with the Project schedule.
D. Abide by the decision of the Architect to case of conflict or interference of the other trades.
E. Work under this Section shall be performed in accordance with associated local, state, and national building codes.
F. Coordinate requirements of ceiling and floor mounted outlets with the Electrical Contractor.
G. If the Data Communication System Installer shall re-enter an area of a previously completed phase of Work, the Installer shall be responsible for returning that area back to the condition it was in before the Installer re-entered the area. This includes re-installing ceiling tiles, cover plates, cleaning floors, and all other services required. Coordinate the cutting and patching of holes with the Construction Manager, and comply with the Cutting and Patching Section.
H. The Communication System Installer is responsible for furnishing and installing all Category 6A between patch panel ports and switch ports, and all fiber patch cables between the fiber optic backbone and the network electronics.
I. The Communication System Installer shall furnish and install all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware required to ensure that all equipment is properly installed and supported according to the manufacturer's recommendations.
J. Make modifications for system functionality and full network connectivity of equipment specified in related sections and Owner's equipment. Make all necessary modifications to the network configuration during installation of Owner equipment. Coordinate with Owner's vendors during all programming.
K. Take precautions to prevent and guard against electromagnetic and electrostatic

interference. Avoid potential sources of EMI in all aspects of installation. If interference is experienced, the Communication System Installer shall provide all required testing to identify the source of interference and provide a remedy including but not limited to re-routing and/or replacing cables

L. Prior to ordering equipment, meet with the Owner and Owner representatives to confirm bill of materials and to review the network design and general installation plan of all equipment. Prior to installing equipment, meet a second time with the Owner and Owner representatives to confirm the installation and configuration requirements of all equipment.

3.02 **NETWORK SWTICHES AND ACCESSORIES**

A. Un-box and install all equipment in the various rooms. Dispose of all refuse from site.

B. Conduct onsite meetings with all involved parties to discuss network design considerations for the deployment of the network switches. Conduct on-site data collection meetings with the Owner, other system installers, and technology vendors to obtain details and requirements such as IP addresses, switch names, VLAN names and numbers, WLAN connectivity, district fiber connectivity, to create the design for the network. Document all requirements and provide regular updates to the Owner and all involved parties.

C. Review all configuration and programming options with the Owner and preconfigure switches and network according to Owner requirements.

D. Install UPS in equipment racks designated for equipment in MDF room and IDF and connect UPSs to power source and test UPS prior to installation of all switch equipment.

E. Install all switch hardware in racks in MDF and IDF rooms and connect switches to UPS.

F. Communicate with SECTION 270100 STRUCTURED CABLING SYSTEM for the quantity, color, and lengths of patch cords based on the location of switch hardware relative to patch panels in the racks.

G. Configure all network equipment and assign proper IP address information and create VLANs for all Owner equipment and services being connected to the network as well as other systems being provided by Owner vendors and/or project related systems installers.

1. Configuration of network switches shall support other systems to include but not be limited to the wireless network hardware, classrooms audio-video equipment. video over IP distribution systems, servers, firewalls, networked computers and printers, VoIP equipment, HVAC system, Lighting Controls, Building Management System, Public Address System, and Security Surveillance, Access control and Intrusion alarm systems.
2. Configuration of the network switches shall support other building services to include but not be limited to internet service provider, Telco, CATV, Fiber WAN, and any other service provider required to connect to the school’s network.
3. All programming and configuration of network switches shall be provided by a certified Fortinet network engineer(s).

H. Contact and coordinate with the manufacturers/vendors of all devices and appliances connecting to the network to determine specific requirements and make the necessary ACLs and programming attributes.

I. Contact and coordinate with developers/vendors of all applications to determine specific requirements (i.e. QoS, Multicast requirements) and make the necessary programming attributes.

J. Document all third-party vendors/manufacturers/developers specific network settings and provide to the Owner.
K. Provide turn-key programming and configuration for the network in accordance with Owner's requirements, providing connectivity for all systems.
L Install and dress appropriate size patch cords between active switch ports and all patch panel ports.
M. Work directly and coordinate closely with the Owner's IT staff and Owner's equipment vendors during Owner equipment installations and provide any and all programming, integration, configuration and other network related services.
N. Provide a certified network engineer on site, full time for the duration of Owner equipment installation, testing and commissioning.
O. Integrate all network switches into the Owner's networking environment and management console.
P. Provide testing of the network for full connectivity (access layer to Internet, servers, district head end, and other devices to provide a complete and fully functional sytem.
Q. Collect all configuration files created and provide to the Owner at project completion.
R. Startup Installation Support:
    1. Provide one certified network engineer on site, full time during the first week of school to assist the Owner's technology staff with startup and connection of all equipment and to make all necessary and requested modifications to the network switches.

3.03 **WIRELESS ACCESS POINTS**

A. Perform predictive heat map based on a set of the architectural plans of completed facility and verify optimal locations for placing wireless access radios for maximum coverage of the facility utilizing existing cabling designated for wireless access points.
B. Submit heat map and location recommendations as part of submittal package.
C. Coordinate with architect and Owner's Project Manager for the installation of a sample installation of a wireless AP in both suspended ceiling and at a wall location for review and approval by the architect and Owner's Project Manager prior to the installation of AP's
D. Coordinate locations and installation methods of access points with Architect, including how to interface with existing building wide structured cabling system.
E. Prior to installation of wireless access points provide the following for review and approval by the Owner's Project Manager (OPM), architect and Owner's Project Manager.
    1. Complete sample classroom mockup of a wireless access point installed on suspended ceiling tile.
    2. Complete sample mockup of a wireless access point installed on an interior wall surface.
    3. Complete sample mockup of an exterior wireless access point (if indicated on plans).
F. Install wireless access radios at pre-wired locations and any other locations required as an outcome of the Heat Map.
G. Wireless access points being mounted to the suspended ceiling tile grid shall be mounted with appropriately sized and/or modified brackets so that ceiling tiles lie flat in the ceiling grid after the access points are fully installed.
H. Make pass-through hole in the ceiling tile using accepted methods by OPM and Architect for running a patch cord through from wireless access point to the data jack above the finished ceiling serving the wireless access point. Patch cords shall be

white and furnished by section 270100 STRUCTURED CABLING SYSTEM and installed by section 272000 DATA COMMUNICATIONS SYSTEMS.

I. Ensure that both the patch cord and passthrough hole through the ceiling tile are not visible from anywhere below the installed wireless access point.
J. Wall mount access points shall be mounted to wall mounted WAP data outlet work box using manufacturer wall mount bracket in order to conceal data outlet including data jacks, connections, and patch cord behind access point.
K. Closet side patch cords shall be furnished by section 270100 STRUCTURED CABLING SYSTEM and installed by section 272000 DATA COMMUNICATION SYSTEMS.
L. Provide tie wraps for a neat and professional installation.
M. Install and implement a complete wireless access system with specified and accepted AP's with input from the Owner during the system configuration. Provide test reports and verify functionality, coverage and performance of the final installed system.
N. Make all necessary modifications for system functionality and full connectivity of all equipment. All programming and configuration shall be provided by an Extreme certified specialist.
O. Startup Installation Support
    1. Provide one wireless certified network engineer on site, full time during the first week of school to assist the Owner's technology staff with startup and connection of all equipment and to make all necessary and requested modifications to the wireless network.
P. Fully install and configure all related software on Owner's virtual server.

3.04 **INSTALLATION SUPPORT**

A. Provide a network engineer familiar with the installation for 40 hours during Owner's other equipment installations to assist in the networking of Owner's other systems. Owner's other systems shall include but are not limited to building systems (lighting, HVAC, and Building Management System); computers systems; core server storage and firewall systems; public address systems, and; audio visual systems. This block of hours is not intended to complete work governed by this Section, but to provide assistance to the Owner in networking of other Owner related equipment.
B. After the first week of school, provide one certified network engineer who is familiar with the installation for eighty hours at the Owner's request during the first six weeks of school to assist the Owner's technology staff with all network and wireless equipment issues. Whatever hours are not required during the first six weeks shall be provided over the course of the school year at the Owner's request.
C. Make all necessary and requested modifications to the network switch and wireless configuration during this period of time after school's opening.

3.05 **TESTING**

A. Test all switch ports for functionality and connectivity and proper configuration. Verify configurations. Make all necessary modifications for system functionality and full network connectivity of equipment specified in related sections and Owner's equipment. Make all necessary modifications to the network configuration during installation of Owner equipment.
B. The system shall be fully tested by the Data Communication System installer prior final to project signoff to ensure that all equipment and systems are fully functional. Systems are defined as functional when all equipment is connected and working as intended with all end user devices. All testing shall be completed in accordance with

the project schedule. Testing shall include but not be limited to:

1. Proper connection of all equipment and verification that all Aps are operational, and properly configured on Owner's Extreme Cloud Network platform.
2. Verification of all SSIDs.
3. Verification of VLANs of each SSID.
4. Confirmation of channel assignments.
5. Bandwidth/Speed tests for each AP and SSID.

C. The installer shall perform a post-installation active wireless site survey to identify any interference and to confirm coverage in all areas.

D. The installer shall make modifications to the system including but not limited to signal power setting adjustments and locations of Aps to optimize performance, where necessary.

E. The installer shall provide a Microsoft Excel (latest version) based test report detailing the date of testing, room name and number, equipment tested, type of tests conducted, and the results of testing in each space. Test report shall not be submitted until all systems have been fully tested and confirmed as fully functional by the installer.

F. The installer shall provide the Owner with a 90-day period of acceptance testing, beginning on the first day of school after the installer has completed their testing. This will give end users an opportunity to test the network under normal operating conditions, identify any recurring performance issues, and to be sure that the system will function properly long term. The Owner will be entitled to a refund to correct any performance issues within 30 days of being notified of an issue during the acceptance testing period."

3.06 **TRAINING**

A. Train systems administrative and/or maintenance personnel in procedures involved in operating, troubleshooting, servicing and preventative maintenance of each system specified. Provide no less than 20 hours of training to review the following at a minimum:

1. Physical configuration and interrelationship of the system components.
2. Labeling and interconnection techniques used in the installation.
3. All system configurations and how to make modifications.
4. Warranty documents for the system.
5. Technical Manual prepared per "Closeout Submittals."
6. System operation and maintenance procedures.

B. For each session, provide two thumb drives of recorded training. The Owner will not accept "train the trainer" models. Provide owner with complete user instructions used for training purpose as well as training log of all users who attended training classes.

3.07 **CLEANING**

A. Clean all equipment and work areas under this Section, prior to scheduling Owner training. Include wiping of work areas and surfaces, and the removal of dust, streaks, stains and all contaminants from all equipment specified. Leave installed systems and components clean and undamaged.

END OF SECTION

SECTION 27 30 00
VOICE COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section to be included in Sub-Bid for Section 26 00 10 ELECTRICAL.

B. Filed Sub-Sub Bid Requirements:

1. Sub-sub-bid requiring a paragraph “E” listing on the form for sub-bid required per M.G.L. Chapter 149 Section 44F, as amended to date. The Electrical Subcontractor shall be responsible for all related building preparation and coordination. See specification for additional Paragraph “E” listing requirements and coordination of responsibilities. Failure to meet or exceed these requirements, as detailed in this specification, shall be grounds to reject the applicable bidder.
2. It is the sole intent of this Paragraph E listing to ensure to the end user, single source responsibility from a single qualified Voice Communication System installer listed as the Paragraph “E” sub-sub bidder for this Class of Work.
3. Paragraph E sub-subcontractors for the work of this section shall be factory authorized to install the specified products. Trade Bidders shall be factory-authorized to install the specified systems in order to list themselves as Paragraph E subcontractors.

C. Drawing and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

A. Section includes state of the art Voice over IP Telephone system to support all building telephone communication needs and shall include but not be limited to the following:

1. VOIP System Controller.
2. Voicemail System.
3. IP Phones for classrooms, general offices, administration, and conference rooms.
3. Unified Communications including E-911.
4. All licensing and Software Assurance.
5. Standalone UPS.
6. Integration with Owner’s public address system.
7. Integration with the Owner’s service provider.
8. Complete programing and configuration of system to the Owner’s specific requirements.
9. System administration and user training

B. Work to be done under this SECTION is shown on the following technology drawings and related details: T0.10, T0.11, T1.11, T1.12, T1.13, T1.14, T2.20, T1.21, T1.22, T1.23, T1.24, T0.30, T1.31, T1.32, T1.33, T1.34, T1.41, T2.01, T2.02, T2.03, T2.04, T2.05, T2.06, T2.07, T2.08, T2.09, T2.10, T2.11, T2.12.

1.03 RELATED WORK IN OTHER SECTIONS

A. Section 01 91 13 MEP Commissioning

B. Division 26 00 10 Electrical

C. Division 27 01 00 Structured Cabling System

D. Section 27 08 00 Communications Systems Commissioning

E. Division 27 50 00 Distributed Communications System
F. Section 01 25 00 Substitution Procedures
G. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.
H. Technology workboxes, back boxes, floor boxes, conduits, sleeves, cable tray, corridor cable support and grounding systems are per Electrical Section 26 00 01.

1.04 **TECHNICAL REFERENCES**

A. The product specifications, design considerations, and installation guidelines provided in this document are in part derived from recommendations found in recognized telecommunications industry standards. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed below, the more stringent requirements shall apply. The bidder is responsible for determining and referencing the most recent releases of all specifications during bidding and installation. Design, manufacture, test, and install all structured cabling systems per manufacturer's requirements and in accordance with NFPA 70 (National Electric Code), state codes, local codes, Underwriters Laboratories (U.L.), requirements of authorities having jurisdiction, ADA requirements, and the most current version of the following specifications:
   1. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
   2. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard.
   3. ANSI/TIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
   4. ANSI/TIA-569-C, Telecommunications Pathways and Spaces.
   5. Building Industries Consulting Services International (BICSI) Telecommunications Distribution Methods Manual (TDMM)
   6. BICSI Information Transport Systems Installation Manual (ITSIM)
   7. ISO/IEC 18010, Pathways and Spaces for Customer Premises Cabling
   8. TIA-942-A-1, Telecommunications Infrastructure Standard for Data Centers
   9. ANSI-J-STD-607-A, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   10. ISO/IEC 11801, Information Technology – Generic cabling for Customer Premises
   11. TIA-862, Building Automation Systems Cabling Standard for Commercial Buildings
   12. ISO/IEC 14763, Implementation and Operation of Customer Premises Cabling
   13. TIA/EIA-606-A, Administration Standard for Commercial Telecommunications Infrastructure
   14. IEEE Standard 802.3an – 10GBASE-T over copper twisted pair cable

A. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed above, the more stringent requirements shall apply. All references listed above were current during development of this publication. The bidder is responsible for referencing to the most recent releases when developing bid proposals.
B. This document does not take precedence over any code, either partially or wholly.

1.05 **SUBMITTALS**

A. General: Submit shop drawings, samples, and related submittals all together, at the same time, for coordinated review. Isolated items submitted shall not be reviewed

until all items have been submitted for review.

B. Equipment List: Provide a detailed Equipment List showing quantities by manufacturer and model number of all major items of equipment and installation material to be used in the system as specified herein.
C. Product Data: Include complete sets of indexed cut sheets, in quantity as dictated by the project, of all major pieces of equipment, cable and connectors being supplied. Arrange these sheets in the order the equipment appears in the Specification. Clearly highlight information showing compliance with this and/or all applicable Specifications. In the event that the manufacturer or representatives' cut sheet contains more than one item, clearly indicate which items of the cut sheet are intended for installation.
D. Shop Drawings: Submit a set of complete Shop Drawings, by system, showing equipment to be installed, including but not limited to:
    1. System configuration block diagrams of all equipment, indicating equipment type and model numbers. Show each and every component, system and subsystem, as well as all proposed connections between system components, and cable types connecting components.
    2. Proposed layouts and elevations of equipment racks.
E. Close-Out Submittals:
    1. Technical Manual: Submit for approval a draft of the complete Technical Manual at least two weeks prior to the time of final system check out. When the final drafts are accepted, provide five copies of detailed technical manuals. The manuals shall include the following:
        a. Table of contents.
        b. Installer Name; contact name; address, telephone number, fax number, and email address.
        c. Product Information: Include original copies of manufacturer's installation and operating instructions, and service manuals, arranged alphabetically. All service manuals shall be originals; there shall be no Xerox copies of the service manuals and schematic supplied. Warranty information shall be filled out in the Owner's name.
        d. Detailed Description of the complete system and all subsystems.
        e. Maintenance Documentation: Include the following:
            1) Information necessary to perform routine and corrective maintenance by the Owner's technical staff, or other qualified technicians.
        f. List of all equipment by manufacturer, model or part number, and serial number.
        g. List of spare parts.
    2. Submit written certifications that the installation conforms to Specification, is complete and operable, and ready for approval by the Architect.
    3. Technical Diagrams and Drawings:
        a. Simplified single line block diagrams showing the interconnection of all equipment and functional relationships for all systems specified. Show all equipment, patch panels, cables and jacks, and all other hardware, whether connected or not. These drawings shall be on Engineering size E, 36 inches by 48 inches. The intent of these diagrams is to provide sufficient clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.
        b. All technical diagrams and drawings shall be mounted on the wall behind a

clear plastic cover for protection. There shall be one set of the above drawings and diagrams provided for the Head End Room/MDF.

1.06 **QUALITY ASSURANCE**

A. The Voice Communication System installer shall have at least ten years' of experience in designing, installing, and testing voice communication systems similar to what is specified and described herein. Additionally, the Voice Communication System installer shall:
   1. Be fully certified by Avaya and be in good standing with the manufacturers, having satisfied all training and product certification requirements of each Manufacturer.
   2. Include proof that the installer is both trained and certified by the manufacturer to represent, furnish, install, and support the specified system for projects similar in size/complexity to the Scituate Hatherly Elementary School project.
   3. Utilize personnel who are fully trained and certified by Avaya, providing final system warranties on all equipment. The onsite supervisor/foreman shall have satisfied all training and product certification requirements of Avaya.
   4. Own and maintain tools and equipment necessary for successful installation and testing of all specified systems.

B. The Voice Communication System shall adhere to the engineering, installation and testing procedures of the Manufacturer of the components specified, and use only the cabling, components and methods of provisioning the Project authorized by the Manufacturer(s).

1.07 **DELIVERIES, STORAGE AND HANDLING**

A. Perform all tasks necessary to properly coordinate with all involved parties/trades for: Shipment, arrivals, loading dock, elevators (as applicable), acceptance, storage, and security of equipment and materials. Do not, during these tasks, interfere with other trades or the progress of this Project.

B. Assure that all deliveries are in correct quantities, within the appropriate times, and in compliance with all manufacturers' shipping instructions.

C. Protect all materials according to manufacturer's Specifications and/or instructions.

1.08 **SYSTEM WARRANTY, SERVICE AGREEMENT AND PERFORMANCE ASSURANCE**

A. Warranty all systems to be free of faulty workmanship and defects, and from damage due to contamination from the site for a period of five years from the date of final project completion.

B. The Warranties required by this section shall not be diminished by other warranties in the Contract Documents, equipment manufacturer's warranties, and all other rights and remedies available to the Owner under this Contract and public law. In addition, this Warranty shall not diminish the terms of individual manufacturer's warranties.

C. The Warranties required by this section shall be for the benefit of the Owner to whom Registration Certificate is issued and any successor in interest to the site.

D. Any repair or replacement of Cabling or Equipment resulting from this warranty shall be warranted for either (a) 90 days or (b) the remainder of the original warranty period, whichever is longer.

E. Service Agreement: The Voice Communication System installer shall respond to all requests for service during the warranty period. During this period, the Voice Communication System installer shall replace defective material and repair items of faulty workmanship at no charge to the Owner. All requests for service shall be responded to by telephone within two business hours, and technicians shall be dispatched within twenty-four hours. Only certified technicians shall be dispatched.

1.09 **SEQUENCING AND SCHEDULING**

A. A set of “as-built” documents shall be provided to the Owner by the Voice Communication System installer showing the unique label (based on actual final room numbering) for each device installed.

1.10 **TRAINING OF OWNER'S PERSONNEL**

A. Conduct a Training Program on the proper use of the system.
B. The Training Program shall include a demonstration of the configuration of all systems for the IT Staff
C. End-user training for all School Staff.
D. Schedule the Training Program at the convenience of the Owner, after the Technical Manual has been submitted and accepted. All materials in the Technical Manual shall be reviewed during the training program. All training sessions shall be videotaped with five copies provided to the Owner with closeout submittals.

1.11 **SYSTEM START UP AND COMMISSIONING**

A. During the first full week of operation by the Owner at the start of the School year, provide a full time technician who is knowledgeable of the installation and the configuration of the system to assist the Owner with issues and questions that may arise or changes that may need to be made to the system during the first full week of School.

PART 2 PRODUCTS

2.0 **GENERAL**

A. It is the intent of the Specification that one manufacturer, not a combination, be selected for each particular class of material
B. Certain equipment is listed by manufacturer and model number. This is to define and establish a level of quality and functionality. The words, "or equal", are understood to follow all names of these specified products, trade names, catalog numbers, and detailed descriptions. It shall be interpreted to apply to any material, article, assembly or system, which in the opinion of the Owner is at least equal in quality, durability, appearance, strength and design to the material specified, and shall perform at least equally the functions imposed by the general design. The words, "or equal", shall not be construed to permit departure from the detailed requirements of the Specification. Other manufacturers’ products accepted by the Awarding Authority shall be equal to the specified products in terms of construction, quality, durability, performance, and appearance. Refer to Section 01 25 00 regarding product substitutions.
C. All materials and equipment shall be new and unused.
D. All part numbers and manufacturers shall be according to this Specification unless otherwise noted on the construction Drawings.
E. Provide all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware required to support all cabling and equipment specified.

2.01 **MANUFACTURERS**

A. Acceptable “or equal” manufacturers for the Voice Communication System include:
   1. Yealink (Proprietary)

2.02 **TELEPHONE SYSTEM**

A. The project consists of a new VOIP-Based telephone, voice mail, handsets, turn-key installation, programming, training, warranty, and post-installation support.
B. Manufacturers shall be Avaya. The Telephone System and Voicemail system shall be provided from the same manufacturer Avaya. The dealer/provider shall be an

authorized reseller for not less than 6 years, in good standing at the time of bid and for the duration of this project, authorized to sell, service and support the specified products.

C. Provide all equipment, power supplies, interfaces, media modules, cards, cables, brackets, rack mounting hardware, and equipment required for a fully functional system. The system shall consist of the latest version of software, and include the following minimum equipment, licenses and features.
   1. Enterprise Zoom Licenses and Voicemail for all phones.
   2. Dedicated 15-minute Rack Mountable Uninterruptible Power Supply (UPS) for all head end equipment. The UPS shall also protect the system from primary power source fluctuations and be used for only the Voice Communication System equipment.
   3. Integration with the Owner's paging/intercom system. The Voice Communication System installer shall provide interface units, cabling, and licenses to connect the system to the Owner's paging/intercom system. The installer shall work closely with the installer of the paging/intercom system under Section 27 50 00 DISTRIBUTED COMMUNICATION SYSTEM for making all connections between the Voice Communication System and the paging/public address system so that public address announcements can be made from any telephone station by dialing an authorized access code.
   4. E911 capabilities are required by the proposed telephony solution so that it can do a 'crisis alert' process at individual unique stations for public use to notify security of an emergency call. The proposed solution system also supports the sending of emergency calls to the appropriate public safety answering point (PSAP) for the caller's location and supports the ability of the PSAP to identify the caller's location, meeting State Laws and E-911 regulations and Ray Baum's Act.
      a. The emergency calling solution shall automatically track and update equipment moves and changes for Emergency 911 safety and security purposes.
      b. All 911 calls initiated shall automatically be routed to the PSAP while providing local notification in the form of notification to designated telephony devices.
      c. The system shall support CESID (Customer Emergency Services ID). A CESID is a unique number that accompanies a 911 call when it arrives at a PSAP. The CICID is then utilized to screen pop information about the location of a caller. The Voice Communication System installer shall work with the Carrier Service Provider to accomplish the implementation of the Ray Baum's Act.
   5. The System shall be equipped to support services from 23 SIP Trunks and have the capability to support SIP Trunks, POTS, and Ethernet services.
   6. All licenses required for Phones, Voice Mail, Unified Messaging, and all other components shall be included.
   7. The System shall be equipped at a minimum with six analog trunk ports for back up to 23 SIP Trunks or some type of backup solution.
   8. The System shall provide seamless IP Networking across multiple sites when needed without additional charge, including clustering the new solution with the existing Yealink (Zoom) environment at the existing schools.
   9. Support all industry standard networking protocols.

10. Unlimited help desk support for the duration of the project.
11. Unlimited, remote adds, moves and changes for the duration of the project.
12. The Installer shall provide Live Answer Support 7days/week by 24hours/day by 365 days per year.
13. The system shall be equipped with the following minimum requirements:
    a. System shall be equipped for Six Central Office trunks for back up to be wired to analog phones for Disaster Recovery.
    b. The system shall be equipped for minimum of 23 SIP Trunk Licenses.
    c. The system shall be equipped with all licenses required for all IP phones specified.
14. Wall Phones (P): Phones shall be an Yealink T33G IP phone, with wall mounting bracket or equal. Provide all necessary mounting hardware for wall phone locations.
15. Desk/Office Phones (P1): Phones shall be an Yealink T46U IP Phone. Provide all necessary mounting hardware for wall phone locations.
16. Administration Phones (P2): Six total phones with five installed and one spare phone. Phones shall be Yealink T54W IP phone, with HD audio through the voice optimized handset, Bluetooth 4.1 interface with MobileLink mobile integration, mobile phone USB charging point General phone locations are shown on the technology outlet plans. Coordinate exact locations and any additional locations with Owner prior to installation.
17. Conference Room Phones (P3): two total phones, one installed and one spare phone. Phone shall be Yealink CP965or equivalent with multi-party audio conferencing, in-room presentation display, and remote collaboration for personal offices and conference rooms.
18. The Expansion Module shall be Yealink EXP50 Expansion Module. Provide expansion modules for each of the main office phone locations.
19. Provide emergency transfer of CO lines during a power outage. Provide emergency transfer panels, cabling, cross connections, as well as two analog phones to be located in the school by the Owner, utilizing Owner's data network cabling system.
20. 10-minute Uninterruptible Power Supply (UPS) for communication only head end equipment. The UPS shall also protect the system from primary power source fluctuations.

PART 3 EXECUTION

3.01 INSTALLATION GENERAL

A. Pre-installation: Meet with the Construction Manager, Project manager, and any other appropriate parties for coordination meeting prior to beginning work and to coordinate requirements.

B. Conduct detailed station reviews. Station reviews shall include meetings with the Owner to determine the exact requirements of the system at the facility, and properly apply the capabilities of the system to each individual station.

C. Provide coordination with all parties concerned, including both local and long distance telephone service providers, to ensure all necessary features and hardware components are provided**.** The Voice Communication System installer shall inform the Owner immediately upon discovery of any issues, including lack of or delay in obtaining critical information that would affect a successful Cut over. Assumptions

regarding configuration and service shall not be made and any questions regarding alternatives are to be brought to the Owner's attention for a decision.

D. Conduct endpoint reviews, otherwise referred to as "station reviews" with designated department and school personnel to receive input for customization. The database record shall be maintained throughout the project in Excel format and incorporated into a project workbook, describing functionality at all stations for Owner review and approval. Include the following, at a minimum:
   1. Extension
   2. IP address where applicable
   3. First and Last Name
   4. Building
   5. Floor
   6. Department
   7. Function or Title
   8. Jack Number
   9. Cable Pair
   10. Cable Reference
   11. Name Display Data
   12. Restriction Service Class
   13. Service Feature Class
   14. Voice Mailbox
   15. System performance/cutover during power failures
   16. Call Processing/Forwarding
E. All equipment shall be labeled clearly and accurately.
F. Provide complete turn-key engineering and customizing of the telephone and voice mail systems.
G. All equipment supplied shall be new and contain only factory accepted devices, which shall not void any equipment warranty.
H. The telephone and voice mail equipment shall reside in the MDF/Head End Room.
I. Install all system components according to Manufacturer recommendations and industry accepted installation methods.
J. Telephone and Voice Mail systems shall have 10-minutes of uninterrupted back up power in the event of power failure. UPS shall be rack mounted. Connect to emergency backup power.
K. Assist the school with ordering telephone service in a timely manner and work with the School District and the Telco line provider to connect all lines to the system. The Voice Communication System installer shall connect all cabling and PRI, SIP, and POTS lines terminated by local exchange carrier, and voice riser cabling. The installer shall also provide all mounting hardware required.
L. The Voice Communication System installer shall program and deploy all telephones, in a neat and professional manner. Provide any required hardware for wall mount locations.
M. Meet in person with the Owner to establish system programming requirements.
N. Provide all system programming and configuration to meet owner requirements.
O. Coordinate the requirements for space, power, and environmental requirements for the telephone system and voice messaging equipment prior to installation.
P. Coordinate Work with adjacent Work of other trades to facilitate installation and prevent conflicts.
Q. Staff job appropriately to keep pace with the Project schedule.

R. Abide by the decision of the Architect to case of conflict or interference of the other trades.
S. Work under this Section shall be performed in accordance with associated local, state, and national building codes.
T. Coordinate requirements of ceiling and floor mounted outlets with the Electrical Contractor.
U. In the event that the Voice Communication System installer shall re-enter an area of a previously completed phase of Work, the installer shall be responsible for returning that area back to the condition it was in before the installer re-entered the area. This includes re-installing ceiling tiles, cover plates, cleaning floors, and all other areas. Coordinate the cutting and patching of holes with the Construction Manager and comply with the Cutting and Patching Section.
V. Voice Communication System installer shall furnish and install all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware required to ensure that all equipment and cabling is properly installed and supported according to the manufacturer's recommendations.
W. Take precautions to prevent and guard against electromagnetic and electrostatic interference. Avoid potential sources of EMI in all aspects of installation. If interference is experienced, the Voice Communication System installer shall provide all required testing to identify the source of interference and provide a remedy including but not limited to re-routing and/or replacing cables.

3.02 **TRAINING**

A. Train systems administrative and/or maintenance personnel in procedures involved in operating, troubleshooting, servicing and preventative maintenance of each system specified. Provide no less than 16 hours of onsite training and be available for another 8 hours of remote training via the web.
    1. Review of the physical configuration and interrelationship of the system components.
    2. Labeling and interconnection techniques used in the installation.
    3. Applications of systems including any unique connections or interfaces required in the use of systems on site.
    4. A review of warranty documents for the system.
    5. A review of the Technical Manual prepared per "Closeout Submittals."
    6. A Review of operation manuals and users guides for the system.
    7. System operation and maintenance procedures.
    8. Review of all user programmable options and how to modify options.
    9. Provide no less than twenty-four hours of admin and user training split up in up to eight separate three hour sessions at the Owner's discretion.
B. Provide two electronic video copies of recorded training. The Owner will not accept "train the trainer" models. Provide owner with complete user instructions used for training purpose as well as training log of all users who attended training classes.

3.30 **CLEANING**

A. Clean all equipment and work areas under this Section, prior to scheduling Owner training. Include wiping of work areas and surfaces, and the removal of dust, streaks, stains, and all other contaminants from all equipment specified. Leave installed systems and components clean and undamaged.

END OF SECTION

SECTION 27 40 00
AUDIO-VIDEO COMMUNICATION SYSTEMS

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section to be included in Sub-Bid for Section 26 00 10 ELECTRICAL.

B. Filed Sub-Sub Bid Requirements:

1. Sub-sub-bid requiring a paragraph “E” listing on the form for sub-bid required per M.G.L. Chapter 149 Section 44F, as amended to date. The Electrical Subcontractor shall be responsible for all related building preparation and coordination. See specification for additional Paragraph “E” listing requirements of the listed AV trade contractor, and coordination of responsibilities. Failure to meet or exceed the requirements of the Construction Manager, as detailed in this specification, shall be grounds to reject the applicable bidder.
2. It is the sole intent of this Paragraph "E" listing to ensure to the end-user, single source responsibility from a single qualified Audio-Video Communication Systems Installer listed as the Paragraph “E” sub-sub bidder for this Class of Work.
3 Paragraph E sub-subcontractors for the work of this section shall be factory authorized to install the specified products. Filed Sub-Bidders shall be factory-authorized to install the systems specified in order to list themselves as Paragraph E subcontractors.

C. Drawing and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

A. Digital Messaging System
B. Classroom Speech Reinforcement Systems
C. Gymnasium Audio-Visual System
D. Cafeteria and Drama Area Audio-Visual System
E. Work to be done under this SECTION is shown on the following technology drawings and related details: T0.10, T0.11, T1.11, T1.12, T1.13, T1.14, T0.20, T1.21, T1.22, T1.23, T1.24, T0.30, T1.31, T1.32, T1.33, T1.34, T1.41, T2.01, T2.02, T2.03, T2.04, T2.05, T2.06, T2.07, T2.08, T2.09, T2.10, T2.11, T2.12.

1.03 RELATED REQUIREMENTS

A. Section 08 71 00 Door Hardware
B. Section 11 52 13 Projection Screens
C. Section 26 00 10 Electrical
D. Section 27 10 00 Structured Cabling System
E. Section 27 50 00 Distributed Communication System
F. Section 28 10 00 Integrated Security System
G. Section 01 25 00 Substitution Procedures
H. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.
I. Technology workboxes, back boxes, floor boxes, conduits, sleeves, cable tray, corridor cable support and grounding systems are per Electrical Section 26 00 10.

1.04 TECHNICAL REFERENCES

A. The product specifications, design considerations, and installation guidelines provided in this document are in part derived from recommendations found in recognized telecommunications industry standards. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed below, the more stringent requirements shall apply. The bidder is responsible for determining and referencing the most recent releases of all specifications during bidding and installation. Design, manufacture, test, and install all systems per manufacturer's requirements and in accordance with NFPA 70 (National Electric Code), state codes, local codes, Underwriters Laboratories (U.L.), requirements of authorities having jurisdiction, ADA requirements, and the most current revision of the following specifications:
   1. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
   2. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard.
   3. ANSI/TIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
   4. ANSI/TIA-568-C.4, Broadband Coaxial Cabling and Components Standard.
   5. ANSI/TIA-569-C, Telecommunications Pathways and Spaces.
   6. Building Industries Consulting Services International (BICSI) Telecommunications Distribution Methods Manual (TDMM)
   7. BICSI Information Transport Systems Installation Manual (ITSIM)
   8. ISO/IEC 18010, Pathways and Spaces for Customer Premises Cabling
   9. TIA-942-A-1, Telecommunications Infrastructure Standard for Data Centers
   10. ANSI-J-STD-607-A, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   11. ISO/IEC 11801, Information Technology – Generic cabling for Customer Premises
   12. TIA-862, Building Automation Systems Cabling Standard for Commercial Buildings
   13. ISO/IEC 14763, Implementation and Operation of Customer Premises Cabling
   14. TIA/EIA-606-A, Administration Standard for Commercial Telecommunications Infrastructure
   15. IEEE Standard 802.3an – 10GBASE-T over copper twisted pair cable

B. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed above, the more stringent requirements shall apply. All references listed above were current during development of this publication. The bidder is responsible for referencing to the most recent releases when developing bid proposals.

C. This document does not take precedence over any code, either partially or wholly.

1.05 **SUBMITTALS**

A. General: Submit shop drawings, samples, and related submittals all together, at the same time, for coordinated review. Isolated items submitted shall not be reviewed until all items have been submitted for review.

B. Equipment List: Provide a detailed Equipment List showing quantities by manufacturer and model number of all major items of equipment and installation material to be used in the system as specified herein.

C. Product Data: Include complete sets of indexed cut sheets, in quantity as dictated by the project, of all major pieces of equipment, cable and connectors being supplied. Arrange these sheets in the order the equipment appears in the Specification.

Clearly highlight information showing compliance with this and/or all applicable Specifications. In the event that the manufacturer or representatives' cut sheet contains more than one item, clearly indicate which items of the cut sheet are intended for installation.

D. Firestop: Include cut sheets on all firestopping materials.
E. Shop Drawings: Submit a set of complete Shop Drawings, by system, showing equipment to be installed, including but not limited to:
    1. System configuration block diagrams of all equipment, indicating equipment type and model numbers. Show each and every component, system and subsystem, as well as all proposed connections between system components, and cable types connecting components.
    2. Proposed layouts and elevations of all equipment racks and cabinets showing all equipment specified and spaced accordingly.
    3. Proposed layouts of all other equipment not located in racks and cabinets, including but not limited to connection plates, speakers, signage displays, and all other specified equipment.
    4. Using Bose Modeler Sound System Software, produce optimal predictive loudspeaker models for both the Cafeteria and Gymnasium, provide predictive heat map images with optimal speaker placement and rigging information.
F. Quality Assurance Submittals:
    1. Provide the name and certification of at least one employee who is AVIXA CTS certified and shall be onsite during the installation period. In addition, provide the name and certifications of at least one other employee with a minimum certification of CTS-D.
    2. Provide the name and certifications of the site Supervisor/Foreman who shall be in charge of, and responsible for, all activities at the job site for the duration of the Project. The job Supervisor/Foreman shall not be changed during the Project without notification and approval from the Owner.
    3. Provide supporting information that the Audio Video Communication Systems Installer is an authorized reseller/installer of all products specified, and that installers are certified and proficient in all systems, including programming of all systems specified.
    4. Provide five references of similar systems installed in similar applications over the past three years.
    5. Provide supporting information that the project is in the Installers local area of service and that the Installer has the ability to address all service and warranty related issues on-site within 3 business days.
    6. Complete warranty information of all products
G. Close-Out Submittals:
    1. Technical Manual: Submit for approval a draft of the complete Technical Manual at least two weeks prior to the time of final system check out. When the final drafts are accepted, provide five copies of detailed technical manuals. The manuals shall include the following:
        a. Table of contents.
        b. Installer Name; contact name; address, telephone number, fax number, and email address.
        c. Product Information: Include original copies of manufacturer's installation and operating instructions, and service manuals, arranged alphabetically. All service manuals shall be originals; there shall be no Xerox copies of the

service manuals and schematic supplied. Warranty information shall be filled out in the Owner's name.

d. Detailed Description of the complete system and all subsystems.

e. Maintenance Documentation: Include the following:

1) Information necessary to perform routine and corrective maintenance by the Owner's technical staff, or other qualified technicians.

f. List of all equipment by manufacturer, model or part number, and serial number.

g. List of spare parts.

2. Submit written certifications that the installation conforms to Specification, is complete and operable, and ready for approval by the Architect.

3. Technical Diagrams and Drawings:

a. Simplified single line block diagrams showing the interconnection of all equipment and functional relationships for all systems specified. Show all equipment, patch panels, cables and jacks, and all other hardware, whether connected or not. These drawings shall be on Engineering size E, 30-inch by 42-inch sheets. The intent of these diagrams is to provide sufficient clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.

1.06 **QUALITY ASSURANCE**

A. The Audio-Video System Installer shall have at least 10 years' of experience in designing, installing, and testing Audio-Video Systems as specified and described herein and use employees who are AVIXA CTS and CTS-D certified in the installation process. Additionally:

1. The Audio-Video System Installer shall be fully certified by the manufacturer(s) of the systems specified and shall be in good standing with the manufacturers, having satisfied all training and product certification requirements of each Manufacturer.

2. The System Installer shall utilize personnel who are fully trained and certified by the Manufacturer(s) providing final system warranties on all equipment. The onsite supervisor/foreman shall have satisfied all training and product certification requirements of the Manufacturer(s) specified and being installed.

3. The System installer shall own and maintain tools and equipment necessary for successful installation and testing of all systems specified.

B. Adhere to the engineering, installation and testing procedures of the Manufacturer of the components specified, and use only the cabling, components and methods of provisioning the Project authorized by the Manufacturer(s).

1.07 **DELIVERIES, STORAGE AND HANDLING**

A. Perform all tasks necessary to properly coordinate with all involved parties/trades for: Shipment, arrivals, loading dock, elevators (as applicable), acceptance, storage, and security of equipment and materials. Do not, during these tasks, interfere with other trades or the progress of this Project.

B. Assure that all deliveries are in correct quantities, within the appropriate times, and in compliance with all manufacturers' shipping instructions.

C. Protect all materials according to manufacturer's Specifications and/or instructions.

1.08 **SYSTEM WARRANTY, SERVICE AGREEMENT AND PERFORMANCE ASSURANCE**

A. Warranty all systems to be free of faulty workmanship and defects, and from damage due to contamination from the site for a period of five years from the date of final project completion.

B. The Warranties required by this section shall not be diminished by other warranties in the Contract Documents, equipment manufacturer's warranties, and all other rights and remedies available to the Owner under this Contract and public law. In addition, this Warranty shall not diminish the terms of individual manufacturer's warranties.
C. The Warranties required by this section shall be for the benefit of the Owner to whom Registration Certificate is issued and any successor in interest to the site.
D. Any repair or replacement of Cabling or Equipment resulting from this warranty shall be warranted for either (a) 90 days or (b) the remainder of the original warranty period, whichever is longer.
E. Service Agreement: The AV trade contractor shall respond to all requests for service during the warranty period. During this period, the AV trade contractor shall replace defective material and repair items of faulty workmanship at no charge to the Owner. All requests for service shall be responded to by telephone within two business hours, and technicians shall be dispatched within 24 hours. Only certified technicians shall be dispatched.

1.09 **SEQUENCING AND SCHEDULING**

A. A set of “as-built” documents shall be provided to the Owner by the Construction Manager showing the unique label (based on actual final room numbering) for each outlet installed.
B. Where cables are to be installed in Wiremold, or other raceway, the Audio-Video Communication Systems Installer shall closely coordinate cable, equipment and faceplate installation with the Electrical contractor.

1.10 **TRAINING OF OWNER'S PERSONNEL**

A. Conduct a Training Program for the Owner's staff. The Training Program shall include a demonstration of the configuration of all systems. Schedule the Training Program at the convenience of the Owner, after the Technical Manual has been submitted and accepted. All materials in the Technical Manual shall be reviewed during the training program. All training sessions shall be videotaped with five copies provided to the Owner with closeout submittals.

PART 2 – PRODUCTS

2.01 **GENERAL**

A. It is the intent of the Specification that one manufacturer, not a combination, be selected for each class of material.
B. Certain equipment is listed by manufacturer and model number. This is to define and establish a level of quality and functionality. The words, "or equal", are understood to follow all names of these specified products, trade names, catalog numbers, and detailed descriptions. It shall be interpreted to apply to any material, article, assembly or system, which in the opinion of the Owner is at least equal in quality, durability, appearance, strength and design to the material specified, and shall perform at least equally the functions imposed by the general design. The words, "or equal", shall not be construed to permit departure from the detailed requirements of the Specification. Other manufacturers’ products accepted by the Awarding Authority shall be equal to the specified products in terms of construction, quality, durability, performance, and appearance. Refer to Section 01 25 00 regarding product substitutions.
C. All materials and equipment shall be new and unused.
D. All part numbers and manufacturers shall be according to this Specification unless otherwise noted on the construction Drawings.
E. All cabling provided shall be plenum-rated.

F. Provide all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware required to support all cabling and equipment specified.

2.02 **MANUFACTURERS**

A. Acceptable “or equal” manufacturers for the Audio-Video Communication Systems include:
   1. Digital Messaging System
      a. Samsung
      b. NEC
      c. Planar
      d. Spinetix
   2. Gymnasium and Cafeteria Audio-Visual Systems
      a. Bose
      b. Crestron
      c. Epson
      d. Proco
      e. Shure
      f. Listen Technologies
      g. Telex
      h. Community
      i. Renkus
      j. JBL
      k. Crown
      l. RDL
      m. Extron
      n. Sony
      o. Tascom
   3. Classroom Audio Systems
      a. Lightspeed Technologies TopCat (Proprietary)

2.03 **DIGITAL MESSAGING SYSTEM**

A. IP Digital Signage and Message Board
   1. Provide Digital Signage and Message Board systems consisting of the following:
      a. Chief LTM1U mount wall mount with FCAV1U pull out accessory.
      b. HDMI 4K High Speed Cable
      c. Cat 6 Ethernet patch cable
      d. Handheld remote
      e. Spinetix iBX410W with 5 year DSOS license, 5-year SX-SE-ARYA Enterprise license, 5 Year warranty.
      f. Samsung QM55C 4K UHD LED and Samsung QM65C Series 65” 4K UHD LED with 5-year warranty.

B. All displays shall be mounted in landscape mode. All displays shall include professional-grade low profile wall mount that allows display to be pulled out from the wall for servicing behind the display, and all associated hardware and cables. See architectural plans for location and mounting height of each display. Provide all control setup, programming and training.

C. Install and configure/update all firmware and software according to Owner requirements and confirm full functionality. Configure all displays to connect to all network services and signage cloud services.

D. Work with the Owner to assist in the creation of initial signage content templates for all displays, as well as loading content into templates to create the initial digital

signage message boards. Afterward initial installation, provide three separate 90 minute training sessions to review signage; modify templates and content, and; train on using and managing the digital signage and message board system. Training shall be performed by a certified MagicInfo reseller or installer. Training shall be provided at the Owner's discretion during the school year after the installation.

2.04 **CLASSROOM SPEECH REINFORCEMENT SYSTEM**

A. In-ceiling audio system shall be Lightspeed Topcat. Provide in all classrooms and as shown on plans. Install in ceiling grid with proper safety supports. The Electrical Contractor shall provide hardwired power to all systems.
B. Provide one Flexmike Pendant Microphones per system
C. Provide one Sharemike per system
D. Provide one wireless access media connector per installed system.
E. Provide one charging station per system that shall accommodate both the Flexmike and the Sharemike.
F. Provide ten spare Flexmide Pendant Microphones with batteries and lanyards and ten spare Sharemikes with batteries.
G. Provide ten spare batteries for Flexmike and Sharemike microphones.
H. Provide Pagefirst sensors for all systems. Coordinate with Section 27 50 00 Installer and for providing emergency page priority, automatically muting the system during an announcement from the distributed communication/intercom system.
I. Provide connection of cable from Fire Alarm system as part of Section 26 00 10 ELECTRICAL, to allow muting of the Speech Reinforcement system in the event of a fire alarm. Coordinate with Section 26 00 10 fire alarm installer.
J. Provide connection of cable from Call Button provided per Section 27 50 00 DISTRIBUTED COMMUNICATION SYSTEM, to allow the Speech Reinforcement System to initiate calls with the teacher's Flexmike through the Call Button. Coordinate work with the installer of Section 27 50 00. Test system to ensure that Distributed Communication System calls can be initiated by the teacher's microphone of the Speech Reinforcement system through the Call Button in each room.
K. Upon completion, all systems shall be clean, adjusted and left in perfect operating condition. Transmitters shall be plugged in and charging and user manual should be left in a conspicuous place. There shall be no audible components of hum, noise, or distortion.
L. Top Cat Speakers shall be flush mounted in all spaces equipped with finished ceilings. Coordinate with Ceiling Contractor in all cases. In exposed ceilings areas (where no finished ceiling are being installed), furnish and install the Lightspeed Top Cat Mounting Bracket (TCMB) with custom Unistrut and threaded rod to structure above to suspend the Top Cat speaker system flush with the lowest ceiling members, including but not limited to, ceiling pendent lights.

2.05 **CAFETERIA / GYMNASIUM AUDIO-VDIEO SYSTEM**

A. Main Equipment Rack: Supply one equipment rack to house all audio-visual system equipment intended for rack mounting. The rack shall be supplied with lift-off side panels, a top panel and a locking front and rear doors, which can be fitted for either left hand or right hand hinging. The rack, the side panels and all filler and vent panels shall be black. The rack shall have 70 inches min. of equipment mounting space. It shall be at least 26 inches deep. There shall be in internal space provided for running cables within the frame. The rack shall be supplied with heavy-duty casters. There shall be two locking storage drawers provided in the rack. The drawers shall be Middle Atlantic LBX-3. The Audio-Video Communication Systems

Installer shall fill all empty space in the rack with blank rack panels. Provide AC power strips to accommodate all AC powered units with a spare capacity of at least three outlets for the connection of test equipment. The rack shall be Middle Atlantic MRK-3726 with side panels, top, lockable vented front door, and locking rear door with caster kit.

1. Shelves for electronic equipment with load carrying capacity to support at least 100 percent of each piece of electronic equipment weight. Shelves shall have adequate openings within them to dissipate heat and flow for adequate ventilation of all equipment.
2. Mounting brackets specifically designed to support the equipment installed within the rack.
3. Hook and loop (Velcro) horizontal and vertical cable management system to properly dress the electronic equipment power cords through the rack. Tie-wraps are specifically prohibited.
4. Bonding and grounding cables required for any and all equipment.
5. Furnish and install locking front hinged door.
6. Furnish and install surge suppression power strip. Surge Suppression Power strip shall be SurgeX model SX1120RT or accepted equal.
7. Provide Blank panels to fill all empty spaces in racks.

B. Digital Signal Processors shall be Bose ControlSpaceEX-1280 digital signal processor. The audio DSP shall have 12 balanced inputs and 8 balanced output channels for microphone or line-level analog audio signals, each independently controllable with removable screw-down and labeled connectors. The DSP shall have Dante® digital audio networking up to 64 input and 64 output channels, an Ethernet connection for control and programming on an RJ-45 jack, USB audio and 8 channels of AmpLink on an RJ-45 jack. The audio DSP shall be a 1 RU rack mountable chassis and include configurable signal processing, including but not limited to: signal routing and mixing, equalization, filtering, dynamics, delay, room combining, as well as control, monitoring, and diagnostic tools. The audio DSP shall control and proxy all EX expansion devices and other Dante® endpoints.

C. Gym Ceiling Speakers (S1) shall be Bose ArenaMatch comprised of the following equipment:
   1. Bose ArenaMatch AMU 105 70V speakers, twelve on each side for a total of twenty-four speakers.
   2. Bose M210-WR outdoor subwoofer, one in each corner of the Gym for a total of four speakers.
   3. All speakers shall be white and shall be mounted to ceiling trusses so that the speaker grill is flush with the bottom of the trusses.

D. Gym Power Amplifiers: ArenaMatch AM105 amplifier shall be-Bose PowerShare X PSX1204D 100V, 120V, 230V. One for 12 speakers for a total of 2 amplifier. Base loudspeaker amplifier shall be PowerShare X PSX4804D 100V, 120V, 230V, serving four Gym subwoofer speakers for a total of 1 amplifier.

E. Provide Crestron DMPS3-4K-250-C for controlling source and display information. Signal and control should be sent directly to Projector’s HDBaseT input.

F. Provide AV Input/Output plate with dual RJ45’s flush mounted to the Gym wall.

G. Crestron DM to HDMI Receiver for DM cabling running from the input side of the AV Input/Output plate to the DMPS.

H. Crestron HDMI to DM Transmitter for DM cabling running from the AV system to the

output side of the AV Input/Output plate.

I. Camera Input Plate designated as the “C” outlet shall be Liberty Digitalinx DL-1H1A-WPKT-W-TX with corresponding Liberty Digitallinx DL-1H1A-WPKT-W-RX at the equipment rack for each.

J. Provide Crestron TSW-770-B-S Touchscreen in the Sound System Equipment Rack. Provide XPanel Program and IPad Program and set up to mimic touch panel on at least two Owner furnished devices (iPads and/or Computers).

K. Netgear M4250 or accepted equal with PoE ports for connecting all Dante equipment plus 20% spare ports plus ports for connecting the system to the school network so the system can be controlled by Owner’s computer and/or iPad wirelessly.

L. Crestron C2N-IO Relay and Cresnet cabling.

M. All UTP video cabling and connectors shall be Cat6 Shielded cabling and connectors.

N. Hearing Assistance System: System shall consist of rack-mounted transmitters and wireless receivers and accessories. The Gym and Cafeteria shall be equipped with the following:
   1. Listen Technologies LT-800-07201 Stationary RF Transmitters***.
   2. Listen Technologies LA-326 Rack mount kits.
   3. Listen Technologies LA-122 Universal antenna. Mounted in each space for optimal performance. Use RG58 for less than 100ft and RG6 for more than 100ft runs (50 0hm).
   4. Listen Technologies LR-4200-072 Intelligent DSP RF Receivers. Provide a quantity to meet ADA requirements for maximum occupancy.
   5. Listen Technologies LA-401 Ear Speakers for each receiver.
   6. Technologies LA-430 Intelligent Earphone/Neck Loop Lanyards. Provide a quantity to meet ADA requirements for maximum occupancy.
   7. Listen Technologies LA-423 4-Port USB Charger.
   8. Two Listen Technologies LA-304 ADA Access/Compliance signage kit.
   9. Configurable Charging/Carrying Case for storing, transporting and charging portable equipment.
   10. Cables and connections for a complete and fully installed system.
   11. Installer shall check factory for their recommendation on suitable frequency for operation in site area. The frequency selected shall permit interference free simultaneous operation of a similar systems in the building.

O. Provide all equipment specified and shown on plans and required for a fully functional system.

P. Provide auxiliary HDMI and XLR inputs and XLR outputs on a custom rack panel for both the Gym and Cafeteria systems.

Q. Cafeteria Program Loudspeakers: Speakers shall be Bose Panaray MSA12X Digital Beam-Sterring Loudspeakers (S2). Each side of the Cafeteria space shall be comprised of one vertical array for a total of two speakers. Each side of the Drama space shall be comprised of one vertical array for a total of two speakers. Refer to Architectural Interior Elevations and confirm heights and location of speakers with Architect. Confirm color of Panarays with Architect prior to ordering.

R. Cafeteria Base Loudspeakers (S3): Speakers shall be Bose MB210-WR Outdoor subwoofer. One subwoofer shall be mounted above the finished ceiling of the suspended ceiling area in the cafeteria and one in the Drama room area.

S. Cafeteria Panaray Speaker (S2) power shall be provided by a single 120V recessed/flush mounted receptacle aligned behind each Panaray speaker so to

conceal cordage and plugs behind the speaker.

T. Cafeteria and Drama room Base Power Amplifiers: ArenaMatch AM105 amplifier shall be Bose PowerShare X PSX1204D 100V, 120V, 230V.
U. Provide Crestron DMPS3-4K-350-C for controlling source and display information. Signal and control should be sent directly to Projector's HDBaseT input.
V. Crestron DM to HDMI Receiver for DM cabling running from the input side of the AV Input/Output plate to the DMPS.
W. Crestron HDMI to DM Transmitter for DM cabling running from the AV system to the output side of the AV Input/Output plate.
X. Provide Extron SMP 351 3G-SDI with 80GB SSD Streaming Media Processor or equal. Device shall record audio and video sources of choice onto the system's hard drive, USB drive, or stream directly onto the building network.
Y. Provide Sony BDPS-6700 Blu Ray player with custom rack shelf and connections to the Crestron DMPS via HDMI and IR Control.
Z. Provide Bluetooth Receiver: Rack Mount Bluetooth Receiver shall be Tascam CD-400U. Initialization of pairing should be controlled from the touch panel interface.
AA. Provide two Crestron TSW-770-B-S Touchscreen, one in the Cafeteria area and one in the Drama room area. Provide XPanel Program and IPad Program and set up to mimic touch panel on at least two Owner furnished devices (iPads and/or Computers).
BB. Netgear M4250 or accepted equal with PoE ports for connecting all Dante equipment plus 20% spare ports plus ports for connecting the system to the school network so the system can be controlled by Owner's computer and/or iPad wirelessly.
CC. Provide all programming for a fully functional system. All uncompiled source code and graphics files are to be turned over to the Owner.
    1. All Speaker cabling shall be 14 Gauge.
DD. Hardwired Microphones and Accessories:
    1. Microphone wall plates shall be Proco WP1004 for single microphone locations in the Cafeteria and Gym. Four for each.
    2. Four Shure Beta 58A microphones with cables
    3. Four On-Stage DS7200QRB Desktop Microphone Stands
    4. Four Shure MS-10C Microphone Stands
    5. Four Shure C-25E 25' Microphone Cables
EE. Wired Microphone Interface shall be accomplished using the ControlSpace EX-8ML mic/GPIO Dante endpoint.
FF. Wireless Microphones: Wireless Receivers shall be rack mounted. Provide all antenna equipment including but not limited to dual rack mount kit, passive antenna splitters, active antenna amplifiers, antenna cable and antenna. Locate two antenna in the ceiling of each space they are serving for optimal performance. Provide four complete systems for each of the Cafeteria and Gym to include two handheld microphone transmitters and two lavalier microphones with bodypack transmitters. Wireless microphones and combiners shall be by Shure or equal and as shown on plans. Provide all wireless microphone equipment required for a complete system, including but not limited to:
    1. Shure ULXD4Q Quad Receiver for each of the Gym and Cafeteria wireless systems.
    2. Shure UA844+SWB Combiner; Shure UA834WB inline amplifiers; UA8-470-530 antenna; Shure UA8100 coaxial cable. Locate remote antennas for optimal

performance. Provide two lithium batteries and chargers for all handheld and body pack transmitters.

3. Wireless Handheld Microphones: Two Shure ULXD2/B58 Digital Handheld Transmitter for each of the Cafeteria and the Gym for a total of four microphones.
4. Wireless Lavalier Microphones: Two Shure ULXD1 Digital Bodypack Transmitters with WL185 lavalier microphones for each of the Cafeteria and Gym for a total of four bodypack transmitters and lavalier microphones.
5. Two complete sets of Shure Lithium-Ion Rechargeable Batteries for each transmitter
6. Two Shure Dual Docking Chargers.

GG. Cafeteria Rear Projection System. The projector shall be mounted even with the top of the image of the rear projection screen being provided at the front of the Cafeteria proscenium under separate contract. Refer to Architectural Section. Install projector to avoid conflict with all lighting, curtains, and other fixtures. Refer to architectural details. Provide all required mounting hardware for a complete, neat, and professional installation. Provide a cover plate for the ceiling tile to conceal all mounting hardware and provide a clean finish. Field verify all dimensions prior to ordering equipment. Projector shall be:

1. Epson Pro EBPU2116
2. Lens shall be Epson ELPLW06 series required to fill screen with image. Prior to ordering lens, verify proper lens required to fill, but not exceed the dimensions of the rear projection screen based on actual location of projector and the projection screen.
3. Projector shall be mounted to structure at the location shown on plans. Provide all mounting hardware required, including but not limited to the following:
   a. H-Patter of Unistrut at the structure above finished ceiling
   b. White Ceiling Plate, Chief CMA110W.
   c. Three inch white suspension pipe, Chief CMS003W.
   d. Vibration Isolation Mount, Chief CMA348W.
   e. Seven to nine feet of adjustable white pipe, Chief CMS0709W.
   f. White Projector mount, Chief VCMUW.

HH. The audio system shall be bypassed in the event of an emergency page/announcement or a fire alarm. Connect cabling from PA system and Fire Alarm system to the Cafeteria System to mute system in the event of emergency public address announcements and/or fire alarms.

II. Provide all cabling and connectors required for a complete and fully functional system. Utilize cabling and connector solutions that shall work within the constraints of conduits and boxes provided. All cabling shall be professional grade. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.

2.06 **MOBILE PROJECTION SYSTEM**

A. Mobile Projection System shall be used with the front projection screen being installed in the Gym under separate contract. Provide all Mobile Projection System equipment, including calibration and training of the system to be used with the front projection screen for a complete, neat, and professional installation. Field verify all dimensions prior to ordering equipment. Mobile Projector Cart shall include:

1. Epson Pro EBPU2116
2. Epson ELPLW08 Short Throw Lens
3. Spectrum Industries, Inc. Custom Immersion XR Cart customized for use as a

large venue projection cart, without foam drawers.

4. Crestron HDMI to DM transmitter, configured in cart with user accessible HDMI connection plate secured at the top of the cart for connecting users presentation equipment.
5. Crestron DM Input/Output plate flush mounted near the bottom of the cart with two accessible shielded RJ45 jacks for plugging in DM cables between the AV Input/Output plate on the Gym wall and the Mobile Projection System.
   a. DM cable shall run in the cart from the projector to the output side of the DM Input/Output plate on the cart.
   b. HDMI cable shall run from an HDMI presentation connection in the cart to the Crestron HDMI to DM transmitter. DM cable shall run in the cart to the Input side of the DM Input/Output plate on the cart.
6. Two 38-inch Crestron DM cables with RJ 45 plugs on either end for making AV connections between the DM Input/Output plate on the cart and the AV Input/Output plate on the wall.
7. Six Outlet Power Strip.
8. Kensington security cable with a combination lock.
9. All cables and connectors necessary.
10. Five year warranty on the projector.
11. Permanently secure projector to the surface of the cart, calibrate to Gymnasium front projection screen and train Owner representatives on the use of all equipment. The system shall fully integrate with the overall installed Cafeteria-Gym Audio Video System when in use, so that the control panel is able to fully automate its use.

2.07 **ACCESSORIES**

A. Provide all professional grade cabling and accessories required to furnish complete and functional systems.

PART 3 EXECUTION

3.01 **EXAMINATION**

A. Prior to commencing Work of this Section or ordering equipment, examine site and conditions under which work shall be performed. Determine exact locations of items shown diagrammatically on Drawings. Determine dimensions needed to install components, move in racks and any custom items. Notify the Architect of any conflicts or special requirements needed to provide for free access to doorways, corridors, stairs, and similar areas, required to move in the specified equipment. If the Systems Installer fails to provide such notification, any additional cost to remove and reinstall any building members shall be back charged to the Systems Installer.
B. Technology Drawings show Audio-Video Communications System component locations. Install quantity and type according to the Technology Outlet Plans and as specified herein. Provide all required adapters and/or accessories for a complete installation in all raceways, and other locations.
C. Commencement of Work of this Section indicates acceptance of existing site conditions.

3.02 **WORKMANSHIP**

A. Audio-Video Communications System shall be installed in a neat, workmanlike manner. Workboxes, equipment, and enclosures are to be plumb and square. Install the system elements in cooperation with all trades to achieve coordinated progress and desired results. Watch for conflicts with Work being performed by other trades that have impact on the installation of the system components. Make moderate

moves or changes in equipment locations as are necessary to accommodate other equipment as directed by the Architect, without a claim for additional payment.

3.03 **INSTALLATION, GENERAL**

A. Pre-installation: Meet with the Construction Manager, Project manager, and any other appropriate parties for coordination meeting prior to beginning work and to coordinate requirements.
B. Coordinate Work with adjacent Work of other trades to facilitate installation and prevent conflicts.
C. Staff job appropriately to keep pace with the Project schedule.
D. Abide by the decision of the Architect to case of conflict or interference of the other trades.
E. Work under this Section shall be performed in accordance with associated local, state, and national building codes.
F. Coordinate requirements of ceiling and floor mounted outlets with the Electrical Contractor.
G. In the event that the AV trade contractor must re-enter an area of a previously completed phase of Work, the Installer shall be responsible for returning that area back to the condition it was in before the Installer re-entered the area. This includes re-installing ceiling tiles, cover plates, cleaning floors and all other items and areas. Coordinate the cutting and patching of holes with the Construction Manager, and comply with the Cutting and Patching Section.
H. Every effort shall be made to schedule the Work under this Specification in such a manner so as to complete all above ceiling Work prior to ceiling panel installation. In the event that the Communication Systems Installer is required to remove ceiling panels, such Work shall not break or disturb the existing ceiling grid or panels and shall be coordinated with the Construction Manager and Ceiling Contractor.
I. Spare pull strings shall be left in all EMT, Conduits, and Innerduct.
J. AV trade contractor shall furnish and install all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware required to ensure that all equipment and cabling is properly installed and supported according to the manufacturer’s recommendations.
K. Take precautions to prevent and guard against electromagnetic and electrostatic interference. Avoid potential sources of EMI in all aspects of installation. If interference is experienced, the AV trade contractor shall provide all required testing to identify the source of interference and provide a remedy including but not limited to re-routing and/or replacing cables.

3.04 **CABLE SUPPORTS AND ROUTING**

A. Install all cabling shall be installed in accordance with the manufacturer’s guidelines and according to all applicable building codes at the time of installation.
B. Route all cables in large groupings, through main hallways, until cable can be distributed directly to the Audio-Video Communication System component. Route individual cables to the appropriate locations in accordance with all standards described herein.
C. Install cables in cable tray, Snake Tray, J-hooks, pipe and/or sleeves specified in this and other sections.
D. The Installer shall adhere to the manufacturers' requirements for bending radius and pulling tension of all communication cable.
E. Install cables in such a manner to minimize tension and stress on cables, which can lead to changes in the physical and/or electrical characteristics of the cables over

time. This applies to, but is not limited to, horizontal cable support methods, vertical cable support methods, tie wraps, or similar types of cable support methods.

F. Cables exiting floor conduits and sleeves shall be neatly dressed, and securely supported from the floor up to the ceiling so that the cables are not stressed or stretched by the weight of the cables. Acceptable support structures include, but are not limited to: Cable tray runway radius dropout, vertical ladder tray, J-hooks, unistrut, or similar types of support structures. The intent is that cables shall not be supported by the weight of the cables themselves but are supported so that the weight of the cables is assumed by the support structure(s).
G. Route cables at right angles to electrical power circuits and supported only from the building structure when not in cable tray or conduit.
H. Do not support cabling from ceiling tiles, grid or hanger wires.
I. Do not install random or diagonal cable runs. Cable turns and bends shall be made at 90 degrees angles whenever possible, but maintaining manufacturers' requirements for bending radius at all time.
J. Install cables at components, regardless of how routed to the component, with a 5 foot service loop of cable secured above the ceiling where the cable enters the pathway to the component.
K. At all AV Racks, a ten foot service loop of cable shall be provided. Service loops shall be installed in either a figure-eight or “U” pattern. Service loops shall not be installed as tight circular coiled loops.
L. Cables which penetrate a steel stud or steel wall cap shall be protected from damage with a "stud liner".
M. Cables entering power poles, surface mounted raceway, or other cable management systems shall be protected from damage.
N. Meet all requirements regarding use of cable in return air plenums and in raised floor systems. Provide wiring that complies with all applicable state, local building codes, and the National Electrical Code. All cables run in raised floor systems with forced air-cooling shall meet the requirements of NEC Article 645, "Electronic Computer Data Processing Equipment”.

3.05 **CONDUITS, SLEEVES AND WALL/FLOOR PENETRATIONS**

A. Conduits and sleeves between and among all equipment and through all fire rated walls shall be provided by Division 26.

3.06 **FIRESTOPPING**

A. Seal all horizontal and vertical openings between floors, through fire rated fire and smoke walls, used or created by the Installer.
B. Refer to Section 07 84 00 - Firestopping, for all product requirements for maintaining integrity of fire-rated construction at penetrations.

3.07 **LABELING**

A. Clearly label and identify all components. Logically and permanently mark all cable, connectors and electronic equipment.
B. Use a letter quality printer or other mechanically produced lettering for labels.
C. Place permanent cable markers 3 inches from all connectors to allow easy identification. Use Brady Markers with clear plastic ends. Acceptable markers are, Brady B-320, B-292, SL-292, or Brady machine embossed labels with clear vinyl ends. Machine generated markers are required. Place cable markers on cables so that they can be easily seen.

D. Handwritten labels shall not be accepted, even if written with a permanent marker. Temporary handwritten labels may be used only during the “rough-in” stages; they shall be replaced with permanent labels prior to Project completion.

3.08 **BONDING AND GROUNDING**

A. Telecommunications Bonding Backbone utilizing #6-AWG or larger bonding conductor shall be provided by Division 26 at all rack locations. This is part of the grounding and bonding infrastructure (part of the telecommunications pathways and spaces in the building structure), and is independent of equipment or cable.

B. For all systems, provide equipment grounding connections. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

C. For all systems, provide conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

D. For all systems, provide transient protection on the AC power feed and on station lines leaving or entering the building.

E. For all systems, note in the system Drawings, the type and location of these protection devices as well as all wiring information.

F. For all systems, furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground bus bar.

G. Provide any necessary screws, anchors, clamps, tie wraps, distribution rings, and miscellaneous grounding support hardware to complete the installation of the grounding system.

H. Grounding busbars shall be installed at all rack locations by Division 26.

I. All grounding conductors shall be affixed with permanent labels in a visible location at each end of the conductor, and as close as practicable to the bonding point at each end of the conductor. The labels shall clearly identify both the source and destination of the bonding conductors. Hand written labels are not acceptable.

3.09 **TESTING**

A. Audio/Visual Systems

1. Test the proper functioning of all equipment items to ensure components meet manufacturer's published specifications and the intent of this specification. All adjustments shall be made to optimize the system prior to Owner training.
2. Provide full commissioning of all Audio/Visual Systems with a Bose Professional in attendance. All system performance certification and programming shall be performed by a factory certified technician or by a Bose Professional employee. All performance design criteria shall be met and documented utilizing Bose Modeler, “EASE”, or other industry standard for acoustic measurements. Cafeteria System using the Bose MSA12X loudspeakers should provide evenly distributed and intelligible audio for the entire listening area with an SPL of 96.1 dBA (A weighted) dBA, the standard deviation rests at 1.3dB. The Gymnasium using the ArenaMatch Utility series loudspeakers shall produce clear and high quality audio evenly distributed throughout the room with an SPL of 99.3 dBA (A weighted), the standard deviation rests at 1.5dB.

3.10 **TRAINING**

A. Large Venue Audio Video Systems: Train systems administrative and/or maintenance personnel in procedures involved in operating, troubleshooting, servicing and preventative maintenance of all systems specified and installed.

Provide no less than three 2 hour training sessions, to be scheduled at the Owner's discretion, including but not limited to.

1. Review of the physical configuration and interrelationship of the system components, outlets, and cabling.
2. Labeling and interconnection techniques used in the installation.
3. Applications of systems including any unique connections or interfaces required in the use of systems on site.
4. Detailed system(s) operational instructions and procedures.
5. Review of the technical Operations and Maintenance Manual prepared per "Closeout Submittals."
6. Review of warranty documents for the system.
7. Review of users guides for the system.
8. Review of all user programmable options and how to modify options.
9. Review answers to all Owner questions.

B. Digital Messaging System: Provide three separate one-hour training sessions provided by a certified MagicInfo reseller on using and managing the digital signage and message board system. Training shall be provided at the Owner's discretion during the school year subsequent to installation.

C. Classroom Speech Reinforcement System: Provide two separate one hour training sessions for teachers by a manufacturer's certified dealer of the Speech Reinforcement System. Training shall be provided at the Owner's discretion during the school year subsequent to installation.

D. Provide a digital copy of recorded training session of all equipment furnished and installed. The Owner shall not accept "train the trainer" models. Provide owner with complete user instructions used for training purpose as well as training log of all users who attended training classes.

3.11 **CLEANING**

A. Clean all equipment and work areas under this Section, prior to scheduling Owner training. Include wiping of work areas and surfaces, and the removal of dust, streaks, stains, and all other contaminants from all equipment specified. Leave installed systems and components clean and undamaged.

END OF SECTION

SECTION 27 50 00
DISTRIBUTED COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section to be included in Sub-Bid for Section 26 00 10 ELECTRICAL.

B. Filed Sub-Sub Bid Requirements:

1. Sub-sub-bid requiring a paragraph “E” listing on the form for sub-bid required per M.G.L. Chapter 149 Section 44F, as amended to date. The Electrical Subcontractor shall be responsible for all related building preparation and coordination. See specification for additional Paragraph “E” listing requirements and coordination of responsibilities. Failure to meet or exceed these requirements, as detailed in this specification, shall be grounds to reject the applicable bidder.
2. It is the sole intent of this Paragraph E listing to ensure to the end user, single source responsibility from a single qualified Distributed Communication System Installer listed as the Paragraph “E” sub-sub bidder for this Class of Work.
3. The Distributed Communication System Installer shall be DCAM Certified by the State of Massachusetts Division of Capital Asset Management in the Category of Telecommunication Systems
4. Paragraph E sub-subcontractors for the work of this section shall be factory authorized to install the specified products. Filed Sub-Bidders shall be factory-authorized to install the systems specified in order to list themselves as Paragraph E subcontractors.

C. Drawing and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

A. Public Address system, including but not limited to:

1. Public Address System Amplifiers, Zone Controls, and all equipment, cabling and support required to interface the Public Address System to Owner’s Telephone System. Note: Owner’s telephone system is Not in the Contract but is based on Cisco VoIP system.
2. Administrative Phone.
3. Public Address System Speakers.
4. Intercom Call Buttons
5. Network Interface port for systems combining and system programing.
6. Master Clock System
7. Secondary Analog Clocks.
8. Integration between Public Address System and Telephone System.
9. Cabling from Call Button to Speech Reinforcement System
10. Ten minute UPS on all equipment
11. Work to be done under this SECTION is shown on the following technology drawings and related details: T0.10, T0.11, T1.11, T1.12, T1.13, T1.14, T1.20, T1.21, T1.22, T1.23, T1.24, T1.30, T1.31, T1.32, T1.33, T1.34, T1.41, T2.01, T2.02, T2.03, T2.04, T2.05, T2.06, T2.07, T2.08, T2.09, T2.10, T2.11, T2.12.

1.03 RELATED REQUIREMENTS

A. Section 01 91 13 General Commissioning Requirements

B. Section 07 84 00 Firestopping

C. Section 08 71 00 Door Hardware
D. Section 26 00 10 Electrical
E. Section 27 01 00 Structured Cabling System
F. Section 27 08 00 Communications Systems Commissioning
G. Section 27 40 00 Audio-Video Communication Systems
H. Section 27 50 00 Distributed Communication System
I. Section 28 10 00 Integrated Security System
J. Section 01 25 00 Substitution Procedures
K. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.
L. Technology workboxes, back boxes, floor boxes, conduits, sleeves, cable tray, corridor cable support, grounding systems, and fire safing are per Electrical Section 26 00 10.

1.04 **TECHNICAL REFERENCES**

A. The product specifications, design considerations, and installation guidelines provided in this document are in part derived from recommendations found in recognized telecommunications industry standards. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed below, the more stringent requirements shall apply. The bidder is responsible for determining and referencing the most recent releases of all specifications during bidding and installation. Design, manufacture, test, and install all systems per manufacturer's requirements and in accordance with NFPA 70 (National Electric Code), state codes, local codes, Underwriters Laboratories (U.L.), requirements of authorities having jurisdiction, ADA requirements, and the most current version of the following specifications:
    1. TIA-568.0-D, Generic Telecommunications Cabling for Customer Premises.
    2. TIA-568.1-D, Commercial Building Telecommunications Cabling Standard.
    3. TIA-568-C.2, August 2009, Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
    4. TIA-568.3-D, Optical Fiber Cabling and Components Standard.
    5. TIA-568-C.4, Broadband Coaxial Cabling and Components Standard.
    6. TIA-569-D–2015, Telecommunications Pathways and Spaces.
    7. TIA-526-7 (OFSTP-7)-2002+A1:2008, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.
    8. TIA-526-14-B-2010 (OFSTP-14), Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant; IEC 61280-4-1 Edition 2, Fiber-Optic Communications Subsystem Test Procedure- Part 4-1: Installed Cable Plant-Multimode Attenuation Measurement.
    9. TIA-455-C General Requirements for Standard Test Procedures for Optical Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components.
    10. Building Industries Consulting Services International (BICSI) Telecommunications Distribution Methods Manual (TDMM)
    11. BICSI Information Transport Systems Installation Manual (ITSIM)
    12. ISO/IEC 18010, Pathways and Spaces for Customer Premises Cabling
    13. TIA-942-A-1, Telecommunications Infrastructure Standard for Data Centers
    14. TIA-607-C, Generic Telecommunications Bonding and Grounding (Earthling) for

Customer Premises.

15. ISO/IEC 11801, Information Technology – Generic cabling for Customer Premises
1. TIA-862, Building Automation Systems Cabling Standard for Commercial Buildings
2. ISO/IEC 14763, Implementation and Operation of Customer Premises Cabling
3. TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure
4. TIA-607-C Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
5. IEEE Standard 802.3an – 10GBASE-T over copper twisted pair cable.

B. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed above, the more stringent requirements shall apply. All references listed above were current during development of this publication. The bidder is responsible for referencing to the most recent releases when developing bid proposals.

C. This document does not take precedence over any code, either partially or wholly.

1.05 **SUBMITTALS**

A. General: Submit shop drawings, samples, and related submittals all together, at the same time, for coordinated review. Isolated items submitted shall not be reviewed until all items have been submitted for review.

B. Equipment List: Provide a detailed Equipment List showing quantities by manufacturer and model number of all major items of equipment and installation material to be used in the system as specified herein.

C. Product Data: Include complete sets of indexed cut sheets, in quantity as dictated by the project, of all major pieces of equipment, cable and connectors being supplied. Arrange these sheets in the order the equipment appears in the Specification. Clearly highlight information showing compliance with this and/or all applicable Specifications. If the manufacturer or representatives' cut sheet contains more than one item, clearly indicate which items of the cut sheet are intended for installation.

D. Firestop: Include cut sheets on all firestopping materials.

E. Shop Drawings: Submit a set of complete Shop Drawings, by system, showing equipment to be installed, including but not limited to:

1. System configuration block diagrams of all equipment, indicating equipment type and model numbers. Show each and every component, system and subsystem, as well as all proposed connections between system components, and cable types connecting components.
2. Proposed layouts and elevations of all equipment racks and cabinets showing all equipment specified and spaced accordingly.

F. Quality Assurance Submittals:

1. Include certification from the manufacturer(s) that the vendor/installer is factory-authorized representative of all systems provided.
2. Include names, qualifications, and certifications of installation personnel including site Supervisor/Foreman who shall be in charge of, and responsible for, all activities at the job site for the duration of the Project. The job Supervisor/Foreman shall not be changed during the Project without notification and approval from the Owner.
3. Complete warranty information.

G. Close-Out Submittals:

1. Technical Manual: Submit for approval a draft of the complete Technical Manual at least two weeks prior to the time of final system check out. When the final drafts are accepted, provide five copies of detailed technical manuals. The manuals shall include the following:
   a. Table of contents.
   b. Installer Name; contact name; address, telephone number, fax number, and email address.
   c. Certificate of Warranty
   d. Product Information: Include original copies of manufacturer's installation and operating instructions, and service manuals, arranged alphabetically. All service manuals shall be originals; there shall be no Xerox copies of the service manuals and schematic supplied. Warranty information shall be filled out in the Owner's name.
   e. Detailed Description of the complete system and all subsystems.
   f. Maintenance Documentation: Include the following:
      1) Information necessary to perform routine and corrective maintenance by the Owner's technical staff, or other qualified technicians.
   g. List of all equipment by manufacturer, model or part number, and serial number.
   h. List of spare parts.
2. Test Data: Submit for approval in writing the test results including numerical values for all measurements as specified in the Cable Schedules of this Section. Reports shall be titled and submitted in three ring binders. Once accepted, provide one set for the NETWORK room (MDF). Also submit written certifications that the installation conforms to Specification, is complete and operable, and ready for approval by the Architect.
3. Technical Diagrams and Drawings:
   a. Simplified single line block diagrams showing the interconnection of all equipment and functional relationships for all systems specified. Show all equipment, patch panels, cables and jacks, and all other hardware, whether connected or not. These drawings shall be on Engineering size E, 30 by 42 inch sheets. The intent of these diagrams is to provide sufficient clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.
   b. Provide record architectural quality plan drawings at 1/8 inch equals one foot. scale showing all components. These drawings shall be on Engineering size E, 30 by 42 inch sheets. Also provide all plans on thumb drive in AutoCAD 2010 or later .dwg format.
   c. All technical diagrams and drawings shall be mounted on the wall behind a clear plastic cover for protection. There shall be one set of the above drawings and diagrams provided for the network room.

H. Modified Close-Out Submittals: Modified Close-Out Submittals shall include full test reports of all cabling installed and required under this section for all areas completed prior to the completion of the Project. It shall also include “As Built” architectural quality plans drawings at 1/8 inch equals one foot. scale showing component locations. These drawings shall be engineering size E, 30 by 42 inch sheets. Modified Close-Out Submittals shall not eliminate or diminish the requirement for a full set of Close-Out Submittals for the entire Project once all phases of construction

are compete.

I. Modified Close-Out Submittals are required at the conclusion of the project.

1.06 **QUALITY ASSURANCE**

A. The Distributed Communication System Installer shall have at least ten years of experience in designing, installing, and testing traditional Distributed Communication Systems and two years of experience in designing, installing and testing IP based Distributed Communication Systems as specified and described herein. Additionally:
   1. The Distributed Communication system Installer shall be fully certified by the manufacturer(s) of the systems specified and shall be in good standing with the manufacturers, having satisfied all training and product certification requirements of each Manufacturer.
   2. The System Installer shall utilize personnel who are fully trained and certified by the Manufacturer(s) providing final system warranties on all equipment. The onsite supervisor/foreman shall have satisfied all training and product certification requirements of the Manufacturer(s) specified and being installed.
   3. The System installer shall own and maintain tools and equipment necessary for successful installation and testing of all systems specified.

B. Adhere to the engineering, installation and testing procedures of the Manufacturer of the components specified, and use only the cabling, components and methods of provisioning the Project authorized by the Manufacturer(s).

1.07 **DELIVERIES, STORAGE AND HANDLING**

A. Perform all tasks necessary to properly coordinate with all involved parties/trades for: Shipment, arrivals, loading dock, elevators (as applicable), acceptance, storage, and security of equipment and materials. Do not, during these tasks, interfere with other trades or the progress of this Project.

B. Assure that all deliveries are in correct quantities, within the appropriate times, and in compliance with all manufacturers' shipping instructions.

C. Protect all materials according to manufacturer's Specifications and/or instructions.

1.08 **SYSTEM WARRANTY, SERVICE AGREEMENT AND PERFORMANCE ASSURANCE**

A. Warranty all systems to be free of faulty workmanship and defects, and from damage due to contamination from the site for a period of five years from the date of final project completion.

B. The Warranties required by this section shall not be diminished by other warranties in the Contract Documents, equipment manufacturer's warranties, and all other rights and remedies available to the Owner under this Contract and public law. In addition, this Warranty shall not diminish the terms of individual manufacturer's warranties.

C. The Warranties required by this section shall be for the benefit of the Owner to whom Registration Certificate is issued and any successor in interest to the site.

D. Any repair or replacement of Cabling or Equipment resulting from this warranty shall be warranted for either (a) 90 days or (b) the remainder of the original warranty period, whichever is longer.

E. Service Agreement: The Distributed Communication System Installer shall respond to all requests for service during the warranty period. During this period, the Distributed Communication System Installer shall replace defective material and repair items of faulty workmanship at no charge to the Owner. All requests for service shall be responded to by telephone within two business hours, and technicians shall be dispatched within 24 hours. Only certified technicians shall be dispatched.

1.09 **SEQUENCING AND SCHEDULING**

A. A set of “as-built” documents shall be provided to the Owner by the Distributed Communication System Installer as soon as the installation is complete showing the unique label (based on actual final room numbering) for each device installed.

1.10 **TRAINING OF OWNER'S PERSONNEL**

A. Conduct a Training Program for the Owner's staff. The Training Program shall include a demonstration of the configuration of all systems. Schedule the Training Program at the convenience of the Owner, after the Technical Manual has been submitted and accepted. All materials in the Technical Manual shall be reviewed during the training program. All training sessions shall be videotaped with five copies provided to the Owner with closeout submittals.

1.11 **SYSTEM START UP AND COMMISSIONING**

A. During the first full week of operation by the Owner at the start of the School year, provide a full time technician who is knowledgeable of the installation and the configuration of the system to assist the Owner with issues and questions that may arise or changes that may need to be made to the system during daily operations.

1.12 **EXTRA INSTALLATION PROVISIONS, MATERIALS AND SPARE PARTS**

A. Provide and/or install the following. All devices and equipment shall be installed around the time of substantial completion of each phase with the assumption that ceiling grids shall be installed at the time of installation. Spare parts shall be delivered to the Owner with closeout documentation/submittals.

1. Provide and install up to five additional ceiling/wall mounted speakers, including tile bridge, back box and conduit stub not currently shown on plans in locations provided by the Owner. Assume cable runs 275 feet.

PART 2 PRODUCTS

2.01 **GENERAL**

A. It is the intent of the Specification that one manufacturer, not a combination, be selected for each particular class of material

B. Certain equipment is listed by manufacturer and model number. This is to define and establish a level of quality and functionality. The words, "or equal” are understood to follow all names of these specified products, trade names, catalog numbers, and detailed descriptions. It shall be interpreted to apply to any material, article, assembly or system, which in the opinion of the Owner is at least equal in quality, durability, appearance, strength and design to the material specified, and shall perform at least equally the functions imposed by the general design. The words, "or equal", shall not be construed to permit departure from the detailed requirements of the Specification. Other manufacturers’ products accepted by the Awarding Authority shall be equal to the specified products in terms of construction, quality, durability, performance, and appearance. Refer to Section 01 25 00 regarding product substitutions.

C. All materials and equipment shall be new and unused.

D. All part numbers and manufacturers shall be according to this Specification unless otherwise noted on the construction Drawings.

E. Provide all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware necessary to support all cabling and equipment specified.

F. The System shall be a hybrid IP based system utilizing IP head end and closet devices with analog end devices for speakers and call buttons.

G. System shall be supported by multiple manufacturer certified installers within the local of the project, so that the Owner has choices with regard to who provides long term service and support of the installed system.

2.02 **DISTRIBUTED COMMUNICATION SYSTEM**

A. The system shall utilize state-of-the-art IP Technology, Call-in Notification, School Safety Paging and Evacuation tones, IP infrastructure, Analog Station Bridges, Atomic Time Synchronization with Class Change Tones utilizing multiple, programmable schedules for each zone, Two-way hands-free Internal Intercommunications and Paging, and Program Distribution. All standard programming shall be web based and user friendly to allow the system administrator the ability to easily program system features.

B. The system shall be directly connect to the LAN. Configuration, including bell schedules, calendars, and emergency sequences shall be remotely created, changed, stored and downloaded to the system by an authorized user from a browser-based interface.

C. The system shall provide the ability to initiate school safety paging announcements, evacuation tones and take cover tones from any telephone within the facility. All zoning shall be reviewed and accepted by the Owner prior to installation of any equipment or cabling.

D. The system shall provide the ability to initiate school safety paging announcements, evacuation tones and take cover tones from any telephone within the facility.

E. Two-way voice communication shall be available from any Owner provided telephone, zone paging microphone station, or administrative console to/from any speaker in the system. This shall allow hands-free communication to any classroom or any individual loudspeaker unit. A programmable pre-announce tone shall sound immediately before the intercom path is opened and a supervisory tone shall continue to sound at regular intervals when speaker monitoring is active, complying fully with all privacy legislation. Preannounce tone and supervisory tones shall be disabled during designated emergencies automatically.

F. The system shall include and Integrated Master Clock. The platform shall allow control of the bell schedules via the LAN without the need for a separate and dedicated computer at the school. Bell schedules shall be remotely created, changed, stored and downloaded to the system by an authorized user from a browser-based interface.

G. The system shall fully integrate with the school's VoIP telephone system via SIP and have capability of district wide integration for paging, emergency notifications and configuration. Coordinate with Owner's VoIP vendor.

H. All new Public Address main equipment shall be rack mounted in the MDF and connected to UPS and standby power. All system programming of the systems shall be accomplished remotely, by the Administrative Control Consoles located Main Office Areas or over the LAN. It shall not be necessary to attend to the main equipment in the MDF for normal day-to-day operation of the system.

I. The system shall provide multi-node survivability in the event of a processor card failure. If either the primary processor or secondary processor fails for any reason, the remaining processor shall take over as primary, autonomously providing the facility with all scheduled events stored in each of the nodes local non-volatile memory and ability to connect an administrative phone to the local node for paging in the event of network failure.

J. Provide redundant server/controller so that if one system controller fails, that the system shall continue to fully function.

K. System server/controller minimum requirements:
   1. Debian Linux OS (AMD 64-bit version) release 8.10.0 or later

2. Quad-core Intel-based processor running at 3.0 GHz or higher
3. Memory - 16 GB RAM
4. 250 GB disk drives, Redundant Array of Independent Disks (RAID)
5. SAN for backup (weekly backups)
6. NIC 10/100/1000 MB Ethernet port
7. SIP Trunking for VoIP integration
8. One or more PCI/PCI Express (PCIe) slots
9. One or more PCI/PCIe type third-party telephony interface cards (for example, FXO, FXS)

L. Provide Bogen NQ-SYSCTRL or equal.

M. Audio shall be transmitted between the server and the appliances using the LAN/WAN using both G.722 and Opus 48k audio encoding and streaming technology to deliver high-definition audio quality.

N. It shall be possible to make “station-to-station” calls and “remote facility” All-Call pages to a single facility or to all facilities in the district via the Web GUI or an Admin Stations.

O. The server software shall handle all facility and district-wide communications, including but not limited to, inter-facility intercom calling and paging, district-wide Emergency All-Call and local facility point-to-point calls. Via the Web UI, every facility shall be configured with the IP addresses of all the other remote facilities within the district. System shall have the capability to support an unlimited number of facilities.

P. The system shall facilitate the repetitive playing of Normal or Emergency audio tones or announcements directed to a Paging Zone until stopped by the user via the Web UI, an Admin Station, or a dry contact closure connected to the I/O Controller.

Q. A built-in Master Clock shall be included to automatically control class change bells or other time-based signals independent for both schools. The Master Clock shall have an unlimited number of Events that may be programmed into any of the unlimited number of Schedules, and unlimited number of Holidays. The schedules shall be nameable for easy selection when assigning schedules to days or overriding a schedule.

R. Network Time Synchronization. The system shall be capable of periodically updating/synchronizing the processor’s time with a Network Time Server running Network Time Protocol (NTP) via the LAN. Systems that do not provide Network Time Synchronization shall not be deemed equivalent. Connect to the master clock system specified to ensure times are synchronized at all times.

S. VoIP Controller shall provide the following features:
   1. Call routing for paging and intercom for a single facility.
   2. Connect to the school’s VoIP Telephone System for full integration allowing all IP, analog, and digital phones to make pages. Provide all equipment, gateways and software necessary for full integration.
   3. Direct Dialing, two-way amplified voice intercom between any telephone or admin console and speaker without the use of a press-to-talk or talk-listen switch.
   4. Answer intercom call-ins registered at pre-selected telephones.
   5. SIP Interface providing Audio paging access from any telephone to any single intercom speaker, zone (group) of intercom/paging speakers, or all speakers/paging horns throughout the entire facility. Single button access from any telephone on the system to initiate alarm signals within the facility to all or select locations equipped with speakers.

6. Utilize a web-browser and USB microphone to deliver school-wide live emergency paging, pre-recorded messages and tones from any authorized computer in the facility.

T. Analog Station Bridges (ASB) shall provide the following features:
   1. Each ASB shall support up to 24 speakers and call switches with 120 Watts of embedded 25 Volt power. The ASB shall be designed to drive any combination of 25 Volt speakers and horns. Features shall include:
      a. 10/100 Ethernet
      b. 24 station interface - Supports connections to as many as 24 individual 25 Volt speakers with one 25 Volt speaker connection per interface
      c. 24 dry contact closure-type analog Call Switch connections
      d. Half-duplex talkback using speaker as pickup
      e. CAN Bus 2.0 Interface for future NQ-E7020 DCS support and other accessory devices
      f. 120W of available power across all 24 channels; maximum 40W per channel
      g. Two RGB full spectrum LED status indicators
      h. USB 2.0 host port, type A connector (future use)
      i. Universal mains supply (100VAC – 240VAC)
      j. ASB shall be rack, wall, or shelf mountable and shall include the required mounting bracket hardware.
      k. Bogen NQ-E7030 or equal.
   2. Provide ASBs to accommodate all components plus 20 percent for future growth. Do not exceed 80 percent capacity on any ASB (wattage or speaker/zone capacity).
   3. In addition to the above requirements, provide one spare ASB for the MDF and each IDF.

U. I/O Controllers shall provide the following features
   1. Accept contact closure inputs and activate open-collector outputs to drive relay coils.
   2. PoE Class-1; IEEE 802.3af compliant with Optional 48VDC 15W power supply
   3. Eight Dry Contact Closure Inputs that can be used with Fire Alarm Override Relays, external event triggers (for example, Lockdown Buttons)
   4. Eight Relay Driver Outputs (Open-Collector) for use with Clock Correction (Sync Pulse), response to contact closure inputs.
   5. USB 2.0 host port, Type-A connector (future use)
   6. Two RGB full spectrum LED status indicators
   7. Support wall or shelf-mounting options and shall include the required mounting bracket hardware.
   8. Be designed for wall or shelf mounting
   9. Provide connections to security and fire alarm systems and provide all programming.
   10. Bogen NQ-E7010 or equal.

V. Audio Paging/Program Amplifiers shall provide the following features
   1. Provide power amplifier(s) to provide a minimum of two watts of power to all paging speakers, and 15 watts of power to all paging horns.
   2. The maximum load on the paging/program amplifiers shall be 80 percent of the rated maximum output of the amplifiers.

W. Admin Consoles shall provide the following features:

1. Seven inch 800 by 480-pixel color display with backlight
2. Touch screen display for one touch operation
3. Full-duplex hands-free speakerphone with AEC
4. Call, hold, mute
5. Redial, call return, auto answer
6. PoE (802.3af) Class-3 support
7. Headset with EHS support
8. Dual Gigabit Ethernet ports
9. Desk Mountable
10. Optional Wall mount capable
11. Show the time of day and day of week, the current bell schedule(s), and the station numbers and call-in priority of staff stations that are calling in. Depending upon the system programming, an Admin Station shall display menus to activate Zone Paging, All-Call Paging, Emergency All-Call Paging, District All-Call paging, alarm signals, and external functions.
12. Calling either the loudspeaker or Phone at each classroom location.
13. Display the classroom number of any station that calls 911. This allows front-office administrators to direct emergency personnel to the correct physical location in the building when they arrive. If a system is not connected to outside phone lines, then 911 calls can be routed to a designated station within the facility. The system shall automatically record all 911 calls made from any station. The 911 call recording shall begin as soon as 911 is dialed and continue unit the call is terminated. Recorded calls shall be maintained on the system for later playback review and/or retrieval by authorized personnel and/or authorities. Systems that do not provide this feature will not be deemed equal.
14. Bogen NQ-T1100 or equal.

X. Horn Speakers shall provide the following features:
1. Reentrant type: flush mount installation
2. Frequency Response: 600 to 14,000 Hz.
3. Power Handling: 15 Watts RMS, 30 Watts Peak.
4. Variable screw taps, 25 V transformer.
5. Sound Pressure Level: 110 dB at one meter with one watt input.
6. Bogen FMH15T with BBFM6 Flush-Mount enclosure and SGHD8 grille and adapter ring.
7. All Horn Speakers shall be home run as separate zones for full system control.

Y. Ceiling/Wall Mounted Loudspeakers shall provide the following features
1. Type: Speakers in corridors and general spaces shall be flush mounted cone speakers. Speakers in classrooms and offices shall be ceiling tile lay-in type, where there is acoustical ceiling tile**.** Coordinate with architectural ceiling plans.
2. Frequency Response: 50 to 18,000 Cycles.
3. Magnet: Ten Ounce.
4. Axial Sensitivity: 97 dB at one meter with one watt input.
5. For Corridors and General Spaces: Bogen S86T725PG8UBR with 25/70.7 Volt Transformer, RE84 backbox and TB8 tile bridge or approved equal. For locations requiring speakers with volume control, substitute speaker with S86T725PG8UBRVK6 or accepted equal.
6. For Classrooms: Bogen S86T725PG8UBR with 25/70.7 Volt Transformer, RE84 backbox and TB8 tile bridge or accepted equal. Configure speakers as separate zones as talkback speakers.

a. In areas other than Classrooms, Speakers that are adjacent to or can be associated with an a Call Button, shall be configured as talk back speakers.
b. All Talk Back Speakers shall be cabled using Category 6 compliant cabling for to allow the Owner to retrofit with IP speakers in the future without having to recable. Provide three feet of cable slack at the speaker end.
c. Talk Back speaker cabling shall be terminated on Category 6 48 port compliant patch panels adjacent to the ASB's in the Network and IDF Rooms.

7. For Offices: For locations requiring speakers with volume control, substitute speaker with S86T725PG8UBRVK6, RE84 backbox and TB8 tile bridge or approved equal.
8. In exposed ceiling areas (No acoustical ceiling tiles or Gyp) provide surface mount enclosure to mount speakers as specified above.
9. In gypsum ceilings and wall installation provide manufacturer recommended flush mount enclosure to mount speakers as specified.
10. Coordinate installation with ceiling plans (RCPs).

Z. Provide all cabling as recommended by the manufacturer. All cabling shall be plenum rated. Cables routed through underground or under slab conduits shall also be rated for underground/direct burial installation. Coordinate colors of any exposed visible cabling with the Architect.

AA. Coordinate with Owner and Owner's IT vendor for all network installation and configuration. Provide all technical assistance during network configuration and ensure full functionality of entire system.

BB. Provide turn-key installation and configuration. Provide all programming of GUI and admin consoles.

CC. Provide all licensing for all components where required for full functionality and moves/adds/changes/upgrades in the future. All licensing shall be perpetual for the system to fully function. Solutions that will incur additional licensing costs or software maintenance costs for the system to fully function in the future will be rejected.

DD. Call Buttons shall be Bogen CA15C Call Switch, which shall initiate a normal, urgent, or emergency call from classrooms and other locations and support room check-in when the school is in lockdown.

EE. Provide a -1dB balanced audio line level output from the public address system to each local sound systems in the Cafeteria and Gymnasium and any other specified systems and provide equipment for emergency pages to over-ride the local sound systems. Connect to all classroom audio systems for bypass via "pagefirst" feature.

FF. Provide all cabling as recommended by the manufacturer. All cabling shall be plenum rated. Cables routed through underground or under slab conduits shall also be rated for underground/direct burial installation.

GG. Provide full integration with the integrated security system and Owner's VoIP system.

HH. Review all programming options with the Owner prior to installation. Provide turn-key programming, configuration, and customization according to Owner requirements.

2.03 INTEGRATED MASTER AND SECONDARY CLOCK SYSTEM

A. Provide "State of the Art" in Technology for Master Clock and Secondary Clocks, so that they form as an integrated system together and with the Public Address System. Time programming shall be accomplished by way of a microprocessor-based and user-programmable master control system. The system shall be easy to learn and operate. All standard system programming shall be user friendly to allow

the system administrator the ability to easily reprogram system features. Features offered by this system shall be implemented and controlled by software programs that can be changed and expanded as customer needs evolve. The Master Clock shall use an integrated master controller capable of operating and correcting both digital and analog secondary clocks as well as controlling class change signals to all speakers. The Master Clock systems shall provide the necessary signals to assure synchronization of all Secondary Clocks. The Public Address System and Master Clock System shall be fully integrated.

B. The Master Clock shall be the Sapling SMA 3000 Series. The master clock shall have a LED display, as well as a backlit, two rows by twenty-character LCD display. The master clock shall have the capability of receiving time from any SNTP (Simple Network Time Protocol) server. The master clock shall have up to ten pre-programmed SNTP addresses in case the clock does not receive its time from one of the servers, a backup is in place. The master clock shall be capable of receiving signals from all Sapling Master Clocks via RS485. The master clock shall have the capability of running a wired system and/or wireless system (with transmitter option). The master clock shall contain two clock circuits that have the capability to run synchronous wire systems such as 59-minute correction, 58 minute correction, National Time/Rauland or a once a day pulse for intercom systems. The master clock shall be programmed via the 16 button rubber tactile keypad. The master clock shall be powered by 110VAC/60 Hz or 220VAC/50 Hz. Additionally:
    1. The master clock shall be capable of utilizing eight zones that can be used for bell scheduling, lights, and other components. The zones shall be capable of being programmed via the 16 button rubber tactile keypad and LCD display or from the web interface upgrade.
    2. The master clock shall be able to be programmed completely from a web interface that can be accessed through any typical web browser such as Microsoft Internet Explorer or Mozilla FireFox. The interface shall allow the user to program all bell schedules, events, display features, IP settings of the master clock and any system setting that the master clock has.
    3. The master clock shall have the capability to act as a SNTP server that other devices can point to, to receive the time through SNTP protocol.
    4. The master clock shall automatically sync daily to the atomic clock via the web or other interface.
C. Converter Box
    1. The power supply shall be a Sapling Converter Box (part number SCB–000–000–1). It shall have a 24-volt, 150-watt DC power supply. It shall be capable of driving 24 volt analog and digital clock systems. The protocol shall be a two (2) wire digital communication system.
    2. The power supply shall have an output of 5.5 amps, at 24 volts DC. The power supply shall be powered via 110 volts AC and have a RS485 or two wire digital communication input.
    3. It shall have the capability to sense and notify the user in case the power supply is reaching 80% of the temperature threshold, or if 80% of the maximum load capacity is imposed.
    4. It shall have two LEDs to display if the power supply is receiving an input. The power supply shall have four sets of outputs.
    5. The power supply shall have slim, metal housing. It shall be UL and cUL listed, as well as FCC accepted.

D. Secondary Clocks
   1. The secondary clock shall be Sapling SAM Series clock with automatic protocol detection. The clock will have plug and play features with no settings required.
   2. The clock shall have self–diagnostic capabilities for protocol detection, last received communication time and a comprehensive analysis of the entire clock. The clock shall be capable of having remote diagnostic capabilities from the master clock location.
   3. The clock shall have automatic polarity detection, as well as a maximum correction time of five minutes.
   4. The clock shall be designed to be used in a two wire system with Sapling 3000 Series Master Clock systems, which can regulate it by Sapling digital communication protocol. Upon receipt of the digital signal, the clock shall immediately self–correct.
   5. The secondary clock shall have the ability to accept sync–wire communication protocols with hourly and daily correction.
   6. The secondary clock is to have a microprocessor based movement.
   7. The clock shall have a low–profile, semi–flush smooth surface metal case. The crystal shall be shatterproof polycarbonate material. Glass and visible molding marks are unacceptable.
   8. The clocks shall be able to be mounted to a standard single gang box.
   9. The clock is to have black hour and minute hands, as well as a red second hand.
   10. The clock shall have UL, cUL and FCC compliance.

E. Provide all cabling as recommended by the manufacturer. All cabling shall be plenum rated.

F. The quantity of secondary clocks shall be per technology drawings and the type shall be SAM-1BS-12R-4 or approved equal with standard dial and hands. Clocks indicated with 16/SP-WG shall be a SAM-1BS-16R-4 with a protective wire guard.

2.04 **CALL BUTTON TO SPEECH REINFORCEMENT SYSTEM CABLING**

A. Furnish and install one pair cable between each Call Button and the Speech Reinforcement System in the same space or room. Connect cable at the Call Button and provide eight feet of slack at the Speech Reinforcement System for connection by the installer of the Speech Reinforcement System per Section 27 40 00 AUDIO-VIDEO COMMUNICATION SYSTEMS. Test system to ensure that Distributed Communication System calls can be initiated by the teacher's microphone of the Speech Reinforcement system through the Call Button in each room.

2.05 **UNINTERRUPTIBLE POWER SUPPLY (UPS)**

A. A UPS shall be provided for all Public Address/Master Clock System main equipment, ensuring complete system capabilities during power failures, outages, and surges. Once power is restored, the Master Clock shall instantaneously update all clocks with the correct time.

B. UPS shall be rack-mountable and provide a minimum of ten minutes of battery back-up in the event of a power failure to all main equipment.

C. UPS shall be manufactured by APC or accepted equal and contain all necessary hardware for a complete installation, including rack rails for the cabinet or rack it shall be installed in.

2.06 **UNSPECIFIED EQUIPMENT AND MATERIAL**

A. Any item of equipment or material not specifically addressed on the Drawings or in this document and necessary to provide a complete and functional installation shall

be provided in a level of quality consistent with specified items.

PART 3 EXECUTION

3.01 EXAMINATION

A. Prior to commencing Work of this Section or ordering equipment, examine site and conditions under which work shall be performed. Determine exact locations of items shown diagrammatically on Drawings. Determine dimensions needed to install components, move in racks and any custom items. Notify the Architect of any conflicts or special requirements needed to provide for free access to doorways, corridors, stairs, and similar areas, necessary to move in the specified equipment. If the Systems Installer fails to provide such notification, any additional cost to remove and reinstall any building members shall be back charged to the Systems Installer.

B. Technology Drawings designate component locations. Install quantity and type according to the Technology Outlet Plans and as specified herein. Provide all adapters and/or accessories for a complete installation in all raceways, and other locations.

C. Commencement of Work of this Section indicates acceptance of existing site conditions.

3.02 WORKMANSHIP

A. System shall be installed in a neat, workmanlike manner. Workboxes, equipment, and enclosures are to be plumb and square. Install the system elements in cooperation with all trades to achieve coordinated progress and desired results. Watch for conflicts with Work being performed by other trades that have impact on the installation of the system components. Make moderate moves or changes in equipment locations as are necessary to accommodate other equipment without a claim for additional payment.

3.03 INSTALLATION, GENERAL

A. Pre-installation: Meet with the Construction Manager, Project manager, and any other appropriate parties for coordination meeting prior to beginning work and to coordinate requirements.

B. Coordinate Work with adjacent Work of other trades to facilitate installation and prevent conflicts.

C. Staff job appropriately to keep pace with the Project schedule.

D. Abide by the decision of the Architect to case of conflict or interference of the other trades.

E. Work under this Section shall be performed in accordance with associated local, state, and national building codes.

F. Coordinate requirements of ceiling and floor mounted outlets with the Electrical Contractor.

G. In the event that the Distributed Communication System Installer must re-enter an area of a previously completed phase of Work, the Installer shall be responsible for returning that area back to the condition it was in before the Installer re-entered the area. This includes re-installing ceiling tiles, cover plates, cleaning floors and all other items and areas. Coordinate the cutting and patching of holes with the Construction Manager, and comply with the Cutting and Patching Section.

H. Every effort shall be made to schedule the Work under this Specification in such a manner so as to complete all above ceiling Work prior to ceiling panel installation. In the event that the Communication Systems Installer is required to remove ceiling panels, such Work shall not break or disturb the existing ceiling grid or panels and shall be coordinated with the Construction Manager and Ceiling Contractor.

I. Spare pull strings shall be left in all EMT, Conduits, and Innerduct.
J. The Distributed Communication System Installer shall furnish and install all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware necessary to ensure that all equipment and cabling is properly installed and supported according to the manufacturer's recommendations.
K. Take precautions to prevent and guard against electromagnetic and electrostatic interference. Avoid potential sources of EMI in all aspects of installation. If interference is experienced, the Distributed Communication System Installer shall provide all testing to identify the source of interference and provide a remedy including but not limited to re-routing and/or replacing cables.
L. Communications Systems Installer shall meet with Owner to review all programming options of the Public Address System and to obtain specific clarification from the Owner with regard to system requirements prior to cabling installation and final systems programming. This shall include but not be limited to the paging zone coverage and preprogramed paging announcements.
M. Communication Systems Installer shall meet with the Owner to verify final zone coverage plan prior to installation.
N. Power amplifiers shall be installed to provide a minimum power capacity of 2 watts per cone speaker and Door Signaling device plus 15 watts of power per horn type speaker locations.
O. Interior ceiling and wall mounted speakers shall be tapped at .5 watt; interior horn speakers at 7.5 watt; and exterior horn speakers at 15 watts.
P. Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors per manufacturer recommendations to provide control functions indicated or specified.
Q. All wires shall be laid down on patch panels or terminal punch blocks and identified by the actual room/zone location it serves.
R. Provide adequate length of conductors. Bundle, lace, and dress the conductors to terminal points with no excess. Provide and use lacing bars.
S. Make installation in strict accordance with accepted manufacturer's drawings and instructions.
T. The Communications Systems Installer shall provide necessary transient protection on the AC power feed, all station lines leaving or entering the building, and all central office trunks. All protection shall be by the equipment supplier and referenced to earth ground.
U. Provide physical isolation from each other for speaker-microphone, line-level, speaker-level, and power wiring. Run in separate raceways, or where exposed or in same enclosure, provide 12 inch minimum separation between conductors to speaker-microphone and adjacent parallel power and telephone wiring. Provide physical separation by equipment manufacturer for other programmable electronic communications network system conductors.
V. The Communication Systems Installer shall interface the public Address System and the telephone system equipment and test for full integration and all paging functions that rely on the telephone system.

3.04 **CABLE SUPPORTS AND ROUTING**

A. Install all cabling shall be installed in accordance with the manufacturer's guidelines and according to all applicable building codes at the time of installation, including but not limited to the NEC and the ANSI/TIA/EIA Telecommunications Building Wiring Standards.

B. Route all cables in large groupings, through main hallways, until cable can be distributed directly to the system components. Route individual cables to the appropriate locations in accordance with all standards described herein.
C. Install cables in cable tray, J-hooks, pipe and/or sleeves specified in this and other sections In suspended ceilings where cable trays or conduit are not available, bundle cables in bundles of 50 or less, with Velcro cable tie wraps pulled snug, but not deforming the cable geometry. Support the cable bundles with accepted "J" style hooks attached to the building structure at a maximum of three foot intervals.
D. The Installer shall adhere to the manufacturers' requirements for bending radius and pulling tension of all communication cable.
E. Install cables in such a manner as to minimize tension and stress on cables, which can lead to changes in the physical and/or electrical characteristics of the cables over time. This applies to, but is not limited to, horizontal cable support methods, vertical cable support methods, tie wraps, or similar types of cable support methods.
F. Cables exiting floor conduits and sleeves shall be neatly dressed, and securely supported from the floor up to the ceiling so that the cables are not stressed or stretched by the weight of the cables. Cables shall be arranged in bundles of not more than 50 cables or less, and secured with Velcro cable tie wraps pulled snug, but not deforming the cable geometry. Acceptable support structures include, but are not limited to: Cable tray runway radius dropout, vertical ladder tray, J-hooks, unistrut, or similar types of support structures. The intent is that cables shall not be supported by the weight of the cables themselves, but are supported so that the weight of the cables is assumed by the support structure(s).
G. Route station cables at right angles to electrical power circuits and supported only from the building structure when not in cable tray or conduit.
H. Do not support cabling from ceiling tiles, grid or hanger wires.
I. Do not install random or diagonal cable runs. Cable turns and bends shall be made at 90 degrees angles whenever possible, but maintaining manufacturers' requirements for bending radius at all time.
J. Install cables at components, regardless of how routed to the component, with a five foot service loop of cable secured above the ceiling where the cable enters the pathway to the component.
K. In the network room, a ten foot service loop of cable shall be provided in the cable tray above terminations. Service loops shall be installed in either a figure “8” or “U” pattern. Service loops shall not be installed as tight circular coiled loops.
L. Cables which penetrate a steel stud or steel wall cap shall be protected from damage with a "stud liner".
M. Cables entering power poles, surface mounted raceway, or other cable management systems shall be protected from damage.
N. Extend cabling between floors utilizing inter-floor sleeves and conduit as shown.
O. Conduit and sleeves provided as a means of routing cables between various rooms and floors shall be used according to the following requirements: Install cabling through separate conduits and/or sleeves for each system. In each group of conduits and/or sleeves, one four inch conduit and/or sleeve shall remain empty as a spare conduit or sleeve for future cabling. It is imperative that the cables for each system remain separate from the other systems. Cables routed in violation of this requirement shall be pulled back and rerouted, even if already terminated, at no additional cost to the Owner.

P. Conduit and sleeves provided as a means of routing cables between various rooms and floors, and those which remain empty as spare, shall be sealed with an accepted fireproof, removable safing material. Sleeves which pass vertically from floor to floor shall be sealed in a similar manner using an accepted re-enterable system. Additional penetrations through rated assemblies necessary for passage of wiring shall be made using an accepted method, coordinated with the Construction Manager, and permanently sealed after installation of cables.

Q. Meet all requirements regarding use of cable in return air plenums and in raised floor systems. Provide wiring that complies with all applicable state, local building codes, and the National Electrical Code. All cables run in raised floor systems with forced air-cooling shall meet the requirements of NEC Article 645, "Electronic Computer Data Processing Equipment".

R. Cables installed partially or fully within the network and IDF rooms shall be routed through and secured in the cable tray wherever possible. Cables placed in the cable tray are to be laced or tie wrapped with Velcro tie wraps frequently to keep them neatly bundled and not permitted to shift from one side of the tray to the other as they are routed in the tray.

S. Color of cable jacket for each system shall be unique and distinguishable from other system cabling

T. Cables routed in main corridors shall be installed in corridor cable support as specified in this Section. The Systems Installer shall size and select the correct product so that no more than 75 percent of the manufacturer's loading capacity is achieved in any given corridor area. The installer shall use the manufacturers' recommended attachment hardware for hanging the corridor cable support. Corridor cable support shall be suspended from integrated mounting hardware every four feet along the center spine.

3.05 CONDUITS, SLEEVES, CABLE TRAY AND WALL/FLOOR PENETRATIONS

A. Conduits, Sleeves, Cable Tray and Wall/Floor Penetrations between NETWORK/IDF rooms and main corridors shall be provided by Division 26 for cabling under this section.

B. The installer shall be responsible for coordinating room and/or space for cabling within all conduits, sleeves, cable tray and wall/floor penetrations between network and IDF rooms and main corridors provided by Division 26.

C. Conduit sleeves between all main corridors and hallways into all rooms, offices, and spaces showing devices, and through all fire rated walls shall be provided by Division 26.

3.06 FIRESTOPPING

A. Seal all horizontal and vertical openings between floors, through fire rated fire and smoke walls, used or created by the Installer.

B. Refer to Section 07 84 00 - Firestopping, for all product requirements for maintaining integrity of fire-rated construction at penetrations.

3.07 LABELING

A. Clearly label and identify all components. Logically and permanently mark all cable, connectors and electronic equipment.

B. Use a letter quality printer or other mechanically produced lettering for labels.

C. Place permanent cable markers three inches from all connectors to allow easy identification. Use Brady Markers with clear plastic ends. Acceptable markers are, Brady B-320, B-292, SL-292, or Brady machine embossed labels with clear vinyl

ends. Machine generated markers are required. Place cable markers on cables so that they can be easily seen.

D. Handwritten labels shall not be accepted, even if written with a permanent marker. Temporary handwritten labels may be used only during the “rough-in” stages; they shall be replaced with permanent labels prior to Project completion.

3.08 **BONDING AND GROUNDING**

A. Telecommunications Bonding Backbone utilizing #6-AWG or larger bonding conductor shall be provided by Division 26. This is part of the grounding and bonding infrastructure (part of the telecommunications pathways and spaces in the building), and is independent of equipment or cable.

B. For all systems, provide equipment grounding connections. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

C. For all systems, provide conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide five ohm ground at main equipment location. Measure, record, and report ground resistance.

D. For all systems, Installer shall provide transient protection on the AC power feed and on station lines leaving or entering the building.

E. For all systems, Installer shall note in the system Drawings, the type and location of these protection devices as well as all wiring information.

F. For all systems, Installer shall furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground bus bar.

G. Provide any necessary screws, anchors, clamps, tie wraps, distribution rings, and miscellaneous grounding support hardware to complete the installation of the grounding system.

H. Grounding busbars shall be installed in the network room, IDF rooms and the Service Entrance Room by Division 26.

I. All non-current carrying system components (passive) shall be bonded to the grounding busbar utilizing two-hole lugs for all bonding connections.

J. All grounding conductors shall be affixed with permanent labels in a visible location at each end of the conductor, and as close as practicable to the bonding point at each end of the conductor. The labels shall clearly identify both the source and destination of the bonding conductors. Handwritten labels are not acceptable.

3.09 **TESTING**

A. Test the proper functioning of all equipment items to ensure components meet manufacturer's published specifications and the intent of this specification. All adjustments shall be made to optimize the system prior to Owner training.

B. Provide full commissioning of the System. All system performance certification and programming shall be performed by a factory certified technician.

C. Measure the impedance of each amplifier's connected loudspeaker load after all speakers are installed and all transformer "taps" properly set. All room or area volume controls shall be set at "full on" for these measurements. Where more than one zone is connected to the same amplifier, each zone shall be measured individually and then combined. These measurements shall be made with proper test equipment using a 1000 Hz sine wave signal. The results of these measurements shall be recorded for inclusion in the operation manuals.

D. Where the measurement of any amplifier's loudspeaker load is less than 1.25 times the amplifiers' nominal output impedance, make required corrections.
E. The gain controls of all electronic equipment shall be set and then capped or locked into position. Controls which are used for normal system operation are excluded from this requirement. All control settings shall be recorded for inclusion in operation manuals.
F. Test the proper functioning of all equipment, items and components of the system to ensure components meet manufacturer's published specifications and the intent of the specification.
G. Test each paging zone. Measure system acoustic performance using a calibrated ANSI Standard Type 1 or IEC precision sound level meter set for "slow" meter damping. Measure the response with the sound level meter at a height of four to five feet AFF at multiple locations with all finishes and furnishings in place. Readings of 70-80dB at 10dB above back ground noise should be recorded, except as otherwise noted.
H. Test to ensure two-way talk-back speakers function properly.
I. Test for proper volume level adjustment. Testing shall include subjective evaluations by school personnel listening from various positions under various operating conditions. The objective of these tests shall be to verify system functioning under conditions of normal operation and be ensure that the Owner is satisfied with volume levels in all spaces. Adjust volume-controlled speakers in coordination with the Owner. Adjustments shall be made by the installer at no additional cost up to six months after final Substantial Completion.
J. After supplying diagrams and completing initial tests and adjustments specified, notify the Architect, in writing, that the installation fulfills this specification, and is complete and ready for inspection by representatives of the Architect and Owner.
K. In case the need for further adjustments becomes evident during the demonstration and testing, continue work until the installation operates properly.
L. Provide covers, caps, or locks for control settings for inclusive with the final documentation on all units with front panel volume controls. Use colored labels to mark the normal level setting of system volume controls. Install security covers to protect controls from tampering.
M. Document testing in accordance with Submittal paragraph. Provide a table of test results in a three-ring binder submitted with the as-built Drawings.

3.10 **TRAINING**

A. Train systems administrative and/or maintenance personnel in procedures involved in operating, troubleshooting, servicing and preventative maintenance of each system specified. Provide no less than three two-hour sessions of training at the Owner's discretion, including:
    1. Review of the physical configuration and interrelationship of the system components.
    2. Labeling and interconnection techniques used in the installation.
    3. Applications of systems including any unique connections or interfaces required in the use of systems on site.
    4. A review of warranty documents for the system.
    5. A review of the Technical Manual prepared per "Closeout Submittals."
    6. A Review of operation manuals and users guides for the system.
    7. System operation and maintenance procedures.
    8. Review of all user programmable options and how to modify options.

B. For each session, provide two thumb drive copies of recorded training. The Owner will not accept “train the trainer” models. Provide owner with complete user instructions used for training purpose as well as training log of all users who attended training classes.

3.11 **CLEANING**

A. Clean all equipment and work areas under this Section, prior to scheduling Owner training. Include wiping of Work areas and surfaces, and the removal of dust, streaks, stains, and other contaminants from all equipment specified. Leave installed systems and components clean and undamaged.

END OF SECTION

SECTION 27 53 19

EMERGENCY RESPONDER RADIO SIGNAL AMPLIFICATION SYSTEM (BDA SYSTEM)

(Part of Sub Bid 26 00 01)

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SECTION 27 53 19

EMERGENCY RESPONDER RADIO SIGNAL AMPLIFICATION SYSTEM (BDA SYSTEM)

(Part of Sub Bid 26 00 01)

PART 1 - GENERAL

1.01 GENERAL PROVISIONS – FILED SUB-SUB BID REQUIRED

A. Attention is directed to the Contract And General Conditions and all sections within Division 01 - General Requirements which are hereby made a part of this section of the Specifications.

B. Examine all other sections of the specifications for requirements that affect work of this section whether or not such work is specifically mentioned in this section.

C. Coordinate work with that of all other trades affecting, or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the Contract.

D. Sub-Sub-Bid Requiring A Paragraph “E” Listing on the Form For Sub-Bid required per M.G.L. Chapter 149 Section 44A to 44L, as amended to date. The Electrical Subcontractor shall be responsible for all related building preparation and coordination, see specification for additional Paragraph “E” Listing requirements of the BDA System SubContractor, and coordination of responsibilities.

E. Section 27 53 19 Emergency Responder Radio Signal Amplification System (BDA System) shall be a Filed Sub-Sub Bid of Section 26 00 01 Electrical, requiring a Paragraph “E” Listing on the Form For Sub-Bid.

1.02 RELATED DOCUMENTS

A. The General Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.03 SUMMARY

A. This specification describes the criteria for deploying an Emergency Responder Radio Signal Amplification System (BDA System). The BDA components specified in this document include: Bi-Directional Amplifiers (BDA), Donor Antennas, Coverage Antennas, Coax Cable, Coax Connectors, Splitters, Combiners and Couplers. These devices shall be used as part of a system, by the BDA integrator, experienced with designing projects for in-building, public safety, 2-way radio systems.

B. Provide pre-test to determine coverage.

C. Related Sections include the following:

1. Division 27, 27 01 00 Structured Cabling System.

1.04 ABBREVIATIONS AND ACRONYMS

A. ACG: Automatic Gain Control

B. AHJ: Authority Having Jurisdiction

C. ATP: Acceptance Test Plan

D. BDA: Bi-Direction Amplifier

E. BOM: Bill-of-Material

F. DAS: Distributed Antenna System

G. EBS: Educational Broadband Service

H. ESMR: Enhanced Specialized Mobile Radio

I. FCC: Federal Communications Commission

J. GUI: Graphical User Interface

K. LMR: Land Mobile Radio
L. MTBF: Mean Time Between Failure
M. NFPA: National Fire Protection Association
N. NMS: Network Management System
O. PSN: Public Safety Network
P. RoF: Radio-over-Fiber
Q. RSL: Received Signal Level
R. SMR: Specialized Mobile Radio
S. SMS: Short Message Service
T. SNIR: Signal-to-Noise Interference Ratio
U. SOW: Statement of Work
V. VSWR: Voltage Standing Wave Ratio

1.05 DEFINITIONS

A. Acceptance: Expressed approval by the AHJ and owners representative

1.06 GENERAL DESCRIPTION

A. The building shall be both pre and post tested for Fire and Police departments radio signal strength. A test shall be scheduled with the Fire and Police Departments. Any expense incurred by the test shall be the responsibility of the BDA System SubContractor.

B. A site survey to determine the RF signal strength on or near the building grounds to determine the level of amplification necessary to provide clear and reliable radio communications over 95 percent of the overall area inside the building will be required, and 100 percent of critical areas as defined in the code is required.

C. The Fire and Police Departments radio test shall check the signal reception in several locations on the floor area. Signal strength shall be for clear reception throughout the building utilizing the type of hand held radio unit that is used by the Fire and Police Department. Quantity of test locations shall be determined and conducted by the local department representative. Each floor of the building shall be divided into a grid of approximately 20 equal areas. A maximum of one area will be allowed to fail the test per floor. A spot located approximately in the center of a grid area will be selected for the test. Once the spot has been selected, prospecting for a better spot within the grid area will not be permitted. Field strength testing instruments are to be recently calibrated (One year) and of the frequency selective type incorporating a flexible antenna similar to the ones used on the hand held transceivers.

D. Required Signal Levels:

1. Signal strength shall be for clear reception throughout the building utilizing hand held radio units of the type(s), which are used by the Fire/Police Department. Signal strength testing shall follow TSB-88 standards using delivered audio quality measurements (DAQ).
2. A minimum signal strength of –95 dBm (DAQ4) shall be available on over 95 percent of the floor area required to be covered when transmitted from the fire department.
3. A minimum signal strength of –95 dBm (DAQ4) shall be received at the fire department system from over 95 percent of the floor area required to be covered.

E. Required Broadcasting Frequency:

1. Frequency to be compatible with Fire, Police Department, and Haverhill Facilities equipment.
2. The building owner will be responsible for keeping the operational frequencies of the BDA compatible with the Fire and Police Departments radio system.

F. It is the responsibility of the BDA System SubContractor to coordinate with the Town and provide the required Police and Fire frequencies. Frequencies include Police, Fire, Middlesex County and Scituate Facilities.

G. Emergency Responder Radio Signal Amplification System (BDA System)

1. Provide an in-building radio signal amplification system to provide complete coverage in the building for the public safety agencies per the local fire department and other agencies and authorities having jurisdiction. System users shall receive and transmit radio broadcasts from their portable radio units within the building. This shall be accomplished utilizing the following components:
   a. Bi-Directional Amplifiers (Signal Boosters)
   b. Plenum rated Coaxial Cable
   c. Antennas
   d. Cable taps
   e. Connectors
   f. Power dividers
   g. Other components and interconnecting circuitry.
2. The system shall comply with the requirements UL2524 In-Building 2-Way Emergency Radio Communication Enhancement systems, NFPA 72 2013 Edition, NFPA 1221 2016 Edition and IFC 2015, as referenced.
3. The entire system shall meet the requirements of the Fire Department, the Building Department and all other agencies and authorities having jurisdiction (AHJ).
4. The work in this section shall include the responsibility for all permit requirements with the AHJ. Where filings require engineer's signature, documents shall be submitted for his or her review and signature. This responsibility shall include furnishing of required quantities of floor plans, descriptive notes and/or specifications, wiring diagrams, shop drawings and amendment forms.
5. Early completion of the in-building emergency radio communication enhancement system will be required as to permit a Certificate of Occupancy to be obtained in a timely manner
6. Any permits necessary for the installation of the work shall be obtained prior to the commencement of the work. All permit costs and inspection fees shall be included
7. The in-building emergency radio communication enhancement system shall use a UL2524 Listed, NFPA 72, NFPA 1221 and IFC 2018 compliant signal booster or approved equal.

1.07 DESIGN REQUIREMENTS

A. In-building radio signal amplification systems for emergency responders are an integral component of the life safety equipment of a building or structure. The primary function is to provide reliable emergency responder communications at the required signal strength within the specified areas.

B. Critical Areas such as emergency command center, fire pump room, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations and similar critical areas shall be provided with 100 percent floor area radio coverage.

C. General building areas shall be provided with 95 percent radio coverage, or as specified by AHJ.

1. The In-building emergency radio communication enhancement systems shall provide the following signal strengths:
   a. Downlink - Minimum signal strength of -95 dBm throughout the coverage area.
   b. Uplink - Minimum signal strength of -95 dBm received at the AHJ Radio System.
   c. OR As otherwise required by the AHJ
2. The system shall be complete with all components and wiring required for compliance with all applicable codes and regulations, and for its operations described hereinafter.
3. An approved manufacturer or a qualified and approved vendor shall supply, test and determine locations of components which are required for proper operation as well as to supply, install, test and certify the performance of the complete system. Vendor qualifications shall be acceptable to the AHJ.

4. Design may include iBwave software-simulated radio propagation modeling with heat maps showing predicted signal coverage levels within the building. The iBWave design shall be done by iBWave certified personnel.
5. All tests shall be conducted, documented, and signed by a person in possession of an FCC General Radio Telephone Operators License. All testing personnel shall be certified and authorized by the signal booster manufacturer in the installation and operation of their equipment. Personnel qualifications shall be acceptable to the AHJ.
6. The system design shall be based on the Radio Solutions, Inc (Norwell, MA) line of Public Safety Signal Boosters UL2524, NFPA 72, NFPA 1221, IFC and FCC certified to establish standards of quality for materials and performance. The naming of a specific manufacturer or a catalog number does not waiver any requirement or performance of individual components described in the specifications.
7. Assembly and installation of all components of the Emergency Responder Radio Communication Enhancement System shall comply with all applicable sections of the National Electrical Code.
8. Survivability from attack by fire shall meet requirements of NFPA 72, NFPA 1221, IFC per the local authority having jurisdiction.
9. The system shall comply with all applicable sections of the FCC rules. Signal booster shall have FCC certification prior to installation.
10. Antenna isolation shall be maintained between the donor antenna and all inside antennas (D.A.S.) to a minimum of 20dB under all operating conditions

PART 2 - PRODUCTS

2.01 TECHNICAL SPECIFICATIONS AND PERFORMANCE REQUIREMENTS

A. The system specified shall be based upon Radio Solutions, Inc (Norwell, MA) line of Public Safety UL2524 Listed and NFPA72, NFPA 1221, IFC compliant signal boosters

B. The signal booster shall be a Class B Public Safety type as designated by the FCC or the AHJ.

C. The secondary power supplies, battery chargers and system monitoring shall be fully compliant with NFPA 72, NFPA 1221 and IFC. The signal booster shall have both the primary and the secondary power supplies within a waterproof, type-4 approved enclosure.

D. All signal boosters and other active system components shall have FCC certification prior to installation. The equipment FCC ID shall be shown on the product datasheets and technical submittals. The ID shall also be displayed on the product per the FCC.

E. The signal booster shall be pre-set by the equipment manufacturer for the frequencies specified by the AHJ. Field tuning of RF filters and duplexers is not allowed.

F. UHF and VHF signal boosters shall be band selective type with a maximum 3dB channel bandwidth of 200KHz (Fc +/- 100KHz) per band. Non-selective wide-band signal boosters shall not be accepted, unless required to cover multiple channels within the same band.

G. Signal Boosters shall have oscillation suppression circuitry to protect the public safety radio system in case of system malfunction or other causes. The oscillation suppression circuit shall not disable the system operation. Systems that automatically disable the signal booster upon oscillation detection shall not be allowed.

H. Signal Boosters shall have uplink noise suppression function to eliminate uplink noise while in standby (i.e. no radio transmission from within a building). Systems that produce any measurable level of uplink noise while in standby shall not be allowed.

I. Signal Booster gain shall be rated at minimum of 80dB and the gain shall be adjustable in a minimum of 30dB range. System gain shall be set and documented at the time of the final system test.

J. Maximum Propagation delay of the signal booster system shall be the lesser of 14µs (microseconds) or as specified by AHJ.

K. The signal booster system shall include built-in automatic supervision of malfunctions of the signal booster and battery system as per NFPA 1221 NFPA 72 and IFC. Non-OEM equipment add-ons and modifications to comply with this specification shall not be allowed.

L. A dedicated supervised monitoring panel shall be provided within the emergency command center next to the fire alarm panel / annunciator or other location as designated by AHJ to annunciate the status of all signal booster locations. The monitoring panel shall provide visual and labeled indication of the following for each signal booster:

1. Normal AC power
2. Signal booster trouble
3. Antenna Failure
4. Loss of normal AC power
5. Failure of battery charger
6. Low battery capacity

M. The vendor shall verify the system monitoring requirements and the required annunciator location with the AHJ prior to system installation. System monitoring shall be fully compliant with the AHJ requirements.

N. Non-OEM External filters, duplexers, power supplies or other non-OEM additions or modifications of the original equipment shall not be allowed.

O. All signal booster components shall be contained in a type-4 approved and listed waterproof enclosure. All enclosures shall be painted red with external labeling per the AHJ.

2.02 INSTALLATION REQUIREMENTS

A. Installation of all components of the Emergency Responder Communication Enhancement System shall comply with all applicable sections of the National Electrical Code NFPA-70, NFPA-72, NFPA 1221, IFC and per the local AHJ.

B. At least 2 independent and reliable power supplies shall be provided as specified in NFPA 72, NFPA 1221 and IFC.

C. The primary power source shall be supplied from a dedicated 20 ampere branch circuit and comply with NFPA-70 National Electrical Code, NFPA 72 and NFPA 1221 2016 edition.

D. The signal booster shall be equipped with a secondary source of power. The secondary source of power shall be a battery system with a dedicated battery charger powered by a separate, dedicated 20 ampere branch circuit. The secondary power supply shall power on automatically when the primary power source is lost. The secondary source of power shall be capable of operating the emergency responder radio coverage enhancement system for a period of at least 24 hours. The battery system shall automatically charge in the presence of external power input. Battery charger and all other electronic components shall be fully enclosed in a waterproof Type-4 approved enclosure. Batteries shall be enclosed in a separate, vented Type-3R or Type-4 approved enclosure. External UPS (Uninterruptable Power Supplies) are not acceptable.

E. The signal booster shall be designed to allow continued operation in adverse environmental conditions, such as high temperatures in the event heat from a nearby fire, water spray, voltage fluctuations or other abnormal conditions that may occur during an emergency. Circuits that intentionally disable the signal booster in such situations (i.e. under/over voltage, over/under current, over/under temperature) are not acceptable, unless required for FCC regulatory or safety compliance. It is the purpose of this specification to assure the maximum possible level of communications to public safety personnel depending upon the signal booster, even to the extent of damaging the signal booster, as long as some communications benefit can be provided during the emergency.

F. External UPS (Uninterruptable Power Supplies) are not acceptable

G. The power supply system design shall be such that neither the failure of the normal power source, the transfer to an emergency source, nor the re-transfer to the normal source shall cause an interruption or change in system status.

H. The amplifier shall be housed in a room or other suitable space per the Engineer or Architect, or where specifically shown on the drawing.

I. Radiating cable, if used, shall be run without conduit. All other cable can be run in conduit if required for mechanical protection of the cable, or where specified by the electrical engineer.

J. RF Coaxial Cable shall be a fire-resistant, low-smoke type, U.L. classified as plenum. The classification shall be clearly marked on the outer surface of the cable regular intervals.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The BDA System SubContractor shall install the BDA in accordance with the integrator's instructions and recommendations.

B. Installation shall include the delivery, unloading, setting in place, fastening to walls, floors, ceiling, or other structures and where required, penetration fire-stop, interconnecting wiring of the system components, equipment alignment and adjustments, and all other work whether or not expressly required herein which is necessary to result in complete operational system.

C. All installation practices shall be in accordance with, but not limited to, these specifications and drawings. Installation shall be performed in accordance with the applicable standards, requirements and recommendations of National, State, and Local Authorities having jurisdiction. All distributed antenna cables shall be installed such that the cables are straight as possible.

D. During the installation, and up to the date of final acceptance, the integrator shall be under obligation to protect his finished and unfinished work against damage and loss. In the event of such damage or loss, he shall replace or repair such work at no cost to the owner.

E. All equipment shall be properly mounted on equipment racks or walls and secured in place. Wall mounted equipment shall be mounted over a ½ inch. plywood securely attached to the wall.

F. Cables shall be properly supported with dedicated hangers or brackets. Cable trays shall be used only if they are dedicated low voltage trays and only with approval from the owner.

G. Fastenings and supports shall be adequate to support their loads with a safety factor of at least three.

H. All boxes, equipment shall be secured plumb, level and square.

I. In the installation of equipment and cable, consideration shall be given to operational efficiency and overall aesthetic factors. Antennas shall be centered and in-line with other ceiling mounted devices

J. All cables, regardless of length, shall be marked with cable markers reading "Public Safety Radio", at regular intervals but not less than every 30 feet. There shall be no unmarked cables at any place in the system. In addition, markings codes at each end of the cables and patch panels shall correspond to codes shown on drawings and/or run sheets.

K. All cables the integrator installs shall be handled in accordance with the manufacturers guidelines. Transmission line cables have minimum bending radius specifications that shall be followed. In the event a cable is kinked or bent excessively during installation that section of cable cannot be used, even if subsequently straightened. The damaged area of the cable shall be removed and a new section installed using correct splice methods. Ultimately the cable must pass the testing and meet the manufacturers requirements

L. Radio communications cabling shall not be grouped with electrical cabling. It can only share sleeves and raceways with other low voltage data and communications cables.

M. Connection between cables and other antenna components shall use N-Type premium connectors. No splicing is permitted.

N. All power dividers shall be securely mounted in place by bolting the mount to a solid surface or securing each by suspension on the cables within four inches of each connector termination at the power divider. The transmission lines connecting to the device shall be routed in the shortest possible path.

3.02 GROUNDING PROCEDURE

A. In order to minimize problems resulting from improper grounding, and to achieve maximum signal-to-noise ratios, the following grounding procedures shall be adhered to:

B. System Ground: A signal primary “system ground” shall be established for the system. All grounding conductors in that area shall connect to this primary system ground. The system ground shall consist of a copper bar of sufficient size to accommodate all secondary ground conductors. An extension of the ground shall connect to the buildings lightning protection system per the direction of the on-site electrical engineer.

C. A copper conductor, having a maximum of 0.1 Ohms total resistance, shall connect the primary system ground bar to the primary system ground ring.

D. Secondary system grounding conductors shall be provided from all racks, radio consoles, and undergrounded radio equipment in each area, to the primary system grounding point for the area. Each of these grounding conductors shall have a maximum of 0.1 Ohms total resistance.

E. Under no conditions shall the AC neutral conductor, either in the power panel or in receptacle outlets, be used for a BDA system ground.

F. Radio cable Shields: All radio cable shields shall be grounded at both ends.

G. General: Because of the great number of possible variations in grounding systems, it shall be the responsibility of the installer to follow good engineering practice, as outlined above, and to deviate from these practices only when necessary to minimize crosstalk and to maximize signal to- noise ratios and reduce interference in the radio systems.

3.03 CABLE AND CONDUIT

A. Note the following circuitry requirements:

1. Conduit intended for use with the firefighter’s communication bi-directional radio amplifier system shall be steel electric metallic tubing (EMT), except as follows:
    a. It shall be galvanized steel intermediate conduit where mounted within 8 feet.-0 inches. of the floor in mechanical spaces or otherwise exposed to mechanical damage, or where intended for embedment in concrete.
    b. It shall be galvanized steel intermediate conduit if local authorities prohibit use of EMT.
    c. It shall be rigid galvanized steel conduit for the power supply to the central equipment and to all outlying equipment cabinets requiring a 120-volt or 120/208- volt supply.
2. Where wires and cables are permitted to be run without conduit, they shall be independently supported from the building structure or ceiling suspension systems at intervals not exceeding four feet on center, utilizing cable supports specifically approved for the purpose. Wires and cables shall not rest on or depend on support from suspended ceiling media (tiles, lath, plaster, as well as splines, runners or bars in the plane of the ceiling), nor shall they be supported from pipes, ducts or conduits. Bundling and/or supporting ties shall be of a type suitable for sue in a ceiling air handling plenum regardless of whether or not installed in a plenum.
3. Cables shall be tagged or labeled at each termination point and in each intermediate junction box, pull box or cabinet through which they pass, as well as intervals not exceeding 50 feet on centers where cables are run without conduit.
4. Comply with applicable building and electrical code requirements for locating and routing circuitry, for installing circuitry, and for fire stopping.
5. The covers of all dedicated junction, pull boxes shall be painted red and labeled “Fire Dept. Radio System”. Junction and pull boxes will not be shared with other systems.
6. Cables other than radiating coaxial cables shall be run in conduit where indicated by the Engineer. Where not indicated, cable shall be installed per manufacturer’s recommendation. Conduit shall be electric metallic or threaded conduit subject to the restrictions specified elsewhere for light and power circuitry.

7. Radiating coaxial cables shall be run without conduit. Where installed in a plenum type ceiling cable insulation shall be of a fire-resistant low-smoke producing type, with a minimum rating of CATVR. This classification shall be clearly marked on the outer surface of the cable at regular intervals.

3.04 ACCEPTANCE TESTING

A. Acceptance and Test Procedures

1. Acceptance testing for an in-building radio system is required upon completion of installation.
2. The coverage testing shall be done in accordance with NFPA 72, National Fire Alarm and Signaling Code, 2013 edition, and per the local AHJ
3. All tests shall be conducted, documented, and signed by a person in possession of a current FCC General Radio Operator License.
4. All test records along with system diagrams, equipment specifications, user manuals, RF link budget calculations, battery backup calculation and other design data shall be submitted upon completion of the project.

END OF SECTION

SECTION 28 10 00
INTEGRATED SECURITY SYSTEM

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section to be included in Sub-Bid for Section 26 00 10 ELECTRICAL.

B. Filed Sub-Sub Bid Requirements:

1. Sub-sub-bid requiring a paragraph “E” listing on the form for sub-bid required per M.G.L. Chapter 149 Section 44F, as amended to date. The Electrical Subcontractor shall be responsible for all related building preparation and coordination. See specification for additional Paragraph “E” listing requirements and coordination of responsibilities. Failure to meet or exceed these requirements, as detailed in this specification, shall be grounds to reject the applicable bidder.
2. It is the sole intent of this Paragraph "E" listing to ensure to the end-user, single source responsibility from a single qualified Integrated Security System Installer listed as the Paragraph “E” sub-sub bidder for this Class of Work.
3. The Integrated Security System Installer shall be DCAM Certified by the State of Massachusetts Division of Capital Asset Management in the Category of Electronic Security Systems and/or Alarm Systems.
4. Paragraph E sub-subcontractors for the work of this section shall be factory authorized to install the specified products. Trade Bidders shall be factory-authorized to install the systems specified in order to list themselves as Paragraph E subcontractors.

C. Drawing and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

A. Integrated Security System, including but not limited to:

1. Access Control System
2. IP-Based Video Surveillance System (CCTV)
3. Intrusion Detection System
4. System Cabling (except for Fiber and Cat6A cabling by Division 27 01 00)
5. UPS Equipment
6. Additional Requirements (See 28 10 00, 1.11 Extra Installation Provisions)
7. Integration with Mass Notification System

B. Video Intercom and Door Control System

C. Work to be done under this SECTION is shown on the following technology drawings and related details: T0.10, T0.11, T1.11, T1.12, T1.13, T1.14, T1.21, T1.20, T1.22, T1.23, T1.24, T1.30, T1.31, T1.32, T1.33, T1.34, T1.41, T2.01, T2.02, T2.03, T2.04, T2.05, T2.06, T2.07, T2.08, T2.09, T2.10, T2.11, T2.12.

1.03 RELATED REQUIREMENTS

A. Section 01 91 13 General Commissioning Requirements

B. Division 07 81 00 Applied Fireproofing

C. Section 07 84 00 Firestopping

D. Division 08 71 00 Door Hardware

E. Division 26 00 10 Electrical

F. Division 27 01 00 Structured Cabling System

G. Section 27 08 00 Communications Systems Commissioning

H. Division 27 20 00 Data Communications System
I. Division 27 40 00 Audio-Video Communications System
J. Division 27 50 00 Distributed Communications System
K. Division 28 10 00 Integrated Security System
L. Division 28 08 00 Commissioning Electronic Safety and Security
M. Section 01 25 00 Substitution Procedures
N. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the contract.
O. Technology workboxes, back boxes, floor boxes, conduits, sleeves, cable tray, corridor cable support and grounding systems are per Electrical Section 26 00 10.
P. Division 32 and Landscape Drawings.

1.04 **TECHNICAL REFERENCES**

A. The product specifications, design considerations, and installation guidelines provided in this document are in part derived from recommendations found in recognized telecommunications industry standards. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed below, the more stringent requirements shall apply. The bidder is responsible for determining and referencing the most recent releases of all specifications during bidding and installation. Design, manufacture, test, and install all systems per manufacturer's requirements and in accordance with NFPA 70 (National Electric Code), state codes, local codes, Underwriters Laboratories (U.L.), requirements of authorities having jurisdiction, ADA requirements, and the most current version of the following specifications:
   1. TIA-526-7 (OFSTP-7), *Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant*.
   2. TIA-526-14-B-2010 (OFSTP-14), *Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant; IEC 61280-4-1 Edition 2, Fibre-Optic Communications Subsystem Test Procedure- Part 4-1: Installed Cable Plant-Multimode Attenuation Measurement*.
   3. ANSI/TIA-568-C.0, *Generic Telecommunications Cabling for Customer Premises.*
   4. ANSI/TIA-568-C.1, *Commercial Building Telecommunications Cabling Standard.*
   5. ANSI/TIA-568-C.2, *Balanced Twisted-Pair Telecommunications Cabling and Components Standard.*
   6. ANSI/TIA-568-C.3, *Optical Fiber Cabling Components Standard.*
   7. ANSI/TIA-568-C.4, *Broadband Coaxial Cabling and Components Standard.*
   8. ANSI/TIA-569-C, *Telecommunications Pathways and Spaces.*
   9. Building Industries Consulting Services International (BICSI) *Telecommunications Distribution Methods Manual* (TDMM)
   10. BICSI *Information Transport Systems Installation Manual (ITSIM)*
   11. ISO/IEC 18010, *Pathways and Spaces for Customer Premises Cabling*
   12. TIA-942-A-1, *Telecommunications Infrastructure Standard for Data Centers*
   13. ANSI-J-STD-607-A, *Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications*
   14. ISO/IEC 11801, *Information Technology – Generic cabling for Customer Premises*
   15. TIA-862, *Building Automation Systems Cabling Standard for Commercial Buildings*

16. ISO/IEC 14763, *Implementation and Operation of Customer Premises Cabling*
17. TIA/EIA-606-A, *Administration Standard for Commercial Telecommunications Infrastructure*
18. IEEE Standard 802.3an – *10GBASE-T* over copper twisted pair cable

B. In cases where product specifications, design considerations, and installation guidelines provided in this document are in conflict with the references listed above, the more stringent requirements shall apply. The bidder is responsible for referencing to the most recent releases of the above references when developing bid proposals.
C. This document does not take precedence over any code, either partially or wholly.

1.05 **SUBMITTALS**

A. General: Submit shop drawings, samples, and related submittals all together, at the same time, for coordinated review. Isolated items submitted shall not be reviewed until all items have been submitted for review.
B. Equipment List: Provide a detailed Equipment List showing quantities by manufacturer and model number of all major items of equipment and installation material to be used in the system as specified herein.
C. Product Data: Include complete sets of indexed cut sheets, in quantity as dictated by the project, of all major pieces of equipment, cable and connectors being supplied. Arrange these sheets in the order the equipment appears in the Specification. Clearly highlight information showing compliance with this and/or all applicable Specifications. If the manufacturer or representatives' cut sheet contains more than one item, clearly indicate which items of the cut sheet are intended for installation.
D. Firestop: Include cut sheets on all firestopping materials.
E. Shop Drawings: Submit a set of complete Shop Drawings, by system, showing equipment to be installed, including but not limited to:
    1. System configuration block diagrams of all equipment, indicating equipment type and model numbers. Show each and every component, system and subsystem, as well as all proposed connections between system components, and cable types connecting components.
    2. Proposed layouts and elevations of equipment racks.
    3. Wiring diagrams showing connectivity of all system components including door hardware.
    4. NVR storage calculations.
F. Certifications from manufacturers of Installers for systems specified.
G. Close-Out Submittals:
    1. Technical Manual: Submit for approval a draft of the complete Technical Manual at least two weeks prior to the time of final system check out. When the final drafts are accepted, provide five copies of detailed technical manuals. The manuals shall include the following:
        a. Table of contents.
        b. Installer Name; contact name; address, telephone number, fax number, and email address.
        c. Certificate of Warranty
        e. Product Information: Include original copies of manufacturer's installation and operating instructions, and service manuals, arranged alphabetically. All service manuals shall be originals; there shall be no Xerox copies of the service manuals and schematic supplied. Warranty information shall be filled out in the Owner's name.
        f. Detailed Description of the complete system and all subsystems.

g. Maintenance Documentation: Include the following:
   1) Information necessary to perform routine and corrective maintenance by the Owner's technical staff, or other qualified technicians.
h. List of all equipment by manufacturer, model or part number, and serial number.
i. List of spare parts.

2. Test Data: Submit for approval in writing the test results including numerical values for all measurements as specified in the Cable Schedules of this Section. Reports shall be titled and submitted in three ring binders. Once accepted, provide one set for the NETWORK Room. Also submit written certifications that the installation conforms to Specification, is complete and operable, and ready for approval by the Architect.
3. Technical Diagrams and Drawings:
   a. Simplified single line block diagrams showing the interconnection of all equipment and functional relationships for all systems specified. Show all equipment, patch panels, cables and jacks, and all other hardware, whether connected or not. These drawings shall be on Engineering size E, 30 by 42 inch sheets. The intent of these diagrams is to provide sufficient clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.
   b. Provide "As Built" architectural quality plan drawings at 1/8 inch equals one foot scale showing all components and cabling. These drawings shall be on Engineering size E, 30 by 42 inch sheets. Also provide all plans on CD in AutoCAD 2020 or later .dwg format.
   c. All technical diagrams and drawings shall be mounted on the wall behind a clear plastic cover for protection. There shall be one set of the above drawings and diagrams provided for the NETWORK Room.

1.06 **QUALITY ASSURANCE**

A. The Integrated Security System Installer shall have at least ten years' experience in designing, installing, and testing integrated security systems as specified and described herein. Additionally:
   1. The Integrated Security System Installer shall have attended manufacturer training and shall be able to provide manufacturer certifications that they are able to fully represent, resell and install the specified systems.
   2. The Integrated Security System installer shall be a Milestone Advanced or Premier Certified reseller/installer.
   3. The Integrated Security System Installer shall be Lenel/S2 Certified reseller/installer of the products specified.
   4. The Integrated Security System Installer shall be a Bosch Certified reseller/installer of the products specified.
   5. The System Installer shall utilize personnel who are fully trained and certified by the Manufacturer(s) providing final system warranties on all equipment. The onsite supervisor/foreman shall have satisfied all training and product certification requirements of the Manufacturer(s) specified and being installed.
   6. The System installer shall own and maintain tools and equipment necessary for successful installation and testing of all systems specified.
B. Installation Procedures: Adhere to the engineering, installation and testing procedures of the Manufacturer of the components specified, and use only the cabling, components and methods of provisioning the Project authorized by the

Manufacturer.

1.07 **DELIVERIES, STORAGE AND HANDLING**

A. Perform all tasks necessary to properly coordinate with all involved parties/trades for: Shipment, arrivals, loading dock, elevators (as applicable), acceptance, storage, and security of equipment and materials. Do not, during these tasks, interfere with other trades or the progress of this Project.

B. Assure that all deliveries are in correct quantities, within the appropriate times, and in compliance with all manufacturers' shipping instructions.

C. Protect all materials according to manufacturer's Specifications and/or instructions.

1.08 **SYSTEM WARRANTY, SERVICE AGREEMENT AND PERFORMANCE ASSURANCE**

A. Warranty all systems to be free of faulty workmanship and defects, and from damage due to contamination from the site for a period of five years from the date of final project completion.

B. The Warranties required by this section shall not be diminished by other warranties in the Contract Documents, equipment manufacturer's warranties, and all other rights and remedies available to the Owner under this Contract and public law. In addition, this Warranty shall not diminish the terms of individual manufacturer's warranties.

C. The Warranties required by this section shall be for the benefit of the Owner to whom the Registration Certificate is issued and any successor in interest to the site.

D. Any repair or replacement of Cabling or Equipment resulting from this warranty shall be warranted for either (a) 90 days or (b) the remainder of the original warranty period, whichever is longer.

E. Service Agreement: The Integrated Security System Installer shall respond to all requests for service during the warranty period. During this period, the Integrated Security System Installer shall replace defective material and repair items of faulty workmanship at no charge ``to the Owner. All requests for service shall be responded to by telephone within two business hours, and technicians shall be dispatched within twenty-four hours. Only certified technicians shall be dispatched.

1.09 **SEQUENCING AND SCHEDULING**

A. A set of "as-built' documents shall be provided to the Owner by the Integrated Security System Installer showing the unique label (based on actual final room numbering) for each outlet installed.

B. Where cables are to be installed in Wiremold, or other raceway, the Integrated Security Systems Installer shall closely coordinate cable requirements, equipment and faceplate installation with the Electrical Contractor.

1.10 **TRAINING OF OWNER'S PERSONNEL**

A. Conduct a Training Program for the Owner's staff. The Training Program shall include a demonstration of the configuration of all systems. Schedule the Training Program at the convenience of the Owner, after the Technical Manual has been submitted and accepted. All materials in the Technical Manual shall be reviewed during the training program. All training sessions shall be videotaped with five copies provided to the Owner with closeout submittals.

1.11 **EXTRA INSTALLATION PROVISIONS**

A. Work closely with Owner's security system vendor of record for configuration and integration with Owner's existing security systems.

B. Provide and/or install the following around the time of substantial completion of each phase with the assumption that ceiling grids shall be installed at the time of installation. Spare parts shall be delivered to the Owner with closeout documentation/submittals.

1. Include the furnishing and installation of up to one additional interior surveillance camera of each type, including box and conduit stub not currently shown on plans in locations provided by the Owner. Category 6A cabling to be provided by SECTION 270100 STRUCTURED CABLING SYSTEM. Cameras not installed shall be credited back to the project
2. Include the furnishing and installation of up to three additional exterior surveillance cameras, including box and conduit stub not currently shown on plans in locations provided by the Owner. Assume the most expensive exterior camera of the exterior camera set for the three cameras. Category 6A cabling and/or fiber optic cabling to be provided by SECTION 270100 STRUCTURED CABLING SYSTEM. Cameras not installed shall be credited back to the project.
3. Include the furnishing and installation of up to three additional card readers not currently shown on plans. Include cabling, box and conduit stub, card reader, door controller for locations to be provided by the Owner. Card readers not installed shall be credited back to the project.

1.12 **SYSTEM START UP AND COMMISSIONING**

A. Provide a full-time technician who is knowledgeable of the installation and configuration of security system(s) to assist the Owner with the installation during the first two weeks of school operation.

PART 2 PRODUCTS

2.01 **GENERAL**

A. It is the intent of the Specification that one manufacturer, not a combination, be selected for each class of material.

B. Equipment specified is standard equipment that is used throughout the City and other schools, and the awarding authority has voted for this equipment to be specified as proprietary, which means that no substitutes shall be accepted unless it is work the same as the specified system in relation to all of the other installed systems. The only substitutions shall be those recommended by Bogen if any of the specified equipment are superseded by newer versions of the same equipment or if any of the specified equipment is scheduled to reach end of life within 12 months of the completion of the project. See sections 01 10 00 and 01 25 00.

C. Other equipment, which is not listed as proprietary is specified as the basis of design because it is installed throughout the Owner's other public-school facilities. It is the desire of the Owner for the same equipment to be installed on this project to assist the Owner with the daily maintenance, ongoing management, and support of their district wide security systems. The words, "or equal", are understood to follow all names of these specified products, trade names, catalog numbers, and detailed descriptions. "or equal" shall be interpreted to apply to any material, article, assembly or system, which in the opinion of the Owner is at least equal in quality, durability, appearance, strength and design to the materials specified, and shall perform at least equally in all aspects with the functions of the equipment specified, and installed in other schools. The words, "or equal", shall not be construed to permit departure from the detailed requirements of the Specification. The "or equal" provision of G.L. c.30, §39M(b) is hereby incorporated by reference. Other manufacturers' products accepted by the Awarding Authority shall be equal to the specified products in terms of construction, quality, durability, performance, and appearance. Refer to Section 01 25 00 regarding product substitutions.

D. All materials and equipment shall be new and unused.

E. All part numbers and manufacturers shall be according to this Specification unless

otherwise noted on the Technology Drawings.

F. Provide all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware necessary to support all cabling and equipment specified.

G. System specified shall be supported by multiple manufacturer certified installers, so that the Owner has choices with regard to who provides long term service and support of the installed system.

2.02 **MANUFACTURERS**

A. Acceptable “or equal” manufacturers include:
   1. Access Control – Genetec (proprietary)
   2. Video Surveillance Management System – Genetec (proprietary)
   2. Cameras – Axis (proprietary)
   3. Intrusion – Bosch or accepted equal.

2.03 **CARD ACCESS SYSTEM (PROPRIETARY)**

A. The Card Access System shall be Avigilon Unity Access 7 on-premises access management system. The system shall be an IT-friendly Physical Access Control System (PACS) suitable for enterprise-class installations. It should combine video management, wireless locking, and intrusion control and visitor management into a powerful access management solution

B. The ACM system shall be a .Linux based server pre-loaded with Avigilon Access Manager Software and optimized to manage an IP-based access control system. The ACM shall integrate, within a browser interface, access control, alarm monitoring, and video monitoring. These applications shall be browser based and have no software to install including badging.

C. All equipment and materials used shall be standard components, regularly manufactured and regularly utilized in the manufacturer’s system.

D. All ACM systems and components shall have been thoroughly tested and proven in actual use.

E. The Main system server shall be the ACM Appliance and shall be Located in the MDF Room. Connect server to network switch electronics.

F. Enterprise Level Access Control Manager (ACM) shall be Avigilon
   1. Model: AC-APP-64R-ENT2-6

G. Provide ACM, Full NVR Integration for selected cameras, ID Management Software, and ACM Photo Badging Software.

H. Door Controllers shall be Mercury Security: Products bearing the “Authentic Mercury” mark. Refer to door hardware section of the project manual for complete description of functionality of every door and provide all associated equipment and cabling. Provide quantity of controllers to accommodate the number of total controlled doors plus 20 percent. Provide minimum of one controller in the MDF and one controller in each IDF/Technology Closet. Door controllers shall be wall mounted on available wallboard area. Connect all network nodes to network switch electronics as required.
   1. Controller board: AC-MER-CONT-LP-1502
   2. Subpanel: AC-MER-CON-MR52
   3. Input Board: AC-MER-CON-MR16IN
   4. Output Board: AC-MER-CON-MR16OUT

I. Reader Hardware:
   1. HID Global MultiClass SE RPK40 proximity reader for wall applications
   2. HID Global MultiClass SE RP15 for proximity reader for mullion applications

J. Door Contacts/Switches shall be flush mount double pole/double throw, connecting to the access control and intrusion detection systems. Request to exit devices shall

be motion base, mounted at doors. Request to Exit devices shall be Bosch DS-DS150i or accepted equal.

K. Panic Button shall be connected to the access control system and intrusion detection system.. Pressing of the Panic Button shall put the entire facility in lockdown, engage all door hardware, notify authorities of a lockdown situation through the intrusion detection system, and annunciate a lockdown notification through the Public Address system. Locate the panic button adjacent to the Security Computer Workstation in the Main Office. Coordinate exact location with Owner prior to installation.

L. Connect system to the fire alarm system so that a fire alarm shall bypass and disengage a lockdown situation, unlocking all doors and meet all applicable fire codes.

M. Coordinate with door hardware specified in Division 08 for specific functionality requirements at each door.

N. Provide all cabling and equipment as recommended by the manufacturer for a fully functional system. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.

O. Provide full integration between the CCTV system, access control system, and the intrusion detection system. Integration shall be software based requiring no external hardware or modules of any sort. Upon generation of an alarm that has associated video, the Operator shall be able to recall the video segment associated with the alarm. Once launched, the Operator shall be able to adjust the start and end time of the video segment. Where multiple cameras are associated to a single access control hardware event or alarm, associated cameras shall appear in video player in the appropriate matrix view. The ACM shall provide the ability to launch more than one camera on a generated alarm.

P. Provide all required system programming and adjustments to meet owner requirements.

Q. Provide a ten minute rack mounted UPS by APC, Emerson/Liebert or Eaton with manufacturer accepted mounting rail kits for the racks that they will be mounted in. UPS shall support all main access control system components in order to bridge system loads to emergency backup power. UPS shall be connected to emergency backup power receptacles in MDF.

R. Provide 500 multiclass formatted access cards.

S. Provide one fully operational Access Control Badging Workstation including but not limited to Windows 10 Professional Computer-PC, 24-inch LCD monitor, keyboard, mouse, photo badge printer, digital camera and Tripod and all other equipment meeting criteria according to manufacturer recommendations at the time of final installation. Locate as directed by Owner.

T. Provide one printer and one camera capable of producing Proximity Cards. Install and configure ID Management Software, and Photo Badging Software. Provide full workstation configuration in accordance with all owner requirements. Locate as directed by Owner.

U. Provide a ten minute UPS for the badging workstation and related equipment and connect all systems and connect to power.

2.04 **VIDEO SURVEILLANCE/CCTV (PROPRIETARY)**

A. The Video Surveillance System shall be Genetec Security Center and shall be added onto the Owner’s existing Genetec Security Center installations and include the following: 1. GSC-OM-E-1C - Omnicast License for each camera specified to be

furnished and installed.

B. Local Primary Archiver shall match the Security Center version that is installed on the Owner's GSC-160930-926496 system at the time of installation.
C. Local Primary Archiver shall be installed as expansion servers to the primary directory for Owner's system GSC-160930-926496."
D. Archiver minimum requirements:
    1. Primary Archiver shall be Latest Streamvault 2000 series to meet the requirements listed below:
        a. TB storage (required for all cameras plus 20 percent future cameras, with storage for 30 days at 15fps, with 50 percent motion, at H.264 maximum resolution of cameras
        b. At a minimum, Xeon Silver 4210 processor
        c. 32GB RAM
        d. 2x480 GB M.2 NVMe SSD (RAID1, hot swappable
        e. Two 1GbE RJ45 Ports
        f. Two 1100W PSU
        g. Windows Server IoT 2019 Standard
        h. Supports Data RAID 0,1,5,6 10.
        i. Installed with RAID 5 or 6 based on Manufacturer recommendation.
        j. 5YR NBD KYHD Warranty.
        k. Genetec Security Center pre-installed.
        l. One spare hot swappable power supply.
    2. Local Failover Archiver shall be latest Streamvault 2000 series to meet the requirements listed below:
        a. TB storage (required for all cameras plus 20 percent future cameras, with storage for 60 days at 15fps, with 50 percent motion, at H.264 maximum resolution of camera)
        b. At a minimum, Xeon Silver 4210 processor
        c. 32GB RAM
        d. 2x 480 GB M.2 NVMe SSD (RAID1, hot swappable)
        e. Two 1GbE RJ45 Ports
        f. Two 1100W PSU
        g. Windows Server IoT 2019 Standard
        h. Supports Data RAID 0,1,5,6 10.
        i. Installed with RAID 5 or 6 based on Manufacturer recommendation.
        j. 5YR NBD KYHD Warranty.
        k. Genetec Security Center pre-installed
        l. One spare hot swappable power supply.
E. Furnish and install the Genetec archivers with Camera licenses as required for all camera plus 20 percent overhead storage for growth.
F. On-site archivers shall be configured initially for 60 days at 15fps, with 50 percent motion. Submit system storage calculation for the project at the time of Submittals. All required software shall include Genetec Advantage. to match the existing system plus 3 years for existing and new software.
G. The Genetec archivers shall be installed in the NET/TELE Room. Install archivers in the security system cabinet furnished and installed under Section 27 01 00 STRUCTURED CABLING SYSTEM, which shall be APC NetShelter P/N AR3107 or equal equipped with the following for use in configuring the servers and accessing

the video management software.

1. 19 Inch Rack LCD console shall be APC P/N: AP5719.
2. Sliding shelf shall be APC P/N AR8123BLK
3. Two horizontal cable managers shall be AR8600A
4. Vertical Cable Manager shall be AR7723
5. USB2 Keyboard, Mouse.
6. KVM Switch shall be APC KVM018A with 8KVM-USBN modules

H. Provide and install all necessary mounting hardware, and accessories for a neat, professional and permanent installation.

I. For the archivers, furnish and install a 10-Minute rack mounted UPS by APC with network interface card with manufacturer approved mounting rail kits for the security system cabinet provided under Section 27 01 00. UPS shall support all main surveillance system components to bridge system loads to emergency backup power. UPS shall be connected to emergency backup power receptacles in NET/TELE Room. Coordinate with Division 26 for the correct overhead locking receptacle to utilize for the UPS. Note: Network switches connecting cameras to the network shall be supported by a separate UPS provided under Section 27 20 00, which shall not be used for the archivers.

J. Furnish and install network cables to interface archivers with the Owner's Aruba CX 6300M network in the NET/TELE Room specified under Section 27 20 00 DATA COMMUNICATION SYSTEM.

K. Live and recorded images shall be available to authorized clients/users of the system and software.

L. Provide remote viewing/web interface client software to Owner and Police. Install and configure up to five Owner and five Police Station systems.

M. Provide and install all necessary mounting hardware, and accessories for a neat, professional and permanent installation.

N. Surveillance cameras:

1. Exterior pole, corner mount and surface mount surveillance cameras shall be:
   a. Axis P1465-LE-3 1for cameras designated 1465, with manufacturer approved pole mount and surface mount hardware. Install at the correct height on poles and the building for optimal performance in reading license plates.
   b. Axis P3737-PLE for cameras designed 3737 with appropriate mounting hardware for pole mount and corner mount applications. Fiber terminations and media converter shall be housed in the mount at the pole camera locations.
   c. Axis P3738-PLE for cameras designated 3738 with appropriate mounting hardware for pole mount and corner mount applications. Fiber terminations and media converter shall be housed in the mount at the pole camera locations.
   d. Axis M4317-PLVE 4317 for cameras designated 4317 with appropriate surface mount hardware for mounting at both door applications.
2. Interior ceiling and surface mount surveillance cameras shall be:
   a. Axis P4707-PLVE for cameras designated 4707 with manufacturer approved ceiling mount hardware.
   b. Axis P3267-LV for cameras designed 3267 with manufacturer approved

hardware for all wall mount applications.

c. Axis P3268-LV for cameras designated 3268 with manufacturer approved hardware for all wall mount applications.
d. Axis P3827-PLE for cameras designed 3827 with manufacturer approved hardware for all wall mount applications.
e. Axis M4317-PLVE for cameras designated 4317 with manufacturer approved hardware for all ceiling mount applications.
f. Axis P3265-LV for cameras designed 3265 with manufacturer approved hardware for all wall mount applications.
g. Axis P3737-PLVE for cameras designated 3737 with manufacturer approved hardware for all ceiling applications.
h. Axis P9106-V for cameras designated 9310 with manufacture approved hardware for mounting in the elevator cab. Coordinate installation with installer of elevator system.

P. Axis Communications asdpx files for the project surveillance cameras are available from Axis Communications at Tom.Kelley@axis.com.

Q. Provide all system cabling (except where specified under Section 270100), including power supplies and other miscellaneous equipment necessary for a fully functional system.

R. All Category 6A cabling required to support video surveillance IP cameras shall be furnished and installed under Section 27 01 00 STRUCTURED CABLING SYSTEMS. Coordinate connecting cameras to structured cabling with Section 27 01 00.

S. The Security System Cabinet for housing the system archivers shall be furnished and installed under Section 27 01 00 STRUCTURED CABLING SYSTEMS. Coordinate installation of the archivers with Section 27 010 00.

T. Indoor/outdoor multimode fiber optic cabling and fiber terminations at light poles and in the NET/TELE Room shall be furnished and installed by Section 27 01 00 STRUCTURED CABLING SYSTEM. Coordinate connecting cameras to fiber optic cabling at light poles and in the NET/TELE Room with Section 27 01 00.

U. Network Switches, include PoE and SFP switches with transceivers that are required for connecting all cameras to the network shall be furnished and installed by Section 27 20 00 DATA COMMUNICATION SYSTEMS. Coordinate connecting cameras to network switches with Section 27 20 00.

V. Provide all necessary miscellaneous equipment including but not limited to media converter power supplies, electrical safety kit between 120V power receptacles and power supplies, fiber patch cables, and any other accessory hardware required at all camera locations. Cat6A patch cords for use with connecting camera to the structured cabling system shall be furnished by Section 27 01 00 STRUCTURED CABLING SYSTEM.

W. Coordinate with electrical contractor for pathways, grounding of equipment and for power required at the designated light poles.

X. Cameras shown on plans are for designating type, location, and quantity of cameras only. Coordinate with the Architect regarding the exact camera location and mounting height. Coordinate with the Owner for individual camera views, setting focal length, and any other user defined adjustments of all cameras.

Y. Review all camera images with the Owner prior to final installation of the camera at

the light pole. Make final adjustments according to Owner provided input.

Z. Make adjustments to all camera views requested by the Owner.

AA. Provide recessed ceiling mounting brackets when available for all ceiling mounted cameras, for a secure and permanent installation.

BB. Furnish and install all required system cabling other than what is provided by Section 27 01 00 STRUCTURED CABLING SYSTEM.

CC. In areas where cameras are outside and acceptable Ethernet distance, coordinate with Division 26 and Section 270100 for providing fiber optic cabling with media converters as may be required to support those cameras.

DD. Provide all required system programming and adjustments of the final installed system to meet owner requirements. Addendum No. 3

EE. Provide all equipment necessary for a fully functional system.

FF. All manufacturer recommended grounding and surge protection equipment required to support the installation of all exterior pole mount cameras and equipment.

2.05 **INTRUSION DETECTION SYSTEM**

A. Main Control Panel shall be Bosch B9512GV4 Control Panels with Universal Enclosure. Power supplies, standby batter and all mounting hardware. Locate Panel in the MDF on wallboard

B. All alarm points on the system shall be individually home run to alarm panels.

C. Door contacts shall be flush mount, double pole/double throw, connecting to the access control and intrusion detection systems. Include door contacts on all doors including roof hatches and access ways whether indicated or not.

D. Recessed Steel door contacts shall be Interlogix 1076D-N.

E. Ethernet Communication Module shall be B426.

F. Motion Sensors shall be Bosch or accepted equal for optimal coverage and protection against false alarms and shall work seamlessly with alarm control panels.

G. Wall mount sensors shall be Bosch Blue Line Gen2 TriTech Motion Detectors ISC-BDL2-W12G.

H. Long range wall mount sensors shall be Bosch Professional Series TriTech Curtain Detectors, part number ISC-PDL1-WC30G.

I. Ceiling mounted sensors shall be Bosch DS9370/DS9371 Series TriTech detectors.

J. Use Manufacturers recommended mounting heights and hardware to provide maximum coverage of applicable areas.

K. Keypads shall be the Bosch B942W. Provide clear protective covers with all keypads.

L. Duress Button shall be Potter HUM-M or equal, with cabling extending from a custom satin stainless steel wall plate. Duress Button shall be a Double Pole, Double Throw Latching switch. Connect the panic button to both the access control system and the intrusion detection system so that when the Panic Button is pressed it shall initiate an entire facility lockdown, which shall include the releasing of fire alarm hold-open doors, the locking of all access controlled doors, the notification of law enforcement authorities, and annunciation of a lockdown through the Distributed Communication System. Coordinate the exact location and mounting methods of the Duress Button with the architect and furniture consultant so that the button is concealed and protected from accidentally being pushed, while being fully accessible by administrators and office personnel.

M. System shall interface with Owner’s Central Monitoring Service provider. Coordinate requirements with the Owner.

N. Provide all cabling and intrusion detection system accessories for a complete and functional system. All cabling shall be plenum rated. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.
O. Provide AC-SW-LIC-BOSCHINTR-1PANEL Access Control Manager (V5.8 & later) license for Bosch intrusion panel integration per panel.
P. Provide AC-SW-LIC-BOSCHINTR-10PANEL Access Control Manager (V5.8 & later) for ten panels for Bosch intrusion panel integration.
Q. Provide full integration between the video surveillance and access control system. Integration shall be software based requiring no external hardware or modules of any sort.
R. The intrusion detection system shall include auto dialer and dial police dispatch directly upon activation of any lockdown situation.
S. Any fire alarm shall disarm the intrusion detection system.
T. Make all necessary connections to telephone lines. Connections shall be made six weeks before Substantial Completion.
U. Provide all cabling accessories for a complete and functional system. All cabling shall be plenum rated. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.
V. Connect all systems and sub systems to ten minute UPS for bridging all loads to emergency backup power.

2.06 **VIDEO INTERCOM SYSTEM**

A. Video intercom system shall be Avigilon Video Intercom Reader Pro
   1. Camera Resolution: 5MP
   2. Recording Rate: 25 fps
   3. Wide Dynamic Range: HDR (87dB)
   4. Smart Hub for supporting locking hardware.
   5. Full integration with six selected administrative workstations all running Avigilon Unity Access Control System for answering incoming calls from video intercom readers and managing the remote unlocking of specific controlled doors.
   6. Provide all power and signal cabling recommended by manufacturer(s).
   7. Provide all Cat 6A and other cabling recommended by manufacturer for a fully operational system. Cables routed through underground or under slab conduits shall be rated for underground/direct burial installation.
   8. Install cable so as to not exceed the manufacturer’s maximum length of cable between power supply and Video Monitor.
   9. Door Station device shall be flush mounted. Coordinate location of device with architect and install according to manufacturer recommendations. Provide custom workbox to the electrical contractor for installation. Connect to door hardware. Coordinate with card access system and any other hardware related to door operation.
   10. Coordinate with door hardware specified in Division 08 for specific functionality requirements at each door. Connect to door hardware. Coordinate with card access system and any other hardware related to door operation.
   11. Connect to network switches specified herein and provide all programming and configuration.
   12. Verify mounting requirements for Master Station device with Owner prior to installation. Be prepared to provide either desk top option or wall mount option. Wall mounting option shall utilize work box and mounting bracket as

recommended by manufacturer. Provide custom workbox to the electrical contractor for installation.

13. Provide all installation, configuration and integration for a fully functional system. Provide all system and cabling components as recommended by the manufacturer and adhere to manufacturer's installation requirements.
14. Provide all accessories and other hardware necessary for a complete and functional system.

2.07 **SECURITY SYSTEM WORKSTATIONS**

A. Provide two fully configured, programmed and functional local Security System Computer-PC workstations as directed by the Owner. Systems shall include, but not limited to 24-inch QHD LCD monitor, keyboard and mouse and all other equipment and criteria according to manufacturer recommendations at the time of final installation. Workstations shall meet or exceed the following specifications and requirements:
   1. Windows 11 Professional (64-bit)
   2. 13th Gen Intel Core Intel Core i7-3700 ore better
   3. 32GB DDR5, 4800 MHz RAM
   4. NVIDIA T1000 4GB GDDR6
   5. 1 Gbps NIC
   6. 500 MB M.2, Gen 4 PCIe NVMe, SSD Class 40 Hard Drive
   7. Fully configured with specified client software
   8. Single user interface integrating all access control and alarm events, full NVR integration of all CCTV cameras and AiPhone software. Interface shall provide live video display and access to video archive, showing a full graphic representation of the school and all alarm points, access control points, surveillance cameras and status.
   9. View status, provide control and programming of any aspect of the system.

B. Provide one (1) fully operational Access Control Proximity Card/Badging Workstation. Workstation shall match the performance specifications of the Security System Workstation above and all other equipment and criteria according to manufacturer recommendations at the time of final installation. The badging workstation shall also include photo badge printer, digital camera and Tripod and any other equipment required to print and manage badges. Provide one color printer and one camera capable of producing Proximity Cards. Install and configure all software. Install and configure all software required. Install in Main Office or as directed by the Owner.

C. Each workstation shall have user interface(s) for all access control and alarm events, as well as all video. Install and configure all necessary software for full system control on each workstation. Each workstation shall have the ability to engage a lockdown situation for the facility. Each workstation shall also be configured for full control of the Video Intercom System. Provide a ten minute UPS for each workstation.

PART 3 – EXECUTION

3.01 **EXAMINATION**

A. Prior to commencing Work of this Section or ordering equipment:
   1. Examine site and conditions under which work shall be performed. Determine exact locations of items shown diagrammatically on Drawings. Determine dimensions needed to install components, move in racks and any custom items. Notify the Architect of any conflicts or special requirements needed to provide for

free access to doorways, corridors, stairs, and similar areas, required to move in the specified equipment. If the Systems Installer fails to provide such notification, any additional cost to remove and reinstall any building members shall be back charged to the Systems Installer.

2. Meet with Owner representatives including the Owner's security vendor of record to review system capabilities, identify features and functions, and to acquire information required of the system and installation to fully satisfy and meet the Owner's requirements and standards within the district.

B. Technology Drawings designates Security System component locations. Install quantity and type according to the Technology Outlet Plans and as specified herein. Provide all required adapters and/or accessories for complete installation in all raceways, and other locations.

C. Commencement of Work of this Section indicates acceptance of existing site conditions.

3.02 **WORKMANSHIP**

A. Integrated security system shall be installed in a neat, workmanlike manner. Workboxes, equipment, and enclosures are to be plumb and square. Install the system elements in cooperation with all trades to achieve coordinated progress and desired results. Watch for conflicts with Work being performed by other trades that have impact on the installation of the system components. Make moderate moves or changes in equipment locations as are necessary to accommodate other equipment without a claim for additional payment.

3.03 **INSTALLATION, GENERAL**

A. Pre-installation: Meet with the Construction Manager, Project manager, and any other appropriate parties for coordination meeting prior to beginning work and to coordinate requirements.

B. Coordinate Work with adjacent Work of other trades to facilitate installation and prevent conflicts.

C. Staff job appropriately to keep pace with the Project schedule.

D. Abide by the decision of the Architect to case of conflict or interference of the other trades.

E. Work under this Section shall be performed in accordance with associated local, state, and national building codes.

F. Coordinate requirements of ceiling and floor mounted outlets with the Electrical Contractor.

G. In the event that the Integrated Security System Installer shall re-enter an area of a previously completed phase of Work, the Installer shall be responsible for returning that area back to the condition it was in before the Installer re-entered the area. This includes re-installing ceiling tiles, cover plates, cleaning floors and all other items and areas. Coordinate the cutting and patching of holes with the Construction Manager, and comply with the Cutting and Patching Section.

H. Every effort shall be made to schedule the Work under this Specification in such a manner so as to complete all above ceiling Work prior to ceiling panel installation. In the event that the Communication Systems Installer is required to remove ceiling panels, such Work shall not break or disturb the existing ceiling grid or panels and shall be coordinated with the Construction Manager and Ceiling Contractor.

I. Spare pull strings shall be left in all EMT, Conduits, and Innerduct.

J. The Integrated Security System Installer shall furnish and install all mounting hardware, shelving, bracketing, bracing, support members, and all other hardware

required to ensure that all equipment and cabling is properly installed and supported according to the manufacturer's recommendations.

K. Take precautions to prevent and guard against electromagnetic and electrostatic interference. Avoid potential sources of EMI in all aspects of installation. If interference is experienced, the Integrated Security System Installer shall provide all required testing to identify the source of interference and provide a remedy including but not limited to re-routing and/or replacing cables.

3.04 **CABLE SUPPORTS AND ROUTING**

A. Install all cabling shall be installed in accordance with the manufacturer's guidelines and according to all applicable building codes at the time of installation, including but not limited to the NEC and the ANSI/TIA/EIA Telecommunications Building Wiring Standards.

B. Route all cables in large groupings, through main hallways, until cable can be distributed directly to the security system component. Route individual cables to the appropriate locations in accordance with all standards described herein.

C. Install cables in cable tray, Snake Tray, J-hooks, pipe and/or sleeves specified in this and other sections.

D. In suspended ceilings where cable trays or conduit are not available, and it is not possible to install corridor cable support, bundle cables in bundles of 50 or less, with Velcro cable tie wraps pulled snug, but not deforming the cable geometry. Support the cable bundles with accepted "J" style hooks attached to the building structure at a maximum of three foot intervals. J-Hooks shall not be used in lieu of the corridor cable support Snake Tray. Prior to installing J-Hooks, Systems Installer shall submit a Request For Information stating the location at which he/she requests to use J-Hooks, and justification why Snake Tray cannot be installed.

E. The Installer shall adhere to the manufacturers' requirements for bending radius and pulling tension of all communication cable.

F. Install cables in such a manner to minimize tension and stress on cables, which can lead to changes in the physical and/or electrical characteristics of the cables over time. This applies to, but is not limited to, horizontal cable support methods, vertical cable support methods, tie wraps, or similar types of cable support methods.

G. Cables exiting floor conduits and sleeves shall be neatly dressed, and securely supported from the floor up to the ceiling so that the cables are not stressed or stretched by the weight of the cables. Cables shall be arranged in bundles of not more than 50 cables or less, and secured with Velcro cable tie wraps pulled snug, but not deforming the cable geometry. Acceptable support structures include but are not limited to: Cable tray runway radius dropout, vertical ladder tray, J-hooks, unistrut, or similar types of support structures. The intent is that cables shall not be supported by the weight of the cables themselves but are supported so that the weight of the cables is assumed by the support structure(s).

H. Route station cables at right angles to electrical power circuits and supported only from the building structure when not in cable tray or conduit.

I. Do not support cabling from ceiling tiles, grid or hanger wires.

J. Do not install random or diagonal cable runs. Cable turns and bends shall be made at 90 degrees angles whenever possible, but maintaining manufacturers' requirements for bending radius at all time.

K. Install cables at security system components, regardless of how routed to the component, with a five foot service loop of cable secured above the ceiling where the cable enters the pathway to the component.

L. Install all cabling with service loops.
M. Cables which penetrate a steel stud or steel wall cap shall be protected from damage with a "stud liner".
N. Cables entering power poles, surface mounted raceway, or other cable management systems shall be protected from damage.
O. Extend cabling between floors utilizing inter-floor sleeves and conduit as shown.
P. Conduit and sleeves provided as a means of routing cables between various rooms and floors shall be used according to the following requirements: Install cabling through separate conduits and/or sleeves for each system. In each group of conduits and/or sleeves, one four-inch conduit and/or sleeve shall remain empty as a spare conduit or sleeve for future cabling. It is imperative that the cables for each system remain separate from the other systems. Cables routed in violation of this requirement shall be pulled back and rerouted, even if already terminated, at no additional cost to the Owner.
Q. Conduit and sleeves provided as a means of routing cables between various rooms and floors, and those which remain empty as spare, shall be sealed with an accepted fireproof, removable safing material. Sleeves which pass vertically from floor to floor shall be sealed in a similar manner using an accepted re-enterable system. Additional penetrations through rated assemblies necessary for passage of wiring shall be made using an accepted method, coordinated with the Construction Manager, and permanently sealed after installation of cables.
R. Meet all requirements regarding use of cable in return air plenums and in raised floor systems. Provide wiring that complies with all applicable state, local building codes, and the National Electrical Code. All cables run in raised floor systems with forced air-cooling shall meet the requirements of NEC Article 645, "Electronic Computer Data Processing Equipment".
S. Cables installed partially or fully within the NETWORK and IDF Rooms shall be routed through and secured in the cable tray wherever possible. Cables placed in the cable tray are to be laced or tie wrapped with Velcro tie wraps frequently to keep them neatly bundled and not permitted to shift from one side of the tray to the other as they are routed in the tray.
T. Color of cable jacket for each system shall be unique and distinguishable from other system cabling
U. Cables routed in main corridors shall be installed in corridor cable support as specified in this Section. The Systems Installer shall size and select the correct product so that no more than 75 percent of the manufacturer's loading capacity is achieved in any given corridor area. The installer shall use the manufacturers' recommended attachment hardware for hanging the corridor cable support. Corridor cable support shall be suspended from integrated mounting hardware every four feet along the center spine.

3.05 **EQUIPMENT**

A. Coordinate with the Owner's security vendor of record.
B. Allow for the Owner's vendor to assist with configuration and integration, and to represent sensitive and confidential information, such as logins, on behalf of the Owner.
C. Provide all required system programming and adjustments of the final installed system to meet owners requirements.
D. Doors that are to be directly controlled by the Access Control System are indicated in Architectural Drawings including Door Hardware Schedules.

E. Doors to be held open with magnetic hold-opens and are required to be released and close during Security Lockdown are indicated in Architectural Drawings including Door Hardware Schedules.
F. All exterior doors shall be monitored by the Access Control System.
G. Coordinate all networking of Integrated Security System devices requiring PoE and GbE switch ports with the Data Communication System Installer for Section 27 20 00 DATA COMMUNICATIOIN SYSTEM.
H. Video Surveillance Cameras
    1. Coordinate all cabling requirements, interior and exterior mounting requirements, conduit and exterior wall pass through requirements of all cameras with Section 26 00 10 ELECTRICAL.
    2. Exterior building cameras shall be mounted so that cameras are located at ideal heights for surveillance, ten to 12 feet (height of first floor ceiling plenum spaces) above the finished grade on sides and corners of the building, and to underside of all canopies. Height of Interior cameras shall be coordinated with the architect for installation at ceilings and on walls at approximately 108 inches AFF
    3. Cameras shall be surface mounted providing access of conduit for cabling to run directly through wall into the back of the camera's mounting hardware. Patch cables shall provide the direct connection between the camera and a single data outlet supporting video cameras to be located at the wall of the ceiling plenum space of the first floor. Coordinate all requirements of all exterior video surveillance cameras with Section 26 00 10 ELECTRICAL.
    6. All cameras shown at exterior corners of the building shall use accepted manufacturer corner pendant mounting hardware.
    7. Coordinate the final location of all exterior cameras with the architect for optimal viewing.
    8. Coordinate with landscape design drawings and shift cameras locations on the exterior walls of the building to maximize surveillance due to any anticipated visual obstructions.
    9. Coordinate with Owner representatives for reviewing initial camera images and making adjustments to individual camera settings and field of view in order to optimize each camera to the Owner's requirements. Demonstrate the field of view options of each camera. Make adjustments to each camera to meet the Owner's requirements for field of view.
    10. Interior wall mount security cameras shall be mounted to wall mounted data outlet work box using manufacturer wall mount bracket in order to conceal data outlet including data jacks, connections, and patch cord behind wall mounted camera.
I. Install and configure the remote access control and surveillance software on five Owner and five Police computer workstations.
J. Provide all necessary coordination with IT staff to provide complete remote administration over local area network and wide area network.
K. Provide and install all necessary mounting hardware, and accessories for a neat, professional, and permanent installation. Provide recessed ceiling mount brackets for all ceiling mounted cameras for a secure and permanent installation.
L. Provide full integration between the surveillance system, access control system, and the intrusion detection system. Surveillance system provided shall be fully compatible with the Access Control and Intrusion Detection Systems. Integration shall be software based requiring no external hardware or modules of any sort.

M. Furnish and Install Door Contacts for all roof hatches and roof access doors whether indicated on drawings or not.
N. All equipment and software shall be furnished and installed in the latest revisions and versions available at the time of installation. If changes in the equipment specified occurs between the submittal phase and installation, all equipment that is intended to replace specified and accepted equipment shall be furnished and installed instead of the specified and accepted equipment. This includes all specified equipment that undergoes any advancements in product features and functions from the equipment specified and/or accepted. Integrated Security System Installer shall closely monitor product advancements and updates with the Manufacturers to ensure that the latest equipment revisions and versions of the equipment specified are furnished and installed.
O. No specified equipment shall be installed that shall reach end of life within 3 years of expected substantial completion.
P. Assist Owner with the Integration of the Intrusion Detection System, Access Control System and Surveillance Systems with other like systems installed within the district.
Q. Coordinate with door hardware specification for specific functionality requirements at each door and provide all necessary hardware and connectivity to access control and intrusion detection systems. Provide proper interface equipment to all handicap push-plates, actuators and operators.
R. Coordination of Security Systems with Door Hardware. Refer to notes on Drawing A8.01 DOOR SCHEDULE AND DOOR TYPES
    8. Provide all Surveillance, Access Control and Intrusion alarm system equipment and devices and associated cabling, other than network cabling being provided for surveillance cameras under Section 270100 STRUCTURED CABLING SYSTEM.
    9. Provide all cabling between Access Control and Intrusion Alarm System equipment and door hardware equipment. Note: Centralized power supplies and associated cabling for electrified door hardware shall be provided by the Construction Manager or their assigned sub-contractor.
    10. Provide final connections of the Access Control and Intrusion Alarm system equipment and Door Hardware equipment wiring harnesses.
    11. Coordinate closely with the Construction Manager or their assigned sub-contractor to ensure that the integrated security system and the door hardware perform functionally.
S. Security Lockdown:
    1. Prior to the installation of cabling and Security System components, work with Owner representatives, and local law enforcement representatives, in confirming the various options that are available to the Owner through the Integrated Security System, including but not limited to the Intrusion Detection, Access Control, and Video Surveillance Systems. Review system configuration options to meet the Owner's needs. Review the Owner's requirements of the system in the event of a school wide "Lockdown" and/or "Shelter in Place" condition.
    2. Confirm with the Owner for the exact placement and installation of lockdown Panic Buttons prior to installation of cabling and Panic Button devices.
    3. Work with Electrical Contractor, Fire Alarm Contractor, Door Hardware Installer, Installer of Mass Notification System, and Elevator Contractor to accomplish the requirements of Security Lockdown.

4. Wire one output from the Security Lockdown Panic Button to the Intrusion System to cause the intrusion system to notify the Mass Notification System and Owner's monitoring company that the school has been placed in lockdown.
5. Take another set of contacts and wire them to an input on the Access Control system which shall initiate the closing and locking of all electronically controlled doors on the access control system, and equipped with electronic door hardware, which have been identified by the Owner to become locked during lockdown. This includes but is not limited to cross-corridor doors, doors to stairwells, and doors to rooms and spaces equipped with card readers.
6. Take a set of contacts and relays from the security system and cause the following actions to be initiated:
7. Doors on magnetic hold-opens shall release and close independent of the Fire Alarm and Mass Notification Systems.
    a. Doors on the Access Control System shall be locked on the non-egress side.
    b. The elevator shall return to the recall floor and operation shall only be by fire department key until the alarm activation is reset.
8. Verify with the Owner before performing interface with the Public Address System to provide notice of Lockdown. If so, take another output contact from the intrusion panel or access control panel and connect it to an input of the Public Address System to initiate the playing of an Owner accepted prerecorded lock down message and/or tone sequence over the Public Address speakers in order to notify of a lock down condition. Work with Owner representatives to identify the specific prerecorded message to be played and/or tones to be generated.
9. Lockdown shall also initiate the video surveillance system to start recording and provide date/stamp of all event recordings.
10. Work with Owner's technology personnel and integrators of school's wide area and local area networks, including the wireless network, in securing remote access and monitoring of facility wide surveillance system cameras through client access software and access privileges, to allow Police and other security personnel to gain remote monitoring capability from outside of the building.
11. The lockdown sequence shall put the entire facility in lockdown, engage all access control door hardware, notify authorities of the lockdown situation through the intrusion detection system, start camera recordings, and annunciate a lockdown notification through the public address system.
12. All doors with electric strikes equipped with card readers or noted on drawings to be wired to the Access control system shall be locked during a lockdown:

T. Wire to all exterior doors leading to the outside, which are equipped with an request to exist switch in the door hardware.

U. Access control system shall be programed for monitoring hold open conditions of all exterior doors, and to notify selected school administrators via SMS text messages and via email notifications of any conditions where doors have exceeded the programed time limits to remain open. Time limits for each door, schools administrators, SMS phone numbers, and emails addresses shall be fully configurable by the Owner.

V. Install all Integrated Security System client software on at least five owner provided workstations and demonstrate capabilities to open and fully utilize software from each workstation.

W. All Doors equipped with Card Readers shall be controlled by the Access Control System. In addition, all other exterior doors shall be connected to the access control system for monitoring purposes.
X. Install Access Control system card readers next to elevator call button on each floor. Integrate with elevator control system so that a positive card read is required by the card reader for the elevator call button to work. The elevator call button shall not initiate a request for the elevator without a positive card read by its associated card reader on each floor.
Y. Work closely with the Owner's security integrator of record to facilitate a seamless integration of the new system with the existing system.

3.06 **CONDUITS, SLEEVES, CABLE TRAY AND WALL/FLOOR PENETRATIONS**

A. Conduits, Sleeves, Cable Tray and Wall/Floor Penetrations between NETWORK and IDF Rooms and main corridors shall be provided by Division 26 cabling under this section.
B. The Integrated Security System Installer shall be responsible for coordinating room and/or space for cabling within all conduits, sleeves, and cable tray and wall/floor penetrations between NET/TELE and IDF Rooms and main corridors provided by Division 26.
C. Conduit sleeves between all main corridors and hallways into all rooms, offices, and spaces showing devices, and through all fire rated walls shall be provided by Division 26.

3.07 **FIRESTOPPING**

A. Seal all horizontal and vertical openings between floors, through fire rated fire and smoke walls, used or created by the Installer.
B. Refer to Section 07 84 00 - Firestopping, for all product requirements for maintaining integrity of fire-rated construction at penetrations.

3.08 **LABELING**

A. Clearly label and identify all components. Logically and permanently mark all cable, connectors and electronic equipment.
B. Use a letter quality printer or other mechanically produced lettering for labels.
C. Place permanent cable markers three inches from all connectors to allow easy identification. Use Brady Markers with clear plastic ends. Acceptable markers are, Brady B-320, B-292, SL-292, or Brady machine embossed labels with clear vinyl ends. Machine generated markers are required. Place cable markers on cables so that they can be easily seen.
D. Handwritten labels shall not be accepted, even if written with a permanent marker. Temporary handwritten labels may be used only during the "rough-in" stages; they shall be replaced with permanent labels prior to Project completion.

3.09 **BONDING AND GROUNDING**

A. Telecommunications Bonding Backbone utilizing #6-AWG or larger bonding conductor shall be provided by Division 26. This is part of the grounding and bonding infrastructure (part of the telecommunications pathways and spaces in the building) and is independent of equipment or cable.
B. For all systems, provide equipment grounding connections. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.
C. For all systems, provide conductor and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns,

noise pickup, cross talk, and other impairments. Provide five-ohm ground at main equipment location. Measure, record, and report ground resistance.

D. For all systems, the Integrated Security System Installer shall provide transient protection on the AC power feed and on station lines leaving or entering the building.
E. For all systems, the Security System Installer shall note in the system Drawings, the type and location of these protection devices as well as all wiring information.
F. For all systems, the Security System Installer shall furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground bus bar.
G. Provide any necessary screws, anchors, clamps, tie wraps, distribution rings, and miscellaneous grounding support hardware to complete the installation of the grounding system.
H. Grounding busbars shall be installed in the network and IDF Rooms and the Service Entrance Room by Division 26.
I. All non-current carrying security system components (passive) shall be bonded to the grounding busbar utilizing two-hole lugs for all bonding connections.
J. All grounding conductors shall be affixed with permanent labels in a visible location at each end of the conductor, and as close as practicable to the bonding point at each end of the conductor. The labels shall clearly identify both the source and destination of the bonding conductors. Hand written labels are not acceptable.

3.10 **TESTING**

A. Engage factory-authorized service representatives to inspect components, assemblies, and equipment installations of all systems specified, including connections, and to assist in testing.
B. Tests, Inspections and Adjustments:
    1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
    2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements, best practice, and manufacturer recommendations.
    3. Conduct video surveillance camera tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
        a. Prepare equipment list described in "Submittals" Article.
        b. Verify operation of auto-iris lenses.
        c. Set focus of fixed focal length lenses.
        d. Set focus of zoom lenses. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
        e. Set and name all preset positions; consult Owner's personnel for preferences.
        f. Set sensitivity of motion detection.
        g. Connect and verify responses to alarms.
        h. Verify operation of all control-station equipment.
    4. Perform operational system tests to verify that system complies with specifications. Test equipment for proper operation in all functional modes, including lockdown.
    5. Walk the system with the Owner before or after normal building hours, holidays or Saturdays at Owner’s option. A “Walk Test” shall be performed to verify

correct programming and functionality of the Access Control and Intrusion Detection Systems. Confirm that initiating a lockdown closes and lock doors on fire alarm held doors, notifies the Central Monitoring Stations that a lockdown has been initiated, annunciates a lockdown notification over the Distributed Communication System and lights emergency beacons. Any improperly placed or malfunctioning equipment shall be noted and repaired. Upon repair of discrepancies, system shall be walk-tested again, until no further problems exist. Keep a record of problems noted, and the date they were repaired. A copy of this log shall be supplied to the Owner upon successful resolution of discrepancies.

6. Upon completion of a successful walk test, provide programming sheets and AutoCAD files, showing all areas of coverage and the corresponding hardware zones to the Owner and with closeout submittals.
7. When requested by the Owner, provide adjustments to the system to suit actual occupied conditions. Tasks shall include, but are not limited to, the following:
   a. Adjust camera views to maximize coverage of specific areas that are important to the Owner.
   b. Make changes to cameras including adjustments to varifocal lenses and associated equipment to enhance images important to the Owner.
   c. Provide a written report of all adjustments made.

3.11 **TRAINING**

A. Provide no less than 20 hours of training to the Owner at the Owner's representatives at the Owner's discretion on proper functioning and operation of all system components. Train systems administrative, users and/or maintenance personnel in use of all integrated security system software. In addition, too normal operating procedures, review troubleshooting, escalation procedures for obtaining warranty and servicing, and what is required for preventative maintenance of each system installed. The training shall also include, but not limited to:
   1. Review of the physical configuration and interrelationship of the system components.
   2. Labeling and interconnection techniques used in the installation.
   3. Applications of systems including any unique connections or interfaces required in the use of systems on site.
   4. A review of warranty documents for the system.
   5. A review of the Technical Manual prepared per "Closeout Submittals."
   6. A Review of operation manuals and users guides for the system.
   7. System operation and maintenance procedures.
   8. Review of all user programmable options and how to modify options.

B. For each session, provide two thumb drive copies of recorded training. The Owner will not accept "train the trainer" models. Provide owner with complete user instructions used for training purpose as well as training log of all users who attended training classes.

3.12 **CLEANING**

A. Clean all equipment and work areas under this Section, prior to scheduling Owner training. This shall Include wiping of Work areas and surfaces, and the removal of dust, streaks, stains, and all other contaminants from all equipment specified. Leave installed systems and components clean and undamaged.

END OF SECTION

SECTION 31 00 00
EARTH MOVING

PART1 - GENERAL

1.01 GENERAL PROVISIONS

A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following.
   1) Excavating, backfilling, and compacting the Site as required to complete the Work shown on the Drawings and as specified herein, including selective excavation as required to expose and completely remove building foundations, slabs on grade, utilities, tunnels, and other site features and appurtenances.
   2) Preparing subgrades for landscaping.
   3) Removal of underground utilities as applicable.
   4) Subbase course for concrete pavements and equipment pads.
   5) Subbase and base course for asphalt paving.
   6) Excavating and backfilling for utility trenches and structures.
   7) Removal of items covered by Section 01 22 00 - UNIT PRICES as applicable.
   8) Coordination and maintenance of safe path of travel for the public.

B. Alternates: Not Applicable.

C. Items To Be Installed Only: Not Applicable.

D. Items To Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections.
   1) Section 31 20 00 - EARTHWORK for soil materials, excavating, backfilling, and grading for the building, structures, slabs on grade, walls, and foundations
   2) Section 31 10 00 - SITE CLEARING for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements.
   3) Section 31 23 19 - DEWATERING for dewatering system for excavations.
   4) Section 31 25 00 - EROSION AND SEDIMENTATION CONTROLS for temporary erosion and sedimentation control measures.
   5) Section 31 50 00 - EXCAVATION SUPPORT AND PROTECTION for temporary excavation support and protection systems.
   6) Section 31 63 17 – GROUND IMPROVEMENTS for foundation and earthwork support systems.
   7) Division 02, 22, 23, and 26 Sections for installing underground mechanical and electrical utilities and buried mechanical and electrical structures.

1.03 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
   1) Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2) Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Course placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
   1) Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by the Designer. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
   2) Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
   3) Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by the Architect. Unauthorized excavation, as well as remedial work directed by the Architect, shall be without additional compensation.

F. Fill: Soil materials used to raise existing grades.

G. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed one cu. yd. for bulk excavation or 3/4 cu. yd. for footing, trench, and pit excavation that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

I. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement, or a cement concrete or hot-mix asphalt walk.

J. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

K. Utilities: On-site underground pipes, conduits, ducts, and cables.

1.04 SUBMITTALS

A. Product Data: For the following:
   1) Each type of plastic warning tape.
   2) Geotextile.
   3) Controlled low-strength material, including design mixture.
   4) A detailed construction sequence plan for project excavation indicating temporary stockpile areas, side slopes of excavations, limits of any required temporary excavation support and sequence and procedures for slope protection, subgrade protection, excavation, concrete placement, moisture conditioning of on-site excavated soils used as fill, filling, backfill and compaction.

B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
   1) Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill.
   2) Laboratory compaction curve according to ASTM D 1557 for each onsite and borrow soil material proposed for fill and backfill.
   3) Test reports for compliance with ASTM D2940 requirements for subbase material.
   4) Particle size distribution (gradation) of soils using sieve analysis in accordance with ASTM D6913.

C. Pre-excavation Photographs and Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins. Maintain catalog of up-to-date photographs at the site.

D. Plan to Maintain Safe Path of Travel: Submit plans for maintaining safe paths of travel for the general public during the entire project, including requirement for police details of necessary.

1.05 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify the Owner not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Owner's written permission.
3. Contact utility-locator service for area where Project is located before excavating

B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

1.06 EXAMINATION OF SITE CONDITIONS AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of lack of full knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation at the Site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period, as no allowance will be made for any errors or inaccuracies that may be found except as otherwise provided herein.

1.07 COORDINATION

A. Prior to start of earthwork, the Contractor shall arrange an onsite meeting with the Architect, the Geotechnical Engineer, and the testing agency for the purpose of establishing the Contractor's schedule of operations and scheduling observation and testing procedures and requirements.

B. As construction proceeds, the Contractor shall be responsible for notifying the Geotechnical Engineer and the testing agency prior to the start of earthwork operations requiring observation and/or testing.

C. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to ensure the steady progress of all work of the Contract.

1.08 SUBSURFACE CONDITIONS

A. Subsurface explorations have been performed at the site by the Geotechnical Engineer. The results of the explorations are included in the geotechnical report.

B. The subsurface explorations and geotechnical report were performed primarily for use in preparing the foundation design. Use and interpretation of these data for purposes of the work shall be the responsibility of the Contractor. Subsurface conditions and groundwater levels are not considered as accurate for any times or locations other than the specific time and location of each of the explorations.

C. Contractor may, at his own expense, conduct additional subsurface testing as required for his own information after approval by the Owner.

D. The Contractor shall be responsible for determining the quantities of earth materials necessary to complete the work under this Section. All earth materials shall be included in the Contractor's base bid.

E. Information on subsurface conditions is made available for the convenience of the Bidders. The Owner does not present the information to the Contractor as either an accurate or a comprehensive indication of subsurface conditions. Bidders are invited to review the information to apprise themselves of the information available, and also to make additional investigations at their own expense.

F. No claim for extra cost or extension of time resulting from reliance by the Contractor on information presented herein shall be allowed, except as provided in the Contract Documents.

1.09 PERMITS, CODES AND SAFETY REQUIREMENTS

A. Work shall conform to the Contract Drawings and Specifications and shall comply with applicable codes and regulations. Present in writing to the Architect, all conflicts between the Contract

Drawings, Specifications, and applicable codes and regulations, for resolution before commencing the Work.

B. Comply with all rules, regulations, laws and ordinances of the Town of Wilmington and the Commonwealth of Massachusetts, and of all other authorities having jurisdiction. All labor, materials, equipment, and services necessary to make the work comply with such requirements shall be provided without additional cost to the Owner.

C. The Contractor shall not close any street, sidewalk, or passageway except as indicated on the Contract Drawings. The Contractor shall so conduct his operations as to interfere as little as possible with the use ordinarily made of roads, driveways, sidewalks, or other facilities near enough to the work to be affected thereby.

D. The Contractor shall procure and pay for all permits and licenses required for the complete work specified herein and shown on the Contract Drawings at no additional cost to the Owner. Arrange and pay for legal off-site disposal of all excess excavated materials, obtain proper disposal receipts from the applicable disposal facility for verification.

E. Notify "Dig Safe" and the Owner before starting work; comply fully with utility company requirements.

1.10 LAYOUT AND GRADES

A. The Contractor shall maintain and/or re-establish benchmarks and survey monuments shown on the Contract Drawings or found to exist on the site to provide a base reference for the construction. Replace any that may become destroyed or disturbed. The Contractor shall employ and pay all costs for a registered Civil Engineer or Surveyor who is licensed within the jurisdiction of the project site to lay out all lines and grades in accordance with the Contract Drawings and Specifications, and as necessary or required for the construction.

1.11 DISPOSITION OF EXISTING UTILITIES

A. Active utilities existing on the site shall be carefully protected from damage and relocated or removed by others as specified in the Contract Documents. When an active utility line is exposed during construction, its location and elevation shall be plotted on the record Contract Drawings and both the Architect and Utility Owner notified in writing.

B. Inactive or abandoned utilities encountered within the new building area during construction operations shall be removed. The location of such utilities shall be noted on the record Contract Drawings and reported in writing to the Architect.

C. In removing existing abandoned utilities within the new building area, the Contractor shall also excavate all associated backfill material and replace with compacted Structural Fill.

1.12 DISPOSAL

A. The Contractor shall re-use on-site excavated soils on-site as Ordinary Fill as indicated below and in section 2.2. Solid waste consisting of brick, concrete, asphalt, cobbles, and boulders that measure less than two cubic yards in volume shall become the property of the Contractor and be legally disposed of off-site at no additional cost to the Owner. Excavated on-site soils which are suitable for re-use at the time of excavation but become frozen or too wet for re-use due to poor material handling practices shall be disposed of off-site and replaced as necessary at no additional cost to the Owner.

B. Solid waste resulting from screening or culling operations shall become the property of the Contractor and be legally disposed of off-site at no additional cost to the Owner.

1.13 MEASUREMENT AND PAYMENT

A. The base bid lump sum price shall include all costs of whatever nature associated with the content of this specification section and earthwork shown on the Contract Drawings including, but not limited to: demolition and removal of existing abandoned utilities and associated structures and appurtenances as indicated on the Contract Drawings, excavation for site improvements, removal of existing subsurface obstructions, segregating and all screening operations, stockpiling, handling and re-use of excavated materials, earthwork for paved areas, utilities, and site improvements, construction dewatering, off-site disposal of all solid waste, placement and compaction of the specified fill materials in accordance with procedures documented herein, loading of all materials to be disposed of off-site and trucking and disposal of all Unregulated soil and solid waste.

B. The Contractor shall include in his lump sum price all costs associated with excavating all existing fill, topsoil, subsoil, and natural soil materials down to the surface of the design bearing strata consisting of the natural soil, followed by replacement with compacted fill as specified herein.

C. The Contractor shall include in his lump sum price all costs associated with segregating, culling, and screening operations required for rendering the on-site fill material suitable for reuse on this project as Ordinary Fill material as defined herein.

D. If any part of the excavation is carried through error beyond the depth directed by the Architect and the dimensions indicated on the Contract Drawings, or called for in the Specifications, the Contractor, at his own expense, shall furnish and install compacted Gravel Borrow, Crushed Stone or lean concrete as directed by the Architect up to the required level and/or dimensions.

E. Compensation for all work required under this Section and not specifically covered elsewhere, shall be included in the Contract Lump Sum Price for Earthwork. For purposes of adjusting the scope of construction see the Unit Price Schedule.

1.14 FIELD QUALITY CONTROL

A. The Owner may retain and pay for the services of an independent testing agency to monitor backfill operations and to perform field density tests, and a Geotechnical Engineer to periodically observe the earthwork operations and observe the preparation of the subgrade for paved areas, equipment pads, and utility trenches and structures. The Geotechnical Engineer may from time-to-time request that the contractor excavate tests pits ahead of excavation to confirm subsurface conditions.

B. The Contractor shall make provisions for allowing observations and testing of Contractor's Work by the Geotechnical Engineer and by the independent testing and inspection firm.

C. Costs related to retesting due to unacceptable quality of work and failures discovered by testing shall be paid for by the Contractor at no additional expense to Owner, and the costs thereof will be deducted by the Owner from the Contract Sum.

D. The Owner's Geotechnical Consultant's and/or Testing Agency's presence does not include supervision or direction of work by the Contactor, his/her employees, or agents. Neither the presence of the Owner's Geotechnical Consultant and/or Testing Agency nor any observations performed by him/her, or any notice or failure to give notice, shall excuse the Contractor from deficiencies in the work.

PART 2 – PRODUCTS

2.01 SOIL MATERIALS

A. General: Provide soil materials when sufficient satisfactory soil materials are not available from on-site excavations.

B. Satisfactory Soils: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
2. Onsite material for use in compacted fill shall be natural inorganic granular soil taken from areas of cut after removal of pavement, topsoil, or other unsuitable materials. Onsite materials should be tested for compliance with the specifications before placement. Onsite materials with less than 40 percent fines and with maximum particle size of six inches or less can be reused. Onsite materials that do not meet the gradation requirements of the specification should be used in landscaped areas, relocated onsite if directed by the Owner, or disposed of offsite.

D. Ordinary Fill shall consist of inert, hard, durable sand and gravel, free from ice and snow, organic matter, clay, surface coatings, and deleterious materials, and shall have a plasticity index of less than 6. Ordinary fill shall be placed in 12-inch loose lifts and shall conform to the following gradation requirements:

Sieve Size	Percent Passing By Weight
6-inches	100
1-inch	50-100
No. 4	20-100
No. 20	10-70
No. 60	5-45
No. 200	0-20

E. Crushed Stone shall consist of durable crushed rock or durable crushed gravel stone, free from ice and snow, sand, clay, loam, or other deleterious material, conforming to SSHB, Section M2.01.0 through M2.01.6 size as indicated on Drawings. Crushed stone shall be uniformly blended and conform to the following gradation requirements.

Percent Passing By Weight

Sieve Size	1/2-Inch Stone	3/4-Inch Stone	1.5-Inch Stone
2 inches	100	100	100
1-1/2 inch	100	100	95-100
1 inch	100	100	35-70
3/4 inch	100	90-100	0-25
5/8 inch	100	---	---
1/2 inch	85-100	10-50	---
3/8 inch	15-45	0-20	---
No. 4	0-15	0-5	---
No. 8	0-5	---	---

F. Dense Graded Crushed Stone for base course shall be naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand, consisting of angular material, that is hard, durable and free from clay, loam or other plastic material. Gradation shall conform to MHD Specification Designation, M2.01.7, and the following:

Sieve Size	Percent Passing By Weight
2 inches	100
1-1/2 inches	70-100
3/4 inch	50-85
No. 4	30-55
No. 50	8-24
No. 200	3-10

G. Sand shall consist of clean inert, hard, durable grains of quartz or other hard durable rock, free from clay, organics, surface coatings or other deleterious material, confirming to SSHB Section M.01.08 Sand shall conform to the following gradation:

Sieve Size	Percent Passing by Weight
1/2-inch	100
3/8-inch	85-100
No. 4	60-100
No. 16	35-80
No. 50	10-55
No. 100	2-10

H. Rip Rap shall be sound, durable rock, which is angular in shape, confirming to SSHB. Rounded stones, boulders, sandstone or similar stone or relatively thin slabs will not be acceptable. Each stone shall weigh not less than 50 pounds but not more than 125 pounds and at least 75 percent of the volume shall consist of stones weighing not less than 75 pounds each. The remainder of the stones shall be graded that when placed with the larger stones the entire mass will be compact.

2.02 GEOTEXTILES

A. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2; AASHTO M 288.
2. Grab Tensile Strength: 247 lbf; ASTM D 4632.
3. Sewn Seam Strength: 222 lbf; ASTM D 4632.
4. Tear Strength: 90 lbf; ASTM D 4533.
5. Puncture Strength: 90 lbf; ASTM D 4833.
6. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
7. Permittivity: 0.02 per second, minimum; ASTM D 4491.
8. UV Stability: 70 percent after 500 hours' exposure; ASTM D 4355.

2.03 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of six inches wide and four mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

2.04 USE OF MATERIALS

A. Use of materials shall be as described below and as shown in the Drawings.

B. Ordinary Fill: Use Ordinary Fill as general site fill outside of the new building footprint area for embankments, landscaping, and beneath Processed Gravel for Subbase in paved areas where specified material such as Crushed Stone, Structural Fill, Crushed Stone, and Sand are not indicated.

C. Crushed Stone - Use crushed stone as indicated on the Drawings.

D. Processed Gravel - Use for Subbase under paved areas.

E. Dense Graded Crushed Stone - Use for base under paved areas.

F. Sand – Use sand for bedding for utility bedding, setting bed for concrete block pavers, and as indicated elsewhere on the drawings.

G. Rip Rap – To be used at outlet pipes at flared end sections, emergency overflow at surface basin, and as indicated elsewhere on the drawings.

H. Filter Fabric/Geotextiles- To be used as filter barriers at transition between soil and crushed stone, or other materials to assist in stabilizing soil subgrades, and as indicated elsewhere on the drawings. The edges of the fabric should be overlapped a minimum of one foot.

PART 3 - EXECUTION

3.01 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Section 31 10 00 - SITE CLEARING.

C. Protect and maintain erosion and sedimentation controls, which are specified in Section 31 10 00 - SITE CLEARING, during earthwork operations.

D. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

3.02 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area. Dispose of contaminated water in accordance with regulations of authorities having jurisdiction.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
2. Install a dewatering system to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.03 EXPLOSIVES

A. Explosives: Do not use explosives.

3.04 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
    a. 24 inches outside of concrete forms other than at footings.
    b. 12 inches outside of concrete forms at footings.
    c. Six inches outside of minimum required dimensions of concrete cast against grade.
    d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
    e. Six inches beneath bottom of concrete slabs on grade.
    f. Six inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

3.05 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus one inch If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Pile Foundations: Stop excavations six to 12 inches above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus one inch. Do not disturb bottom of excavations intended as bearing surfaces.

3.06 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.07 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit less than six inches in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
2. For pipes and conduit six inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
3. Excavate trenches six inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.08 SUBGRADE INSPECTION

A. Notify Geotechnical Engineer when excavations have reached required subgrade.

B. If Designer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below the building slabs and pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Designer, and replace with compacted backfill or fill as directed.

D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Designer, without additional compensation.

3.09 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi may be used when approved by Designer.

1. Fill unauthorized excavations under other construction or utility pipe as directed by Designer.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.
2. Stockpile soil materials in a location, acceptable to the Owner Project Manager, that will preclude having to relocate stockpiled soil materials that would otherwise delay or impact the Work.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.

4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 03 30 00 - CAST-IN-PLACE CONCRETE.

D. Provide 4-inch- thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase.

E. Place and compact initial backfill of subbase material free of particles larger than one inch in any dimension, to a height of 12 inches over the utility pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

G. Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. Install warning tape directly above utilities, 12 inches below finished grade, except six inches below subgrade under pavements and slabs.

3.13 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than one vertical to four horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill.
5. Under footings and foundations, use engineered fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than eight inches in loose depth for material compacted by heavy compaction equipment, and not more than four inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent; and areas within 10 feet of structures, building slabs, steps, and pavements at 92 percent.
2. Under walkways, scarify and recompact top six inches below subgrade and compact each layer of backfill or fill soil material at 92 percent.
3. Under lawn or unpaved areas, scarify and recompact top six inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.
4. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus one inch.
2. Walks: Plus or minus one inch.
3. Pavements: Plus or minus 1/2 inch.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.17 SUB DRAINAGE – 36" PERFORATED PIPE

A. Subdrain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a six-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers six inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least dix inches.

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 1557.

B. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers six inches thick. Overlay drainage backfill with 1 layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 1557.
2. Place and compact impervious fill over drainage backfill in 6-inch-thick compacted layers to final subgrade.

3.18 SUBBASE AND BASE COURSES

A. Place subbase and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase and base course under pavements and walks as follows:

1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place base course material over subbase course under hot-mix asphalt pavement.
3. Shape subbase and base course to required crown elevations and cross-slope grades.
4. Place subbase and base course six inches or less in compacted thickness in a single layer.
5. Place subbase and base course that exceeds six inches in compacted thickness in layers of equal thickness, with no compacted layer more than six inches thick or less than three inches thick.

6. Compact subbase and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

C. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.19 DRAINAGE COURSE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:

1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.20 FIELD QUALITY CONTROL

A. Independent Testing Agency: Cooperate with the Independent Testing Agency engaged by the Owner for field quality control activities for the Work of this Section. Refer also to Section 01 43 25 - TESTING AGENCY SERVICES.

B. Cooperate with field quality control personnel.

C. Additional inspections and retesting of materials which fail to comply with specified material and installation requirements shall be performed at Contractor's expense.

D. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

E. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Designer.

F. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least 1 test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than 3 tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least 1 test for each 100 feet or less of wall length, but no fewer than 2 tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for each 150 feet or less of trench length, but no fewer than 2 tests.

G. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify, and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

H. Notify the Independent Testing Agency a minimum of 72 hours prior to start of earthwork operations, to comply with Code requirement that a registered design professional be present at all times during backfill to assure adequate compaction with no bridging effects.

3.21 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Designer; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.22 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the User Agency's property.

END OF SECTION

SECTION 31 10 00
SITE CLEARING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Protecting existing vegetation to remain.
   2. Removing existing vegetation.
   3. Clearing and grubbing.
   4. Stripping and stockpiling topsoil.
   5. Removing above- and below-grade site improvements.
   6. Stockpiling of existing site elements.
   7. Disconnecting, capping or sealing, and removing site utilities or abandoning site utilities in place.
   8. Temporary erosion- and sedimentation-control measures.

B. Related Sections:
   1. Section 01 50 00 "TEMPORARY FACILITIES AND CONTROLS" for temporary utility services, construction and support facilities, security and protection facilities, and temporary erosion- and sedimentation-control measures.
   2. Section 01 56 39 “TEMPORARY TREE AND PLANT PROTECTION” for general protection of existing trees and shrubs.
   3. Section 31 13 00 “SELECTIVE REMOVAL, TRIMMING, AND ROOT PRUNING” for removal and pruning of existing trees and shrubs, including roots.
   4. Section Section 31 00 00 "EARTH MOVING" for site preparation.
   5. Section 31 25 00 "EROSION AND SEDIMENTATION CONTROLS" for temporary erosion and sedimentation control measures.

1.03 DEFINITIONS

A. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow.

D. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than two inches (50 millimeters) in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

E. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.

F. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and indicated on Drawings defined by a circle concentric with each tree with a radius one and a half times the diameter of the drip line unless otherwise indicated.

G. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

H. Caliper: Diameter of a trunk measured by a diameter tape at 4'-6" above the ground or DBH (diameter at breast height). (Standard as defined by the ISA – International Society for Arboriculture).

I. Arborist or Certified Arborist: As referenced here in all "arborists" or "certified arborists" shall be at minimum an ISA Certified Arborist or and ASCA Registered Consulting Arborist unless other specified.

1.04 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become General Contractor's property and shall be removed from Project site.

1.05 INFORMATIONAL SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
   1. Use sufficiently detailed photographs or videotape.
   2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.06 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference at Project site.

1.07 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
   1. Do not proceed with work on adjoining property until required by Owner's Representative.

C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

D. Utility Locator Service: Notify Dig Safe System for area where Project is located before site clearing.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

F. The following practices are prohibited within protection zones:
   1. Storage of construction materials, debris, or excavated material.
   2. Parking vehicles or equipment.
   3. Foot traffic.
   4. Erection of sheds or structures.
   5. Impoundment of water.
   6. Excavation or other digging unless otherwise indicated.
   7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

G. Do not direct vehicle or equipment exhaust towards protection zones.

H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

I. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

PART 2 PRODUCTS

2.01 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 31 00 00 "EARTH MOVING".
   1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

B. Antirust Coating: Fast-curing, lead- and chromate-free, self-curing, universal modified-alkyd primer complying with MPI #79, Alkyd Anticorrosive Metal Primer or SSPC-Paint 20 or SSPC-Paint 29 zinc-rich coating.
   1. Use coating with a VOC content of 420 grams per liter (3.5 pounds per gallon) or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 EXECUTION

3.01 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Flag or wrap a one-inch (25-millimeters) blue vinyl tie tape flag around each tree trunk at 54 inches (1372 millimeters) above the ground.

C. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.02 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Satisfactory Temporary Erosion and Sedimentation Control: Requirements for satisfactory soil material are specified in Section 31 25 00 "EROSION AND SEDIMENTATION CONTROLS."

B. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

C. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

D. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

E. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.03 TREE AND PLANT PROTECTION

A. General: Protect trees and plants remaining on-site according to requirements in Section 01 56 39 "TEMPORARY TREE AND PLANT PROTECTION."

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner accepted by Owner's Representative.

3.04 EXISTING UTILITIES

A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by General Contractor.
   1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
   1. Arrange with utility companies to shut off indicated utilities.
   2. Owner will arrange to shut off indicated utilities when requested by General Contractor.

C. Locate, identify, and disconnect utilities indicated to be abandoned in place.

D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Owner's Representative not less than two days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Owner's Representative's written permission.

E. Excavate for and remove underground utilities indicated to be removed.

F. Removal of underground utilities is included in earthwork sections and with applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security and utilities sections and Section Section 31 00 00 "EARTH MOVING" and Section 02 41 00 "DEMOLITION."

3.05 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches (450 millimeters) below exposed subgrade.
   3. Use only hand methods for grubbing within protection zones.
   4. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of eight inches (200 millimeters) and compact each layer to a density equal to adjacent original ground.

3.06 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth of six inches (150 millimeters) in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects more than two inches (50 millimeters) in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from the edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
   1. Limit height of topsoil stockpiles to 72 inches (1800 mm).
   2. Do not stockpile topsoil within protection zones.
   3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
   4. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.07 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
   2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that remain exposed.

C. Stockpile all existing site elements and furnishings as indicated on the Drawings. Transport reusable elements to a location indicated by the Owner's Representative within the project site and neatly stack or arrange in a stockpile for reuse or off-site storage.

3.08 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION

SECTION 31 13 00
SELECTIVE TREE AND SHRUB REMOVAL, TRIMMING, AND ROOT PRUNING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pruning existing tree vegetation.
   2. Coordinating and scheduling of pruning inspections.
   3. Inspection of trees by Certified Arborist.

B. Related Sections:
   1. Section 01 50 00 "TEMPORARY FACILITIES AND CONTROLS" for temporary utility services, construction and support facilities, security and protection facilities, and temporary erosion- and sedimentation-control measures.
   2. Section 01 56 39 “TEMPORARY TREE AND PLANT PROTECTION” for general protection of existing trees and shrubs.
   3. Section 31 10 00 "SITE CLEARING" for protecting and removal of vegetation, topsoil stockpiling, management of above and below-grade utilities, and erosion and sedimentation control measures.
   4. Section Section 31 00 00 "EARTH MOVING" for site preparation.
   5. Section 31 25 00 "EROSION AND SEDIMENTATION CONTROLS" for temporary erosion and sedimentation control measures.

1.03 DEFINITIONS

A. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.

B. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and indicated on Drawings defined by a circle concentric with each tree with a radius one and one half times the diameter of the drip line unless otherwise indicated.

C. Vegetation: Trees, shrubs, groundcovers, grass, and other plants

D. Caliper: Diameter of a trunk measured by a diameter tape at 4’-6” above the ground or DBH (diameter at breast height). (Standard as defined by the ISA – International Society for Arboriculture).

E. Critical Root Zone: Portion of the root system that is the minimum necessary to maintain vitality or stability of the tree. Encroachment or damage to the Critical Root Zone (CRZ) will put the tree at risk of failure. (Standard as defined by the ASCA - American Society of Consulting Arborists). The ISA – International Society for Arboriculture defines the measure of the Critical Root Zone as an area equal to a one-foot radius from the base of the tree’s trunk for each one-inch of the tree’s diameter at 4’-6” above grade or DBH (diameter at breast height).

F. Arborist or Certified Arborist: As referenced here in all “arborists” or “certified arborists” shall be at minimum an ISA Certified Arborist or and ASCA Registered Consulting Arborist unless other specified.

G. Airspading: The use of a compressed air-powered tool, or AirSpade, facilitates excavation, soil management, and tree healthcare within a tree’s critical root zone (CRZ). Unlike mechanical excavation techniques, air-spading efficiently removes or loosens soil without damaging a tree’s delicate root system.

1.04 MATERIAL OWNERSHIP

A. Except for materials indicated to be stockpiled or otherwise remain the Owner's property, all removed or pruned materials shall become General Contractor's property and shall be removed from Project site.

1.05 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Tree Pruning Schedule: Written schedule detailing scope and extent of pruning of trees to remain that interfere with or are affected by construction.

1. Species and size of tree.
2. Location on site plan. Include unique identifier for each.
3. Reason for pruning.
4. Description of pruning or airspading to be performed.
5. Description of maintenance following pruning.

1.06 INFORMATIONAL SUBMITTALS

A. General Contractor shall provide a written Tree Pruning Schedule detailing scope and extent of pruning of trees to remain that interfere with or are affected by construction.

B. General Contractor shall provide certification from an arborist, certifying that trees indicated to remain have been protected during construction according to recognized standards and that those trees were promptly and properly treated and repaired when damaged.

C. General Contractor shall provide maintenance recommendations from an arborist, for care and protection of trees affected by construction during and after completing the Work.

D. General Contractor shall provide documentation of existing trees and plantings indicated to remain, which shall establish preconstruction conditions that might be misconstrued as damage caused by construction activities.

1.07 QUALITY ASSURANCE

A. Tree Pruning Standard: Comply with ANSI A300 Pruning Standards.

B. Arborist Qualifications: An experienced arborist certified by ISA, be licensed in the jurisdiction where Project is located, and be a current member of ASCA, or registered Consulting Arborist as designated by ASCA.

C. Tree Service Firm Qualifications: An experienced tree service firm that has successfully completed temporary tree and plant protection work similar to that required for this Project and that will assign an experienced, qualified arborist to Project site during execution of the Work.

D. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to selective removal and trimming including, but not limited to, the following:
    a. Construction schedule. Verify availability of materials, personnel, and equipment needed to make progress and avoid delays.
    b. Enforcing tree protection zones protection.
    c. Arborist's responsibilities.
    d. Field quality control.

1.08 PROJECT CONDITIONS

A. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.

7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

B. No Contractor shall not direct vehicle or equipment exhaust towards protection zones.

C. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones and organic mulch.

PART 2 PRODUCTS

2.01 MATERIALS

A. Tree Protection Fencing and Signage Materials: Requirements for satisfactory soil material are specified in Section 01 56 39 “TEMPORARY TREE PROTECTION AND PLANT PROTECTION"

PART 3 EXECUTION

3.01 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Flag or wrap a one-inch (25-millimeters) blue vinyl tie tape flag around each tree trunk at 54 inches (1372 millimeters) above the ground.

C. Protect existing site improvements to remain from damage during construction.

3.02 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. General: Protect trees and plants remaining on-site according to requirements in Section 31 25 00 "EROSION CONTROL."

B. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

C. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

D. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

E. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.03 PROTECTION ZONES

A. General: Protect trees and plants remaining on-site according to requirements in Section 01 56 39 "TEMPORARY TREE AND PLANT PROTECTION".

B. General Contractor shall install protection-zone fencing along edges of protection zones in a manner that will prevent people from easily entering protected area.

C. General Contractor shall install protection-zone signage in visibly prominent locations in a manner approved by the Utility.

D. General Contractor shall repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by the Utility.

E. General Contractor shall maintain protection-zone fencing and signage in good condition as acceptable to the Utility and remove when construction operations are complete and equipment has been removed from the site.

3.04 EXCAVATION

A. General: Protect trees and plants remaining on-site according to requirements in Section 01 56 39 "TEMPORARY TREE AND PLANT PROTECTION".

B. General Contractor shall backfill holes and depressions with approved site soil or imported topsoil. Compact dampened soil to 85-percent. Water to settle. Add soil and grade to conform continuously to adjacent existing grades.

C. Where utility trenches are required within protection zones, the General Contractor shall hand excavate under or around tree roots or tunnel under the roots by drilling, auger boring, or pipe jacking. General Contractor shall not cut main lateral tree roots or taproots; cut only smaller roots that interfere with installation of utilities.

D. General Contractor shall not allow exposed roots to dry out before placing permanent backfill.

3.05 FELLING

A. Fell trees to prevent damage to adjacent structures and to those trees and shrubs designated to remain.

B. Remove stumps and roots to a clear depth of 36-inches (0.9 meters) below existing grades in areas of lawn, and to full-depth in areas of paving, building footings, or utility structures.

3.06 PRUNING

A. Pruning shall be performed by a certified arborist. Prune trees over winter, between the months of November and March. Trees may be pruned at other times of the year, provided that the General Contractor submits to the owner for acceptance a scheduled time, and a description of pruning methods and materials.

B. Prune trees according to ANSI A300 Pruning Standards.

C. Where necessary, repairs to damaged wood shall be performed under the direction of the Owner, or a certified arborist.

D. Evergreens shall only be pruned to remove dead, broken or damaged branches.

E. Perform pruning using scissors-style cutting devices, and not anvil-style hand pruners, pole pruners or loppers

3.07 ROOT PRUNING

A. Prune roots that are affected by temporary and permanent construction. Prune roots under the supervision of a Certified Arborist as shown on Drawings and as follows:

1. Cut roots manually by digging a trench and cutting exposed roots with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not use a backhoe or other equipment that rips, tears, or pulls roots.
2. Cut Ends: Coat cut ends of roots more than 1-1/2-inches (38 millimeters) in diameter with an emulsified asphalt or other coating formulated for use on damaged plant tissues and that is acceptable to arborist.
3. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
4. Cover exposed roots with burlap and water regularly.
5. Backfill as soon as possible according to requirements in Section 31 00 00 "EARTH MOVING".

B. Root Pruning/Airspade Adjacent to and Outside Protection Zone:

1. Any work, excavation or grading required within the protected root zone areas should be limited and will require the approval of the Owner’s Representative. An ISA Certified Arborist shall be hired at the contractors expense to perform any Airspade root pruning.
2. Work in root zone areas where roots exceed 3/4 inch diameter should be done by Airspade, including grading, landscaping and irrigation installation. An air spade should be used in areas where a trench is required across or through CRZ. Should a trench or similar be required within the CRZ, the ideal distance for excavation and continued tree health would be two foot of distance from trunk of tree for each inch diameter of tree at breast height.

Absolute minimum would be one foot distance from the tree trunk for each inch diameter at breast height.

a. Proof and schedule of any such services (Airspade) provided by an ISA Certified Arborist shall have input from Owner's Representative.
b. Tree removals within a fenced or protected area shall be done in a manner that has no negative effect on remaining trees.

C. Root Pruning within Protection Zone: Clear and excavate by hand to the depth of the required excavation to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.

3.08 CROWN PRUNING

A. Prune branches that are affected by temporary and permanent construction. Prune branches and as follows:
   1. Prune trees to remain to compensate for root loss caused by damaging or cutting root system. Provide subsequent maintenance during Contract period as recommended by arborist.
   2. Pruning Standards: Prune trees according to ANSI A300 (Part 1) and the following:
      a. Type of Pruning: Cleaning, Thinning, Raising and Reduction.
      b. Specialty Pruning: Restoration.
   3. Cut branches with sharp pruning instruments; do not break or chop.
   4. Do not apply pruning paint to wounds.

B. Chip removed branches and spread over areas identified by Owner's Representative.

3.09 REGRADING

A. Where the new grade is indicated below existing grade around trees, General Contractor shall slope grade beyond the protection zone. General Contractor shall maintain existing grades within the protection zone.

B. Where the new grade is indicated above existing grades around trees, General Contractor shall slope grade beyond the protection zone. General Contractor shall maintain existing grades within the protection zone.

C. Where the existing grade within the Protection Zone is two inches or less below elevation of finish grade, General Contractor shall fill with topsoil. General Contractor shall place topsoil in a single uncompacted layer and hand grade to required finish grade elevations.

3.10 FIELD QUALITY CONTROL

A. General Contractor shall engage a qualified arborist to direct plant-protection measures in the vicinity of trees, shrubs, and other vegetation indicated to remain and to prepare inspection reports.

3.11 REPAIR AND REPLACEMENT

A. General Contractor shall repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner accepted by the Owner's Representative.
   1. Have arborist perform the root cutting, branch pruning, and damage repair of trees and shrubs.
   2. Treat damaged trunks, limbs, and roots according to arborist's written instructions.
   3. Perform repairs within 24 hours.
   4. Replace vegetation that cannot be repaired and restored to full-growth status, as determined by the Owner's Representative.

END OF SECTION

SECTION 31 21 13
SUB-SLAB VENTILATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
   1. Prepare lowest floor subgrade as shown on Drawings.
   2. Coordinate installation of the sub-slab ventilation system with other under slab utilities, such as sub-slab plumbing.
   3. Coordinate installation of the vertical pipes with Architect.
   4. Install low profile sub-slab ventilation composite, details, vent pipes, and control systems (collectively referred to as "sub-slab ventilation system"), as shown on Drawings.

1.02 ABBREVIATIONS AND ACRONYMS

A. ASTM. ASTM International; www.astm.org.

B. MHD. Massachusetts Highway Department; www.mass.gov/orgs/highway-division

1.03 REFERENCE STANDARDS

A. Editions of listed standards as referenced by applicable codes, or most current edition if not referenced:

B. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

C. MHD - Commonwealth of Massachusetts Highway Department: Standard Specifications for Highways and Bridges.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: A meeting shall be held prior to application of the sub-slab ventilation system and vapor barrier to assure proper substrate preparation, confirm installation conditions, and any additional project specific requirements.

1.05 SUBMITTALS

A. Refer to Section 01 30 00 - Administrative Requirements for submittal procedures.

B. Construction Submittals
   1. Product Data: manufacturer's printed technical data, tested physical and performance properties, instructions for evaluating, preparing, and treating substrates, and manufacturer's specifications for all products to be used with the sub-slab ventilation system.
   2. Shop Drawings: product-specific and project-specific details for overlaps, penetrations, transitions and termination conditions.

C. Sustainability Submittals
   1. The proposed project is intended to be certified as a LEED "Silver" building per the LEED for Schools v4/v4.1 rating system. Sections 01 81 14 - LEED for Schools v4/v4.1 Project Scorecard and 01 81 13 - Sustainable Design Requirements apply to this Section. Additional prerequisite and credit compliance requirement information is available from the USGBC LEED for Schools v4/v4.1 credit library.
   2. The Construction Manager shall provide all documentation indicating applicability of products of this Section to potential LEED credits to the Project LEED Administrator using the 01 81 15 - LEED v4 Product Data - Sustainable Attributes Reporting Form.

D. Closeout Submittals
   1. Submit in accordance with Section 01 70 00 - Execution and Closeout Requirements, and Section 01 78 00 - Closeout Submittals.

2. Project Record Documents: As-built plan of the sub-slab ventilation system, for review by Architect.

1.06 FIELD CONDITIONS

A. It is hereby understood that the Construction Manager has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of lack of full knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation at the site.

B. Plans, surveys, measurements, and dimensions under which he work is to be performed are believed to be correct, but the Construction Manager shall have examined them for themselves during the bidding period, as no allowances will be made for any errors or inaccuracies that may be found, except as otherwise provided herein.

PART 2 PRODUCTS

2.01 MATERIALS

A. Vapor Barrier: as specified in Section 03 30 00 - Cast-in-Place Concrete.

B. Sub-Slab Ventilation Pipe:

1. 4-inch solid and perforated (as indicated on Drawings) PVC pipe conforming to ASTM D1785, Schedule 40.
2. Only mechanical type couplings are allowed. The use of solvents to weld PVC pipes is not allowed.
3. Auxiliary material products specified by the manufacturer, such as fittings, pipe reducers, and reinforcement tape.
4. Flexible connections shall be used at elbow joints and at penetrations through exterior walls and grade beams.

C. Sub-Slab Ventilation Vertical Riser Pipe:

1. Vertical riser pipe shall consist of 4-inch diameter solid PVC pipe.
2. Cap: 4-inch stainless steel VacuStack with screen, or approved equal.

D. Crushed Stone: consisting of inert angular material, derived from a stone quarry, that is hard, durable, washed, and free of deleterious materials. Gradation shall conform to MHD Specification Designation M2.01.4, and the following:

U.S. Sieve No.	Percent Passing by Weight
1 inch	100
3/4 inch	90-100
1/2 inch	10-50
3/8 inch	0-20
#4	0-5

E. Filter Fabric: Mirafi 140 N, or approved equal.

F. In-Line Ventilation Fan:

1. Ventilation fan shall consist of a low pressure / high flow in-line fan that can induce 50 to 300 cubic feet per minute of air flow between 0 to 2 inches of static pressure water column.
   a. Products: RN4 by Fantech, or approved equal.

G. Roof-top support system.

1. 1-5/8 inch slotted or perforated carbon steel framing and support system, including square tube shapes, bracing members, and piping clamp ring. All framing, bracing, clamp members, and fasteners shall be hot dipped galvanized.
   a. Products: Unistrut systems by Unistrut Service Company, or approved equal.

H. Pressure Treated Wood Sleepers: As specified in 06 20 00 - Finish Carpentry.

PART 3 EXECUTION

3.01 PREPARATION

A. Lay out sub-slab ventilation pipe according to Drawings.

B. Prior to beginning of installation, conduct a pre-installation and coordination meeting with all sub-contractors installing below-grade utilities, including plumbing and electrical sub-contractors.

3.02 INSTALLATION

A. Where sub-slab ventilation pipe or low-profile vent composite crosses over footings or grade beams, a solid pipe sleeve shall be installed to ensure the vapor collection system is continuous. The solid pipe sleeve shall be placed on top of, or through, the subject transition area. Utilize the manufacturer's recommended auxiliary fitting and sealant to connect solid piping to the low-profile venting composite. Consult with engineer of record and structural engineer for appropriate use and placement of solid pipe sleeve.

B. Install vertical riser pipes for ventilation of the sub-slab ventilation system, as indicated on Drawings. Coordinate locations of the vertical riser pipes with all other trades to prevent conflicts. Utilize the manufacturer's recommended auxiliary fittings and sealant to connect riser piping to the sub-slab ventilation piping or low-profile venting composite.

C. Vertical riser piping shall extend not less than 12 inches above a pitched roof or 18 inches above a flat roof, and shall not be located within 10 feet of windows / openings and air in-take units into conditioned spaces of the building.

D. Install roof-top ventilation termination support frames at each roof penetration and vent termination as indicated on Drawings. Provide support fame and pressure treated sleepers. Install roof membrane slip sheets, furnished by SC-ROOF, under pressure treated sleepers.

E. Install in-line ventilation fans as indicated on Drawings. Refer to Electrical Drawings for power supply locations for the vent fans.

F. Label all vertical riser pipes as "Sub-Slab Ventilation System Vent".

G. Prepare and submit an as-built plan of the sub-slab ventilation system.

3.03 CLOSEOUT ACTIVITIES

A. Submit in accordance with Sections 01 70 00 - Execution and Closeout Requirements and 01 78 00 - Closeout Submittals.

B. See Section 01 79 00 - Demonstration and Training, for additional requirements.

C. Demonstrate proper operation of system fans to Owner's designated representative.

D. Training: Train Owner's personnel on operation and maintenance of system fans.

3.04 PROTECTION

A. Protect installed sub-slab ventilation system and vapor barrier during placement of reinforcement steel and overburden.

B. Prior to the placement of concrete, perform a visual inspection of the sheeting to confirm no damage has occurred during the placement of reinforcement steel.

END OF SECTION

SECTION 31 25 00
EROSION AND SEDIMENTATION CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The Construction Manager, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section will also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. The Construction Manager will prepare and implement a Stormwater Pollution Prevention Plan (hereinafter called the SWPPP) to prevent storm water, soil erosion, and air pollution due to project construction activities. The SWPPP will implement erosion and sedimentation control prevention and treatment procedures such that stormwater runoff discharged from the site will meet the following general requirements:
    a. The erosion control shown on the plans is a minimum requirement. Additional erosion control measures may be required based on the SWPPP prepared for this project (if applicable), a Conservation Commission Order of Conditions (if applicable), or as changing site conditions warrant. The information shown on the plans is to supplement the developer or Construction Manager's expertise and is not meant to circumvent logical decisions required by a variety of field conditions including weather and the type of equipment available to the Construction Manager.
    b. Best management practices (BMPs) will be used to address storm water pollution prevention in accordance with the Town of Wilmington, MA DEP Stormwater Management Guidelines, and EPA NPDES Regulations.
    c. The SWPPP will be implemented and installed prior to commencement of earthwork activities.
    d. The SWPPP will be kept on-site at all times and review / project inspections will take place as specified therein. Control measures to prevent all erosion, siltation and sedimentation of wetlands, waterways, construction areas, adjacent areas, and off-site areas.
2. Control measures will be accomplished adjacent to or in the following work areas:
    a. Soil stockpiles and on-site storage and staging areas.
    b. Cut and fill slopes and other stripped and graded areas.
    c. Constructed and existing swales and ditches.
    d. Retention ponds.
    e. At edge of wetlands areas, if applicable, as shown on Drawings.
3. Additional means of protection will be provided by the Construction Manager as required for continued or unforeseen erosion problems, at no additional cost to the Town of Wilmington.
4. Periodic maintenance of all sediment control structures will be provided to ensure intended purpose is accomplished. Sediment control measures will be in working condition at the end of each day.
5. After any significant rainfall, sediment control structures will be inspected for integrity. Any damaged device will be corrected immediately.

B. Alternates: Not Applicable.

C. Items to Be Installed Only: Not Applicable.

D. Items to Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
   1. Section 31 10 00 - Site Clearing for protection of existing trees and other vegetation to remain.
   2. Section 31 00 00 - Earth Moving for soil materials, excavating, backfilling, and grading for the building, structures, slabs on grade, walls, foundations, site grading, and removal of site utilities.
   3. Provision of waste management: Section 01 74 19, Construction of Waste Management Plan.

1.03 QUALITY ASSURANCE

A. When applicable, comply with the requirements of the Stormwater Pollution Prevention Plan (SWPPP) prepared for the NPDES permit, which are incorporated herein by reference, and all other applicable requirements of governing authorities having jurisdiction. The specifications and drawings are not represented as being comprehensive, but rather convey the intent to provide complete slope protection and erosion control for both the project site and adjacent property.
   1. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to a sediment and erosion control plan specific to the site, that complies with EPA 832/R-92-005 or requirements of authorities having jurisdiction, whichever is more stringent.
   2. Regulatory Order of Conditions

B. Erosion control measures will be established at the beginning of construction and maintained during the entire period of construction. On-site areas which are subject to severe erosion, and off-site areas which are especially vulnerable to damage from erosion and/or sedimentation, are to be identified and receive special attention.

C. All land-disturbing activities are to be planned and conducted to minimize the size of the area to be exposed at any one time, and the length of time of exposure.

D. Surface water runoff originating upgrade of exposed areas should be controlled to reduce erosion and sediment loss during the period of exposure.

E. When the increase in the peak rates and velocity of storm water runoff resulting from a land-disturbing activity is sufficient to cause accelerated erosion of the receiving stream bed, provide measures to control both the velocity and rate of release so as to minimize accelerated erosion and increased sedimentation of the stream.

F. All land-disturbing activities are to be planned and conducted to minimize off-site sedimentation damage.

G. The Construction Manager is responsible for cleaning out and disposing of all sediment once the storage capacity of the sediment facility is reduced by one-half.

H. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

I. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Straw Bales: Wire or nylon bound bales of straw, oriented around sides, rather than over and under.

B. Straw wattles will be made of straw of oats, wheat, barley, rye, or natural straw inside a flexible and durable tubular netting with metal clips or knotted ends and will be utilized to control sediment runoff during construction activities. The minimum size for the straw wattles is 12-inch diameter. Furnish oak wood stakes 2-inch by 2-inch by 4 feet long or 1/2-inch by 4 feet long rebar with safety caps.

C. Stakes: Stakes for bales will be one of the following materials: Wood stakes of sound hardwood 2 by 2 inches in size or steel reinforcing bars of at least No. 4 size. Lengths will be approximately three feet.

D. Siltation Fence: Fabricated or prefabricated unit consisting of the following filter fabric properties:

1.	Grab Tensile Strength	124	ASTM D4632
2.	Elongation (%)	15	ASTM D4632
3.	Mullen Burst Strength (psi)	280	ASTM D3786
4.	Puncture Strength (lbs)	65	ASTM D4833
5.	Trapezoidal Tear (lbs)	60	ASTM D4833
6.	Flow Rate (gal/min/sf)	8	ASTM D4491
7.	Equivalent Opening Size (US Sieve)	30-80	ASTM D4751
8.	Ultraviolet Radiation Stability (%)	80	ASTM D4355
9.	Permittivity (sec-1)	0.05	ASTM D4491

E. Fencing: Steel posts will be standard 6-foot-long metal stamped drive stakes commonly used to support snow fences. Fencing will be new four-foot height wood lath snow fencing. Provide suitable steel staples or heavy nylon cord for securing filter cloth to support system.

F. Protective Measures: As temporary coverings on ground areas subject to erosion, provide one of the following protective measures, and as directed by the Architect with concurrence of the Town of Wilmington:

1. Hay or straw temporary mulch, 100 pounds per 1,000 square feet
2. Wood fiber cellulose temporary mulch, 35 pounds per 1,000 square feet.
3. Tackafier for anchoring mulch or straw will be a non-petroleum based liquid bonding agent specifically made for anchoring hay or straw.
4. Provide natural (jute, wood excelsior) or man-made (glass fiber) covering with suitable staples or anchors to secure to ground surface. Note that wire stapes and non-biodegradable coverings will not be used for any area that will be mown turf.
5. Temporary vegetative cover for graded areas will be undamaged, air dry threshed straw or hay free of undesirable weed seed.

PART 3 - EXECUTION

3.01 STRAW BALE BARRIERS

A. Excavation will be to the width of the bale and the length of the proposed barrier to a minimum depth of 4 inches.

B. Bales will be placed in a single row, lengthwise on proposed line, with ends of adjacent bales tightly abutting one another. In swales and ditches the barrier will extend to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale.

C. Staking will be accomplished to securely anchor bales by driving at least two stakes or rebars through each bale to a minimum depth of 18 inches.

D. The gaps between bales will be filled by wedging straw in the gaps to prevent water from escaping between the bales.

E. The excavated soil will be backfilled against the barrier. Backfill will conform to ground level on the downhill side and will be built up to 4 inches on the uphill side. Loose straw will then be scattered over the area immediately uphill from a straw barrier.

F. Inspection will be frequent, and repair or replacement will be made promptly as needed.

3.02 STABILIZED CONSTRUCTION ENTRANCE AND STONE BERMS

A. Stone size: Use ASTM designation C-33, size No. 2 (1-1/2” to 2-1/2”). Use crushed stone.

B. Length: As effective, but not less than 50 feet.

C. Thickness: Not less than eight inches.

D. Width: Not less than full width of all points on ingress or egress, but not less than 25 feet.

E. Washing: When necessary, wheels will be cleaned to remove sediment prior to entrance onto public right-of-way. When washing is required, it will be done on an area stabilized with crushed stone which drains into an accepted sediment trap or sediment basin. All sediment will be prevented from entering any storm drain, ditch, or watercourse with sandbags, gravel boards or other accepted methods.

F. Maintenance: The entrance will be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-or-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spoiled, dropped, washed, or tracked onto public rights-of-way will be removed immediately.

G. Place crushed stone berms in locations required and as directed. Berms will have side slopes of 1:3 or less.

H. Inspect stone berms periodically and replace and/or regrade crushed stone as required.

3.03 SILT FENCING

A. Excavate a six-inch trench along the upstream side of the desired fence location.

B. Drive fence posts a minimum of 1'-6" into the ground. Install fence, well-staked at maximum eight-foot intervals in locations as shown on Drawings. Secure fabric to fence and bury fabric end within the six-inch-deep trench cut.

C. Lay lower 12 inches of silt fence into the trench, six-inches deep and six-inches wide. Backfill trench and compact.

D. Overlap joints in fabric at post to prevent leakage of silt at seam.

3.04 EROSION CONTROL GRASSING

A. Grassing will be applied according to State of Massachusetts Highway Department Standard Specifications.

3.05 INLET PROTECTION

A. Install silt fence or straw bales around inlet as specified

3.06 DUST CONTROL

A. Throughout the construction period the Construction Manager will carry on an active program for the control of fugitive dust within all site construction zones, or areas disturbed due to construction. Control methods will include the following: Apply calcium chloride at a uniform rate of one and one-half pounds per square yard in areas subject to blowing. For emergency control of dust apply water to affected areas. The source of supply and the method of application for water are the responsibility of the Construction Manager.

B. The frequency and methods of application for fugitive dust control will be as directed by the Architect with concurrence by the Town of Wilmington.

3.07 TEMPORARY PROTECTIVE COVERINGS (AFTER GROWING SEASON)

A. Place temporary covering for erosion and sedimentation control on all areas that have been graded and left exposed after October 30. Construction Managerwil will have the choice to use either or both of the methods described herein.

B. Hay or straw will be anchored in-place by one of the following methods and as accepted by the Architect with concurrence by the Town of Wilmington. Mechanical "crimping" with a tractor drawn device specifically devised to cut mulch into top two inches of soil surface or application of non-petroleum based liquid tackifier, applied at a rate and in accordance with manufacturer's instructions for specific mulch material utilized.

C. Placement of mesh or blanket matting and anchoring in place will be in accordance with manufacturer's printed instructions.

D. Inspect protective coverings periodically and reset or replace materials as required.

END OF SECTION

SECTION 31 50 00
EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

A. Attention is directed to the Contract and General Conditions and all Sections within Division 01 - General Requirements which are hereby made a part of this Section of the Specifications.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Temporary excavation support and protection systems.

B. Alternates: Not Applicable.

C. Items To Be Installed Only: Not Applicable.

D. Items To Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 31 20 00 - Earth Moving for dewatering system for excavations and soil materials, excavating, backfilling, and grading for the building, structures, slabs on grade, walls, foundations, site grading, and removal of site utilities.
2. Provision of waste management: Section 01 74 19, Construction of Waste Management Plan.

1.03 PERFORMANCE REQUIREMENTS

A. Design, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.

1. Provide professional engineering services needed to assume engineering responsibility, including preparation of Shop Drawings and a comprehensive engineering analysis by a qualified professional engineer registered in the Commonwealth of Massachusetts.
2. Prevent surface water from entering excavations by grading, dikes, or other means.
3. Install excavation support and protection systems without damaging existing buildings, pavements, and other improvements adjacent to excavation.
4. Provide vibration monitoring to prevent impacts on adjacent structures and utilities.

1.04 SUBMITTALS

A. Shop Drawings: Prepared by or under the supervision of a qualified professional engineer for excavation support and protection systems.

1. Include Shop Drawings signed and sealed by the qualified professional engineer responsible for their preparation.

B. Qualification Data: For Installer and professional engineer.

C. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by the absence of, the installation of, or the performance of excavation support and protection systems.

1.05 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01.

1. Review methods and procedures related to excavation support and protection system including, but not limited to, the following:
   a. Geotechnical report.
   b. Existing utilities and subsurface conditions.

c. Proposed excavations.
d. Proposed equipment.
e. Monitoring of excavation support and protection system.
f. Working area location and stability.
g. Coordination with waterproofing.
h. Abandonment or removal of excavation support and protection system.

1.06 PROJECT CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied facilities unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
   1. Notify the Town of Wilmington Project Manager no fewer than two days in advance of proposed interruption of utility.
   2. Do not proceed with interruption of utility without the Town of Wilmington Project Manager's written permission.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. The Town of Wilmington will not be responsible for interpretations or conclusions drawn from the data.
   1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection.
   2. The geotechnical report is referenced elsewhere in the Project Manual.

C. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
   1. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Designer if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.
B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.
C. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.
D. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.
E. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
F. Timber Piling: ASTM D 25, species listed in AWPA C3, pressure-treated in accordance with AWPA C3.
G. Seven Wire Strand: ASTM A 416, Grade 250 or 270., uncoated seven-wire, low-relaxation strand.
H. Grout: Suitable for service, minimum 4,000 psi.

PART 3 - EXECUTION

3.01 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.
   1. Shore, support, and protect utilities encountered.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Town of Wilmington Project Manager and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces are not impeded.

D. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.

E. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

3.02 SOLDIER BEAMS AND LAGGING

A. Install steel soldier beams before starting excavation. Space soldier beams at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wales horizontally at spacings indicated on the accepted shop drawings and secure to soldier beams.

3.03 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment. Cut tops of sheet piling to uniform elevation at top of excavation.

3.04 TIEBACKS

A. Tiebacks: Drill for, install, grout, and tension tiebacks into position. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Test loading will be observed by a qualified professional engineer responsible for design of excavation support and protection system.
2. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.
3. Inspect tiebacks periodically to confirm anchors exhibit no movement.

3.05 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary, to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work, unless otherwise accepted by Engineer.
2. Install internal bracing, if required, to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.06 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlaying construction and abandon remainder.
2. Fill voids immediately with accepted backfill compacted to density specified in Section 31 20 00 Earth Moving, as applicable.

3. Repair or replace, as accepted by Engineer, adjacent work damaged or displaced by removing excavation support and protection systems.

END SECTION

SECTION 31 60 00

GROUND IMPROVEMENTS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The work consists of improving the existing ground by means of Aggregate Pier soil reinforcement or by means of Rigid Inclusions as specified herein. Aggregate Piers and/or Rigid Inclusions shall be installed below building foundations and slabs, retaining walls, stairs, access ramps, and sidewalk attached/connected to the proposed building.

B. Work shall consist of designing, furnishing, and installing Aggregate Pier and/or Rigid Inclusion ground improvements to the lines and grades designated on the project foundation plan and civil drawings as specified herein.

C. The installation of the ground improvements shall also include the removal and disposal of excavation spoils as a result of the installation process. The excavated material is all assumed to be unsuitable and shall either be wasted or used in accordance with the Earth Moving Specifications. The cost of installation of the ground improvements shall include the cost of hauling, stockpiling and disposal, of the excavated material.

D. The Aggregate Piers and/or Rigid Inclusions shall be in a columnar-type configuration and shall be used for support of building foundations, floor slabs, retaining walls, stairs, access ramps, and sidewalk attached/connected to the proposed building.

1.02 WORK INCLUDED

A. Provision of all equipment, material, labor, and supervision to design, furnish, and install Aggregate Piers and/or Rigid Inclusions for support of building foundations, floor slabs, retaining walls, stairs, access ramps, and sidewalk attached/connected to the proposed building and pre-trenching as described on item 1.1.

B. The Aggregate Pier and/or Rigid Inclusion design and installation shall adhere to all methods and standards described in this Specification.

C. These ground improvements are installed by driving a mandrel and hammer to the design depth, feeding the backfill material through the hollow mandrel, and compacting the backfill in one-foot lifts using the hammer; thus, generating no spoils. If the Aggregate Piers or Rigid Inclusions are installed in augered holes, the testing, if needed, and disposal of the spoils shall be included in the contractor’s bid price.

D. The design of the ground improvement shall be verified with a modulus load test.

E. The subsurface conditions at the site included topsoil, asphalt, existing fill, buried organic soil, buried subsoil, and swamp deposits overlying sand and gravel, weathered rock, and rock. Based on the SPT data, the fill and some of the natural sand and gravel were loose to dense.

F. The existing fill contained organic soil and roots and may contain construction debris and other obstructions that need to be pre-trenched. The pre-trenching, if required, shall be performed by the Site Contractor. The cost of pre-trenching, including groundwater control during pre-trenching, shall be part of the ground improvements and no additional cost shall be paid to the Contractor for performing pre-trenching. After the obstructions are removed, the excavated material free of

obstructions shall be placed back and compacted to match the existing fill density. Material that becomes too wet during the pre-trenching operations shall not be placed back until it dries, or shall be replaced with dry material.

G. The ground improvement contractor shall monitor vibration through installation of seismographs at the nearby buildings during installation of Aggregate Piers and/or Rigid Inclusions.

1.03 APPROVED INSTALLERS

A. The Aggregate Pier and/or Rigid Inclusion installer (the Installer) shall be approved by the Engineer. Prior to approval, Installers and their Designers are required to submit to the Owner a qualification statement to demonstrate 5 years of experience on at least 10 projects of a similar scope and nature. Additionally, prior to approval, Installers and their Designers are required to submit to the Owner a preliminary design document. Without exception, no alternate installer will be accepted unless approved by the Owner.

B. Installers of Aggregate Pier and/or Rigid Inclusion foundation systems shall have a minimum of 5 years of experience with the installation of Aggregate Pier systems and shall have completed at least 10 projects in New England.

C. Local installer of Aggregate Piers and/or Rigid Inclusions include:

1. Vibro Stone Columns (VSC) (Aggregate Piers)) or Controlled Modulus Column (CMC) (Rigid Inclusions) by Menard (Phone: (781) 281-0371 or (908) 603-8224).

2. Vibro Piers (VP) (Aggregate Piers) or Vibro Concrete Columns (VCC) (Rigid Inclusions) by Hayward Baker/Keller (Phone: (401) 334-2565).

3. Aggregate Piers (AP) (Aggregate Piers) or GeoConcrete Columns (GCC) (Rigid Inclusion) by Geopier (Phone: 860-531-9137). The Local installer for Geopier Is HDI – (781) 848-2110.

4. Vibro Stone Columns (VSC) (Aggregate Piers) Subsurface Constructors (Phone: (866) 421-2460).

5. Aggregate Piers by H. B. Fleming (207) 799-8514.

1.04 REFERENCE STANDARDS

A. Design

1. “Ground Modification Methods Reference Manual – Volume I,” U.S. Department of Transportation, Federal Highway Administration, FHWA-NHI-16-027, FHWA GEC 013, April 2017.

2. “Control of Settlement and Uplift of Structures Using Short Aggregate Piers,” by Evert C. Lawton (Assoc. Prof., Dept. of Civil Eng., Univ. of Utah), Nathaniel S. Fox (President, Geopier Foundation Co., Inc.), and Richard L. Handy (Distinguished Prof. Emeritus, Iowa State Univ., Dept. of Civil Eng.), reprinted from *IN-SITU DEEP SOIL IMPROVEMENT, Proceedings of sessions sponsored by the Geotechnical Engineering Division/ASCE in conjunction with the ASCE National Convention held October 9-13, 1994, Atlanta, Georgia*.

3. “Settlement of Structures Supported on Marginal or Inadequate Soils Stiffened with Short Aggregate Piers,” by Evert C. Lawton and Nathaniel S. Fox. *Geotechnical Special*

Publication No. 40: Vertical and Horizontal Deformations of Foundations and Embankments, ASCE, 2, 962-974.

4. "Behavior of Geopier®-Supported Foundation Systems during Seismic Events," by Kord Wissmann, Evert C. Lawton, and Tom Farrell. Geopier Foundation Company, Inc. Blacksburg, VA ©1999.

5. "The design of vibro replacement." H.J. Priebe. *Ground Engineering*, London. Dec 1995.

B. Modulus Testing

1. ASTM D 1143 - Pile Load Test Procedures
2. ASTM D 1194 - Spread Footing Load Test

C. Materials and Inspection

1. ASTM D 1241 - Aggregate Quality
2. ASTM D 422 - Gradation of Soils
3. ASTM C39/C39M-12a Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
4. ASTM C-150-05 – Standard Specification for Portland Cement
5. ASTM D1557 – Moisture Density Relationship for Soils

D. Where specifications and reference documents conflict, the Owner shall make the final determination of the applicable document.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. DIVISION 02 – Existing Condition
2. DIVISION 03 – Concrete
3. DIVISION 31 – Earthwork
4. DIVISION 33 - Utilities

1.05 DEFINITIONS

1. Aggregate Piers: VSC, VP, or AP.

2. Rigid Inclusions: CMC, VCC, or GCC.

3. Test Element: Aggregate Pier and/or Rigid Inclusion element installed at as non-production element for the purpose of performing a modulus test. Test elements shall be installed prior to the start of production elements at a location representative of the subsurface conditions and loading. Where different subsurface conditions are encountered that warrant different types of improvements, a modulus test shall be performed for each type of improvement.

1.06 SUBSURFACE INFORMATION

A. Subsurface explorations have been performed at the site by the Geotechnical Engineer. The results of the explorations are included in the geotechnical report titled "Geotechnical Report, Proposed Wildwood Early Childhood Center, North Intermediate School – 320 Salem Street Site,

Wilmington, Massachusetts," prepared by Lahlaf Geotechnical Consulting, Inc. (LGCI) 100 Chelmsford Road, Suite 2, Billerica, MA 01862, dated January 14, 2026.

B. The subsurface explorations and geotechnical report were performed primarily for use in preparing the foundation design and are included for the convenience of the contractor. Use and interpretation of these data for purposes of the work shall be the responsibility of the Installer. Subsurface conditions and groundwater levels are not considered as accurate for any times or locations other than the specific time and location of each of the explorations.

C. The Owner assumes no responsibility for the Installer's failure to make his own site investigation and makes no representation other than the soils reports regarding the character of the soil or subsurface conditions which may be encountered during the performance of the work. The Installer shall refer to the Geotechnical Report. Failure by the Installer to be aware of existing site conditions shall not be cause for additional cost to the Owner.

D. Use and interpretation of these data for purposes of the work shall be the responsibility of the Installer. Subsurface conditions and groundwater levels are not considered as accurate for any times or locations other than the specific time and location of each of the explorations.

E. The Installer may, at his own expense, conduct additional subsurface testing for his own information after approval by the Owner.

F. No claim for extra cost or extension of time resulting from reliance by the Installer on information presented herein shall be allowed, except as provided in the Contract.

1.07 CERTIFICATIONS AND SUBMITTALS

A. Shop drawings that include spacing, diameter, length, installation procedure and sequence of construction with sufficient details, planned cut off and tip elevations, material, proposed equipment, aggregate gradation, and mix design. The design shall conform to the criteria in Subsection G.

B. Design Calculations - The Installer shall submit detailed design calculations and construction drawings prepared by the ground improvement designer (the Designer) for review and approval by the Owner in accordance with Section 3.2 of these specifications. All plans shall be sealed by a Professional Engineer in the State of Massachusetts.

C. Professional Liability Insurance - The Designer and Installer shall have Errors and Omissions design insurance for the work. The insurance policy should provide a minimum coverage of $3 million per occurrence.

D. Modulus/Load Test Reports – A modulus test/load test is performed on a non-production Aggregate Pier/Rigid Inclusion element to verify the design assumptions. The Installer shall furnish the Owner a description of the installation equipment, installation records, complete test data, analysis of the test data, and verification of the design parameter values based on the modulus test results. Test elements shall be installed prior to the start of production elements at a location representative of the subsurface conditions and loading. The report shall be prepared under direction of a Registered Professional Engineer in the State of Massachusetts.

E. Daily Aggregate Pier and Rigid Inclusion Progress Reports – The Installer shall furnish a complete and accurate record of Aggregate Pier and Rigid Inclusion installation to the Owner. The record shall indicate the Aggregate Pier/Rigid Inclusion location, length, volume of aggregate/concrete used or number of lifts, densification forces during installation of the aggregate, and final elevations or depths of the base and top of Aggregate Piers/Rigid Inclusions. The record shall also indicate the type and size of the installation equipment used, and the type of aggregate used. The Installer shall immediately report any unusual conditions encountered during installation to the Designer and to the Owner.

F. Submit calibration records for the load cells, the hydraulic jacks, the pumps, and the pressure gauges At least two weeks before performing the modulus and load tests.

G. The Ground Improvement is a contractor design. The contractor is fully responsible for the adequacy of the design and the performance of the system.

H. If required, the Installer/Designer shall include in its submittal an instrumentation plan as they own the design of the ground improvements and the performance of the proposed footings and slabs.

PART 2 - PRODUCTS

2.01 AGGREGATE

A. Aggregate used by the Installer for Aggregate Pier construction shall be pre-approved by the Designer and Owner and shall demonstrate suitable performance during modulus testing. Typical aggregate consists of Type 1 Grade B in accordance with ASTM D-1241-68, No. 57 stone, or other graded aggregate approved by the Designer.

B. Potable water or other suitable source shall be used to increase aggregate moisture content where required. The Owner shall provide such water to the Installer.

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2.02 PORTLAND CEMENT

A. Type I or Type II.

2.03 GROUT MIX

A. Minimum Compressive Strength:
- 4,000 psi at 28 days.
- 2,000 psi at 7 days.

2.04 CONCRETE

A. Minimum Compressive Strength:
- 4,000 psi at 28 days.
- 2,000 psi at 7 days.

PART 3 - EXECUTION

3.01 AGGREGATE PIER DESIGN AND RIGID INCLUSION DESGN

A. The design of the Aggregate Piers or Rigid Inclusions shall be based on the following:
1. A maximum allowable bearing pressure of 4,000 psf;
2. An allowable total settlement of 1 inch or less and an allowable differential settlement of 3/4 inch or less over a distance of 25 feet under static loads for footings;
3. A maximum of 0.5 inch settlement under slabs.

B. A load transfer platform (LTP) shall be installed on top of the Aggregate Piers and/or Rigid Inclusions, under the footings and slabs, stairs, access ramps, and sidewalk attached/connected to the proposed building, in accordance with the requirements of the specialty contractor designing the Aggregate Piers and/or Rigid Inclusions.

C. The Aggregate Piers and/or Rigid Inclusions shall be designed in accordance with generally accepted engineering practice. The design life of the structure shall be a minimum of 50 years.

D. The Aggregate Pier and Rigid Inclusion elements shall be designed using an Aggregate Pier or Rigid Inclusion stiffness modulus to be verified by the results of the modulus test/load test described in Section 3.7 of these specifications.

E. The specialty contractor shall be prepared to grout the Aggregate Piers if the modulus test reveals that the tested Aggregate Pier bulged during the modulus test.

F. The Aggregate Piers and/or Rigid Inclusions shall be designed for the full bearing capacity of footings regardless of what the actual footing loads are.

3.02 DESIGN SUBMITTAL

The Installer shall submit detailed design calculations, construction drawings, and shop drawings (the Design Submittal), for approval at least two week(s) prior to the beginning of construction. The installation shall not begin until final approval of all design and construction submittals. A detailed explanation of the design parameters for settlement calculations shall be included in the Design Submittal. Additionally, the quality control test program for the Aggregate Piers and/or Rigid Inclusions, meeting these design requirements, shall be submitted. All computer-generated calculations and drawings shall be prepared and sealed by a Professional Engineer, licensed in the State of Massachusetts.

A. The following shall be included in the design calculation submittal:

1. A written summary report that describes the overall ground improvement design.

2. Applicable code requirements and design references.

3. Design criteria including, soil shear strengths including friction angle and cohesion, unit weights, Aggregate Pier/Rigid Inclusion hole diameter, Aggregate Pier/Rigid Inclusion spacing, Aggregate Pier/Rigid Inclusion unit weight and friction angle/concrete compressive strength, composite shear strength parameters, and any other design assumptions.

4. A Structural Fill Footing Pad (or “Load Transfer Platform”) shall be required below all footings to transfer loads to the ground improvement elements. The system shall be designed to limit penetration (punching) of ground improvement elements into the Footing Pad.

5. Design calculation sheets with project number, foundation location, designation, date of preparation, initials of designer and checker, and page number at the top of each page. An index page with the design calculations shall be provided.

6. Design notes including an explanation of any symbols and computer programs used in the design.

7. Detailed subgrade preparation notes and requirements.

8. A complete list of the equipment proposed for use, including a description of the characteristics of each piece of equipment.

9. Detailed description of the methods and equipment proposed for loading of the test element during the modulus test and load test. Any deviation from Section 3.7, of this specification shall be specifically noted with explanation for the requested deviation. Without exception, no deviations will be accepted unless approved by the Owner.

10. Calibration sheets less than 6 months old shall be submitted for dial gages and loading jacks.

B. Working Drawings. Utility locations, right of way, and other applicable information are available on the plans. Working drawings shall include, but not be limited to the following items:

1. A plan view of the Aggregate Pier/Rigid Inclusion ground improvement for identifying:

   a. Right of way, permanent or temporary construction easement limits, location of all known active or abandoned existing utilities, adjacent structures, or other potential interferences. Any drainage structure or drainage pipe centerline behind, passing through, or passing under the structure.

   b. Limits of the Aggregate Pier/Rigid Inclusion ground improvement and layout of the numbered individual Aggregate Piers/Rigid Inclusions.

   c. A schedule showing pier number, pier length, pier diameter, top and bottom design elevations.

2. Subsurface exploration locations shown on a plan view of the proposed structure alignment with appropriate reference base lines to fix the locations of the explorations relative to the structure.

3. Elevation view showing Aggregate Pier/Rigid Inclusion locations, elevations and depth of improvement; location of drainage elements and expansion/contraction joints when applicable.

3.03 APPROVED INSTALLATION PROCEDURES

A. The following sections provide general criteria for the construction of the Aggregate Piers and Rigid Inclusions. Unless otherwise approved by the Designer, the installation method used for Aggregate Pier or Rigid Inclusion construction shall be that as used in the construction of the successful modulus test.

B. Aggregate Piers installed using Rammed Aggregate Pier systems

1. Aggregate Pier (AP) systems shall be constructed by advancing a specially designed mandrel with a minimum 15-ton static force augmented by dynamic vertical ramming energy to the full design depth. The hollow-shaft mandrel, filled with aggregate, is incrementally raised, permitting the aggregate to be released into the shaft, and then lowered by vertically advancing and/or ramming to densify the aggregate and force it laterally into the adjacent soil. The cycle of raising and lowering the mandrel is repeated to the top of pier elevation. The cycle distance shall be determined by the Designer. The mandrel shall be raised at a rate determined from the demonstration pier testing or no faster than 1 foot in 5 seconds. The crowd pressure shall be recorded to provide a measure of the vertical densification force as the mandrel is driven on its compaction stroke.

2. At AP element locations, water or compressed air shall be used if necessary, as determined from the flow test, to enhance free flow of aggregate through the mandrel as determined during the performance of a flow test. Water or air flow shall be discontinued when the mandrel reaches the 3-foot raise height.

3. At the completion of the pier installation, the hammer shall be turned off and the mandrel pushed downward applying full crowd pressure on the top of the pier to provide preloading.

4. At completion of the pier installation, the remaining stone in the mandrel may be emptied outside the pier location to allow for a measure of the remaining volume of aggregate.

5. Special high-energy impact densification apparatus shall be employed to densify the AP elements during installation. The apparatus shall apply direct vertical impact energy to each constructed lift of aggregate.

6. Densification shall be performed using a chained mandrel.

7. Downward crowd pressure shall be constantly applied to the mandrel shaft.

8. The Installer shall provide a full-time Quality Control Representative on-site during the installation process.

C. Aggregate Piers Installed using Vibrator

1. If a vibrator is used to construct the Aggregate Piers, the Installer shall use an electric down-hole vibrator capable of providing at least 80 HP of rated energy and a centrifugal force of 15 tons. The vibrator diameter must be at least 60 percent of the Aggregate Pier design diameter. An appropriate metering device should be provided at such a location that inspection of amperage increase may be verified during the operation of the equipment. The metering device may be an ammeter directly indicating the performance of the vibrator. The vibrator shall be a minimum of 16 inches in diameter. Complete equipment specifications should be submitted to the Engineer prior to commencement of the fieldwork.

2. The probe and follower tubes shall be of sufficient length to reach the elevations shown on the Installer's approved construction drawings. The probe, used in combination with the available pressure to the tip jet, shall be capable of penetration to the required tip elevation.

3. The probe shall penetrate into the foundation soil layer to the minimum depths required in the Installer's construction plans. After penetration to the required depth, the probe shall not be withdrawn more than 2 feet at any time unless the stone stops flowing to the bottom of the probe.

4. Redriving the probe into the treated depth shall be attempted at approximately 12 to 18-inch intervals to observe resistance to penetration and amperage build-up. During redriving, the probe tip shall penetrate to within 1 foot of the previous redriving depth.

5. Amperage build-up and backfill quantities will be contingent upon the type of probe used and procedures. Prior to commencement of work, the contractor shall discuss the equipment capabilities with the Owner to determine if trial probes will be necessary.

6. The Installer shall provide a full-time Quality Control Representative on-site during the installation process.

D. Aggregate Piers installed by other methods may be considered by the Owner upon review and approval by the Owner.

E. Rigid Inclusions

1. Install the Rigid Inclusions in accordance with the sequence detailed in the approved work plan. If adjacent Rigid Inclusions are observed to be influenced by the installation of a neighboring Rigid Inclusion, the installation sequence shall be modified to prevent disturbance of Rigid Inclusions. Modifications to the sequence, or replacement of Rigid Inclusions deemed unusable due to disturbance, shall be completed by the Contractor at no additional cost to the Owner.

2. Cutoff the Rigid Inclusions to the top elevation of the first layer of the load transfer pad, or slightly higher to allow any required trimming or removal of low strength material at the butt of the Rigid Inclusion. The cut-off elevation of each Rigid Inclusion shall be within +/- 0.1 feet. The cut-off shall be made before the concrete sets.

3. Protect the concrete at the top of Rigid Inclusions from mixing with surrounding soil.

3.04 PLAN LOCATION AND ELEVATION OF AGGREGATE PIERS AND/OR RIGID INCLUSIONS

A. The as-built center of each Aggregate Pier and/or Rigid Inclusion shall be within 6 inches of the locations indicated on the plans. Aggregate Piers and/or Rigid Inclusion installed outside of the above tolerances and deemed not acceptable shall be rebuilt at no additional expense to the Owner.

3.05 REJECTED AGGREGATE PIERS AND/OR RIGID INCLUSIONS

A. Aggregate Pier and/or Rigid Inclusion elements installed beyond the maximum allowable tolerances shall be abandoned and replaced with new Aggregate Piers/Rigid Inclusions unless the Designer approves the condition or provides other remedial measures. All material and labor required to replace rejected piers shall be provided at no additional cost to the Owner, unless the cause of rejection is due to an obstruction or mislocation.

3.06 LAYOUT

A. The Contractor shall provide layout (construction staking) of the ground improvement elements. The Contractor shall provide ground elevations in sufficient detail to estimate drilling depth elevations to within two-inches.

3.07 QUALITY CONTROL REPRESENTATIVE

A. The Installer shall have a full-time, on-site Quality Control Representative to verify and report all installation procedures. The Installer shall immediately report any unusual conditions encountered during installation to the Designer and to the Owner. The quality control procedures shall include the preparation of Aggregate Pier and/or the Rigid Inclusion Progress Reports completed during each day of installation containing the following information:

1. Footing and Aggregate Pier and/or Rigid Inclusion location.
2. Pre-auger diameter and soil conditions encountered during drilling (if required).
3. Aggregate Pier and/or Rigid Inclusion length.
4. Planned and actual Aggregate Pier and/or Rigid Inclusion elevations at the top and bottom of the Aggregate Pier and/or Rigid Inclusion.
5. Average lift thickness of each Aggregate Pier and/or Rigid Inclusion.
6. Volume of aggregate used in each Aggregate Pier.
7. Volume of concrete used in each Rigid Inclusion
8. Documentation of any unusual conditions encountered.
9. Type and size of densification equipment used.
10. Compressive strength of concrete used for Rigid Inclusions,

3.08 AGGREGATE PIER MODULUS TEST AND/OR RIGID INCLUSION LOAD TEST

A. A minimum of one (1) Modulus/Load Test is required for this project. When authorized, an Aggregate Pier modulus test or Rigid Inclusion load test(s) shall be performed at locations agreed upon by the Designer and the Owner to verify or modify Aggregate Pier or Rigid Inclusions designs. Modulus Test Procedures shall utilize appropriate portions of ASTM D 1143 and ASTM D 1194, as outlined in the ground improvement design submittal. Aggregate Piers and/or Rigid Inclusions shall be tested to 150 percent of the maximum design stress as shown in the ground improvement design submittal. The modulus tests shall be of the type and installed in a manner specified herein.

B. A telltale shall be installed at the bottom of the test pier so that bottom-of-pier deflections may be determined. Acceptable performance is indicated when the bottom of the pier deflection is no more than 30 percent of the top of pier deflection at the design stress level, the total settlement is less than the design settlement, and the residual movement, i.e., movement after the unloading, is less than 0.5 inch.

C. ASTM D-1143 general test procedures shall be used as a guide to establishing load increments, load increment duration, and load decrements. As a minimum, the following loading increments, decrements and duration shall be used.

Increment	Approximate Load (percent design)	Minimum Duration (min)	Maximum Duration (min)
Seat	< 9	0	N/A
1	17	15	60
2	33	15	60
3	50	15	60
4	67	15	60
5	83	15	60
6	100	15	60
7	117	60	120
8	133	15	60
9	150	15	60
10	100	N/A	N/A
11	66	N/A	N/A
12	33	N/A	N/A
13	0	N/A	N/A

D. With the exception of the load increment representing approximately 117 percent of the design maximum top of ground improvement stress, all load increments shall be held for a minimum of 15 minutes. Loads are then maintained until the rate of deflection reduces to 0.01 inch per hour or for a maximum of 1 hour, whichever is occurs first.

E. The load increment that represents approximately 117 percent of the design maximum stress on the ground improvement shall be held for a minimum of 60 minutes. The load is then maintained until the rate of deflection reduces to 0.01 inch per hour or for a maximum of 4 hours, whichever is occurs first.

F. A seating load equal to 5 percent of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance.

G. At least one Rigid Inclusion load test shall be performed in accordance with ASTM D 1143 to maximum load test of 200 percent of the sign load at 25 percent of the design load increments, when applicable.

H. The location of the Aggregate Pier modulus test and the Rigid Inclusion load test shall be approved by the geotechnical engineer

I. Submit as-built plans showing layout, location and numbers of installed Aggregate Piers and/or Rigid Inclusions.

3.09 BOTTOM STABILIZATION TESTING (BSTS) / CROWD STABILIZATION TESTING (CSTs)

A. Bottom stabilization testing (BSTs) or Crowd stabilization testing (CSTs) shall be performed during the installation of the modulus/load test pier and be observed by the Quality Control Representative and the Owner's geotechnical engineer. The tests are performed by applying downward vertical energy to the tamper, mandrel or probe following lift construction and monitoring the amount of additional deflection from the applied energy. Additional testing by the Designer (typically 10 percent of the production Aggregate Piers and/or Rigid Inclusions) shall be performed on selected production Aggregate Pier and/or Rigid Inclusion elements to compare results with the modulus /load test pier.

3.10 QUALITY ASSURANCE

A. The Owner will retain the geotechnical engineer to provide full-time monitoring of Aggregate Pier and/or Rigid Inclusion construction activities, including observing the Aggregate Pier modulus test and/or the Rigid Inclusion load test.

3.11 SITE PREPARATION AND PROTECTION

A. The Site Contractor shall locate and protect underground and aboveground utilities and other structures from damage during installation of the Aggregate Piers and Rigid Inclusions.

B. Site grades for Aggregate Pier and/or Rigid Inclusion installation shall be a minimum of 2 feet below the finished grade elevation to minimize Aggregate Pier and/or Rigid Inclusion installation depths. Ground elevations and bottom of footing elevations shall be provided to the Aggregate Pier and/or Rigid Inclusion Installer in sufficient detail to estimate installation depth elevations to within 3 inches.

C. The Site Contractor will provide site access to the Installer, after earthwork in the area has been completed. A working surface shall be established and maintained by the Site Contractor to provide wet weather protection of the subgrade and to provide access for efficient operation of the Aggregate Pier and/or Rigid Inclusion installation.

D. Prior to, during and following Aggregate Pier and/or Rigid Inclusion installation, the Site Contractor shall provide positive drainage to protect the site from wet weather and surface ponding of water.

E. If spoils are generated by Aggregate Pier and/or Rigid Inclusion installation, spoil removal from the Aggregate Pier and/or Rigid Inclusion work area in a timely manner to reduce the potential for interruption of Aggregate Pier and/or Rigid Inclusion installation is required.

F. The installer shall coordinate with Site Contractor the installation of support of excavation (SOE) system if required. The purpose of this coordination is to plan the workflow and avoid down time during construction.

G. The Site Contractor will monitor vibration through installation of seismographs at the nearby building during installation of Aggregate Piers and/or Rigid Inclusions.

H. The Site Contractor shall perform test pits within the footprint of the proposed building to explore for the presence obstructions and remove them.

3.12 AGGREGATE AND/OR RIGID INCLUSION LAYOUT

A. The location of Aggregate Pier and/or Rigid Inclusion supported foundations and slabs for this project, including layout of individual Aggregate Pier and/or Rigid Inclusion shall be marked in the field using survey stakes or similar means at locations shown on the drawings.

3.13 EXCAVATIONS FOR OBSTRUCTIONS

A. The existing fill may contain below-ground structures and/or obstructions that need to be pre-trenched. Should any obstruction be encountered during Aggregate Pier and/or Rigid Inclusion installation, the Site contractor shall be responsible for promptly removing such obstruction, or the Aggregate Pier and/or Rigid Inclusion shall be relocated or abandoned. Obstructions include, but are not limited to, abandoned utilities, existing and abandoned foundations or concrete structures, asphalt, demolition debris, cobbles, boulders, wood, metals, and other below-ground structures, and underground tanks, which shall prevent placing the piers to the required depth or shall cause the pier to drift from the required location.

B. Dense natural rock or weathered rock layers shall not be deemed obstructions, and piers may be terminated short of design lengths on such materials. Dense rock or weathered rock may be anticipated within the proposed depths of the Aggregate Piers and/or Rigid Inclusions.

3.14 UTILITY EXCAVATIONS

A. The Site Contractor shall coordinate all excavations made prior and subsequent to Aggregate Pier and/or Rigid Inclusion installations so that excavations do not encroach on the Aggregate Piers and/or Rigid Inclusions as shown in the Aggregate Pier and/or Rigid Inclusion construction drawings.

B. Protection of completed Aggregate Piers and/or Rigid Inclusions is the responsibility of the Site Contractor. If utility excavations are required in close proximity to the installed Aggregate Piers and/or Rigid Inclusions, the Site Contractor shall contact the Aggregate Pier and/or Rigid Inclusion Designer immediately to develop construction solutions to minimize impacts on the installed Aggregate Pier and/or Rigid Inclusion elements.

C. The Site Contractor will repair damaged Aggregate Piers and/or Rigid Inclusions in accordance with procedure included in specialty contractor’s submittal.

3.15 FOOTING BOTTOMS

A. Excavation and surface compaction of all improved subgrades shall be the responsibility of the Site Contractor.

B. Foundation excavations to expose the tops of Aggregate Piers and/or Rigid Inclusions shall be performed with a smooth edge bucket in a workman-like manner, and shall be protected, until the LTP is built on top of the Aggregate Piers and/or Rigid Inclusions, with procedures and equipment best suited to (1) avoid exposure to water, (2) prevent softening of the matrix soil between and around the Aggregate Piers and/or Rigid Inclusions before building the LTP, and (3) achieve direct and firm contact between the dense, undisturbed Aggregate Piers/Rigid Inclusions and the LTP.

C. The proposed footings shall be supported on a minimum of 12 inches of Structural Fill or 3/4-inch crushed stone wrapped in a filter fabric placed directly over Aggregate Piers and/or Rigid Inclusions. The Structural Fill or crushed stone layer shall be thicker if required for the LTP installed in accordance with the requirements of the specialty contractor.

D. All excavations for footing bottoms supported by Aggregate Pier and/or Rigid Inclusion improved subgrades shall be prepared in the following manner by the Site Contractor. Recommended procedures for achieving these goals are to:

1. Limit over-excavation below the bottom of the footing to 3-inches (including disturbance from the teeth of the excavation equipment).
2. Compaction of surface soil and top of Aggregate Piers and/or Rigid Inclusions shall be prepared using a large vibratory plate compactor. Motorized impact compactors ("Wacker Packer," "Jumping Jack," or similar) shall only be used in cohesive soils and when approved by the Designer. Loose or soft surficial soil over the entire footing bottom shall be recompacted or removed, respectively. The surface of the Aggregate Pier and/or Rigid Inclusion shall be recompacted prior to completing footing bottom preparation.
3. Place footing concrete immediately after footing excavation is made and approved, preferably the same day as the excavation. Footing concrete must be placed on the same day if the footing is bearing on moisture-sensitive soils. If same day placement of footing concrete is not possible, open excavations shall be protected from surface water accumulation. A lean concrete mud-mat may be used to accomplish this. Other methods must be pre-approved by the Designer.
4. The Aggregate Piers and/or Rigid Inclusions shall be visible before placing Structural Fill or crushed stone over the top of the Aggregate Piers and/or Rigid Inclusions. Such Structural Fill or crushed stone shall not be placed until the geotechnical engineer has observed the subgrade.

E. The following criteria shall apply, and a written inspection report sealed by the Engineer shall be furnished to the Installer to confirm:

1. That water has not been allowed to pond over the Aggregate Pier and/or Rigid Inclusion subgrade at any time. This statement shall be provided by the Site Contractor.
2. That all Aggregate Piers and/or Rigid Inclusions designed for each structure have been exposed in the footing excavation or prior to fill placement.
3. That immediately before footing construction or fill placement, the tops of Aggregate Piers and/or Rigid Inclusions have been inspected and the top of the Aggregate Piers recompacted with mechanical compaction equipment.
4. That no excavations have been made after installation of Aggregate Pier and/or Rigid Inclusion elements within the excavation limits described in the Aggregate Pier and/or Rigid Inclusion construction drawings, without the written approval of the Installer or Designer.

3.16 SLAB SUBGRADES

A. The proposed slab shall be supported on a minimum of 12 inches of Structural Fill placed directly over Aggregate Piers and/or Rigid Inclusions. The Structural Fill layer shall be thicker if required for the LTP installed in accordance with the requirements of the specialty contractor or in the drawings.

B. The Aggregate Piers and/or Rigid Inclusions shall be visible before placing Structural Fill or crushed stone over the top of the Aggregate Piers and/or Rigid Inclusions. Such Structural Fill or crushed stone shall not be placed until the geotechnical engineer has observed the subgrade.

3.17 VIBRATION MONITORING

A. The Site Contractor shall perform vibration monitoring during installation of Aggregate Piers and/or Rigid Inclusions. The peak particle velocity should be less than one (1) inch per second.

3.18 BASIS OF PAYMENT

A. Payment shall include all costs for design and installation of the Aggregate Piers and/or Rigid Inclusion and in accordance with requirements of the Contract Documents. Payment for the Work of this Section shall be made following approval by the Owner in accordance with requirements of the Contract Documents, and the following Schedule:

1. Preparation of design calculations and construction drawings and installation of Aggregate Pier and/or Rigid Inclusion elements:

   $_____ Lump Sum

2. Unit Price for additional installed Aggregate Pier (w/o remobilization):

   $_____ Lump Sum

3. Unit Price Credit for Aggregate Pier not installed:

   $_____ Lump Sum

4. Unit Price for additional Modulus test (w/o remobilization)

   $_____ Lump Sum

5. Unit Price for additional installed Rigid Inclusion (w/o remobilization):

   $_____ Lump Sum

6. Unit Price Credit for Rigid Inclusion not installed:

   $_____ Lump Sum

7. Unit Price for Load test (w/o remobilization)

   $_____ Lump Sum

8. Alternate – Provide price for laying out Aggregate Piers and/or Rigid Inclusions):

   $_____ Lump Sum

9. Unit Price for additional Mobilizations

   $_____ Each

SECTION 32 12 16
ASPHALT PAVING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The Construction Manager, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section will also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
   1. Hot-mix asphalt paving, including walkways, ramps, and curbs.
   2. Hot-mix asphalt patching.
   3. Pavement-marking paint.

B. Alternates: Not Applicable.

C. Items To Be Installed Only: Not Applicable.

D. Items To Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
   1. Section 31 20 00 - Earth Moving for aggregate subbase and base courses and for aggregate pavement shoulders.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
   1. Job-Mix Designs: Certification, by authorities having jurisdiction, of acceptance of each job mix proposed for the Work.

B. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

C. Material Certificates: For each paving material, from manufacturer.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and accepted by the Massachusetts Highway Department (MHD).

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the Massachusetts Highway Department (MHD) for hot mix asphalt paving work.
   1. Comply with requirements of the Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, including supplemental specifications and special provisions.
   2. Comply with requirements of the Americans with Disabilities Act (ADA) and the Massachusetts Architectural Access Board (MAAB). If these requirements cannot be met with the grades and slopes indicated on the plans, notify the Designer immediately.
   3. Comply with requirements of the local authority having jurisdiction concerning the location and construction of accessible curb cuts.

C. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01.
   1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
      a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.

b. Review condition of subgrade and preparatory work.

c. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.06 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. Tack Coat: Minimum surface temperature of 60 degrees F.

2. Asphalt Base Course: Minimum surface temperature of 40 degrees F and rising at time of placement.

3. Asphalt Surface Course: Minimum surface temperature of 60 degrees F at time of placement.

C. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55 degrees F for water-based materials, and not exceeding 95 degrees F.

PART 2 - PRODUCTS

2.01 AGGREGATES

A. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

B. Fine Aggregate: ASTM D 1073 or AASHTO M 29, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

C. Mineral Filler: ASTM D 242 or AASHTO M 17, rock or slag dust, hydraulic cement, or other inert material.

D. Reclaimed Asphalt Pavement (RAP): Provide material obtained from the highways or streets by crushing, milling, or planning existing hot mix asphalt pavements.

1. The proportion of RAP to virgin aggregate for base course mixtures and intermediate course mixtures will be limited to a maximum of 40 percent for drum mix plants and 20 percent for modified batch plants. The maximum amount of RAP for surface course mixtures will be 10 percent.

2.02 ASPHALT MATERIALS

A. Asphalt Binder Performance Graded: AASHTO M320 or AASHTO MP 1a, performance grade as required by MHD Specifications.

B. Tack Coat: AASHTO M 140 emulsified asphalt, or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

2.03 AUXILIARY MATERIALS

A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.

B. Pavement-Marking Paint: Acrylic/latex type, low VOC, traffic marking paint.

1. Color: As indicated.

C. Wheel Stops: Precast, air-entrained concrete, 2500-psi minimum compressive strength, 4-1/2 inches high by 9 inches wide by 72 inches long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.

1. Dowels: Galvanized steel, 3/4-inch diameter, 10-inch minimum length.

2.04 ASPHALT MIXES

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes accepted contracts by MHD Specifications, HMA Binder for binder courses, HMA Surface Standard Top for surface courses, and MHW 3/8” Top for sidewalks, designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types".

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.02 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

3.03 PATCHING

A. Existing Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. to reseat concrete pieces firmly.

1. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a minimum rate of 0.05 to 0.15 gal./sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Patching: Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.04 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.

2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.05 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
   1. Spread mix at minimum temperature of 250 degree F.
   2. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.06 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
   1. Clean contact surfaces and apply tack coat to joints.
   2. Offset longitudinal joints, in successive courses, a minimum of six inches.
   3. Offset transverse joints, in successive courses, a minimum of 24 inches.
   4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

3.07 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
   1. Complete compaction before mix temperature cools to 185 degrees F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
   1. Average Density: ASTM D 2041, per MHD Specifications.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

G. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.08 ASPHALT CURBS

A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of 250 degrees F.

1. Asphalt Mix: Same as pavement surface-course mix.

B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.09 INSTALLATION TOLERANCES

A. Accessibility: Comply with requirements of Massachusetts Architectural Access Board and ADAAG requirements. Remove and replace paving that does not meet required tolerances, when measured with a two-foot straightedge.

B. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch.
2. Surface Course: Plus 1/4 inch, no minus.

C. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within MHD Specification tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas.

3.10 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Designer.

B. Allow paving to age for a minimum of 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.11 WHEEL STOPS

A. Securely attach wheel stops to pavement with not less than two galvanized-steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.12 FIELD QUALITY CONTROL

A. Independent Testing Agency: Cooperate with the Independent Testing Agency engaged by Town of Wilmington for field quality control activities for the Work of this Section. Refer also to Section 01 45 23 – Testing and Inspecting Services.

B. Test the plane of the finished surfaces of base, binder, and surface courses with a 16-foot straightedge, except use a 10-foot straightedge on vertical courses and on the top course of resurfaced streets which contain manhole covers, valve boxes, and the like.

C. Carefully apply the straightedge immediately after the first compaction by rolling, and from then on as may be necessary until and after the final compaction of the material in place. Hold the straightedge in successive positions parallel to the road centerline and in contact with the road surface; check the entire area from one side of the pavement to the other.

D. Correct irregularities which vary 3/8 inch from a true finished surface in base and binder courses, and 1/4 inch in top courses.

E. Irregularities which may develop before the completion of rolling and while the material is still workable, may be remedied by loosening the surface mixture and removing or adding material as necessary. Should any unsatisfactory irregularities or defects remain after final compaction, correct the defective work by removing and replacing with new material to form a true and even surface.

3.13 OPENING TO TRAFFIC

A. No vehicular traffic or loads will be permitted on the newly completed pavement until adequate stability has been attained, and the material has cooled sufficiently to prevent distortion or loss of fines, and the pavement has achieved a maximum temperature of 140 degrees F.

B. If the climatic or other conditions warrant it, the period of time before opening to traffic may be extended at the discretion of the Architect.

3.14 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-accepted landfill.

END OF SECTION

SECTION 32 12 16.13
ASPHALT | BITUMINOUS CONCRETE PAVING (PEDESTRIAN)

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes:
   1. Paving.

B. Hot-mix asphalt (HMA) | bituminous concrete paving at basketball courts.
   1. Hot-mix asphalt | bituminous concrete shall be composed of mineral aggregate and asphalt | bituminous concrete binder, mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and conformance to the lines, grades, thickness and typical cross sections shown on the plans.
   2. Each course shall be constructed to the depth, typical section, or elevation required by the contract and/or plans and shall be rolled, finished, and accepted before the placement of the next course. Each course shall be placed to a smooth, dense, and uniform appearance.
      a. Sawcutting existing pavements.
      b. Asphalt Emulsion for Tack Coat.
      c. Hot Poured Joint Sealer.
      d. Hot-mix asphalt | bituminous concrete patching.
      e. Hot-mix asphalt | bituminous concrete overlays, including surface preparation, leveling courses, tack coating and all other associated operations required.

C. Acceptance: The acceptance of plant produced material for gradation, asphalt content, and air voids shall be determined by the Designer in accordance with the requirements of the section on acceptance criteria, herein specified.

D. Related Work: The following items are not included in this Section and shall be performed under the designated Sections:
   1. Section 02 41 00 "DEMOLITION" for demolition and removal of existing asphalt | bituminous concrete pavement.
   2. Section 04 43 00 “STONE MASONRY” for granite curbing.
   3. Section Section 31 00 00 "EARTH MOVING" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
   4. Section 32 12 16 “ASPHALT PAVING” for adjacent asphalt | bituminous concrete paving construction.
   5. Section 32 12 16.36 “ATHLETIC ASPHALT-BIT CONC SPORT COURT PAVING” for sport court paving.
   6. Section 32 13 13.13 "CONCRETE PAVING (SITE)" for installation of cement concrete paving for plazas and walkways.
   7. Section 32 13 73 "CONCRETE PAVING JOINT SEALANTS" for joint sealants and fillers at pavement terminations.
   8. Section 32 14 13 "UNIT PAVING ON BITUMEN" for bituminous setting bed for pavers.
   9. Section 32 17 26 “DETECTABLE WARNING SURFACE” for requirements for tactile warning surfaces.

1.03 ACTION SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
   1. Proof of a State or local municipality Department of Transportation's pre-approved Job Mix Formula (JMF).
   2. Tack Coat.
   3. Hot Applied Joint Sealer.
   4. Seal Coat.

C. Material Certificates: For each paving material, from manufacturer.
   1. Submit certified test reports signed by the material producer and General Contractor certifying that materials comply with, or exceed, the specification requirements. The Owner reserves the right to employ an independent testing laboratory for testing materials included in the JMF, and the General Contractor shall, upon request by the Owner, supply suitable quantities of these materials for testing.

D. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
   3. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paver is 29 or greater.
   4. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.04 REFERENCES

A. The following Standards shall apply to the Work of this Section:
   1. Commonwealth of Massachusetts Department of Transportation (MassDOT) Highway Division Specifications: Standard Specifications for Highways and Bridges; latest edition.
   2. AASHTO: American Association of State Highway and Transportation Officials:
      Standard Size of Coarse Aggregate for Highway Construction: M43.
      Emulsified Asphalt: M140.
      Cationic Emulsified Asphalt: M208.
   3. ANSI | ASTM: American Society for Testing and Materials:
      Specification of Concrete Aggregates: C33.
      Test method for Softening Point of Bitumen (Ring and Bell Apparatus): D36.
      Test method for Ductility of Bituminous Materials: D113.
      Penetration-Graded Asphalt Cement for Use in Pavement Construction: D946
      Test Method for laboratory Compaction Characteristics of Soil using Modified Effort [56,000 ft-lbf/ft3 (2,700 kN-m/m3)]: D1557.
      Specification for Viscosity-Graded Asphalt Cement for use in Pavement Construction: D3381.
   4. ACI: American Concrete Institute.
   5. MUTCD: Manual on Uniform Traffic Control Devices

B. Pavement within public rights-of-way. The construction of all pavements within public rights- of-way shall be in accordance with the rules, regulations and requirements of the public agency having control and ownership of such rights-of-way.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by MassDOT, Highway Division.

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of MassDOT, Highway Division for hot mix asphalt | bituminous concrete paving work.
   1. Comply with requirements of MassDOT, Highway Division, Standard Specifications for Highways and Bridges, including supplemental specifications and special provisions.
   2. Comply with requirements of the Americans with Disabilities Act (ADA) and the Massachusetts Architectural Access Board (MAAB). If these requirements cannot be met with the grades and slopes indicated on the plans, notify the Designer immediately.
   3. Comply with the requirements of the local authority having jurisdiction concerning the location and construction of accessible curb cuts.

C. The General Contractor shall establish, provide, and maintain a Quality Control System (QCS) that shall detail the methods and procedures that shall be taken to ensure that all materials and completed construction conform to project specifications, plans, technical specifications, and other requirements, whether manufactured or processed by the General Contractor or procured from subcontractors or vendors.
   1. The General Contractor assumes responsibility for the quality of all materials and construction incorporated into the work and shall control all the processes leading to the final result through this function. Quality Control activities should include:
      a. Maintain a Quality Control System.
      b. Proficiency Testing prior to production with the Independent Testing Agency.
      c. Inspection and Testing of Hot Mix Asphalt | Bituminous Concrete Production.
      d. Inspection and Testing of Hot Mix Asphalt | Bituminous Concrete Placement.
   2. See Section 3.3 “Quality Control of HMA | Bituminous Concrete Pavement” of these specifications for additional information.

D. The Owner, or their authorized representatives, will perform the Quality Acceptance function for this work. All material will be considered for acceptance through a sampling, testing and inspection program performed by the Independent Testing Agency. Quality Acceptance activities include:
   1. Proficiency Testing prior to production.
   2. Inspection of HMA | Bituminous Concrete Production Plant and Testing Laboratory.
   3. Production Trials of HMA | Bituminous Concrete Products Intended for the Project.
   4. Inspection/Testing for Acceptance of Hot Mix Asphalt | Bituminous Concrete Production.
   5. Inspection/Testing for Acceptance of Hot Mix Asphalt | Bituminous Concrete Placement.
   6. HMA | Bituminous Concrete Quality Acceptance Daily Report of Activities.

E. Preinstallation Conference:
   1. Prior to the placing of any HMA | bituminous concrete, a pre-paving conference shall be held to discuss and approve the paving schedule, source of HMA | bituminous concrete, Job Mix Formula/Design Mix Formula approvals, type and amount of equipment to be used, sequence of paving pattern, rate of HMA | bituminous concrete supply, all sampling, testing and reporting procedures to be used, traffic control, safety, and general continuity of the operation. Designers, Installation Contractor, quality control and field representatives and Owner’s Independent Testing Agency’s testing and inspection agents shall attend this meeting. All equipment used should be accepted on the project site prior to starting up each day.
   2. Conduct conference at Project site to comply with requirements in Division 01.

3. Review methods and procedures related to hot-mix asphalt | bituminous concrete paving including, but not limited to, the following:
   a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt | bituminous concrete.
   b. Review condition of subgrade and preparatory work.
   c. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
   d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Coordination. The General Contractor shall coordinate and schedule the Work under this specification with all other work, including underground utility improvement construction, to avoid covering up incomplete, unfinished, and/or uninspected work. Any repaving required due to uncoordinated and/or improper scheduling shall be done by the General Contractor at no cost to Owner.

1.06 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic to sustain construction operations and Owner use of the site. Coordinate with phasing drawings.

B. Weather Limitations.
   1. HMA | bituminous concrete shall only be placed on dry, unfrozen surfaces. The underlaying surface shall be accepted by the Owner's Representative prior to placement of any HMA | bituminous concrete. Underlaying surfaces shall be cleaned of any foreign materials.
   2. The HMA | bituminous concrete shall not be placed when weather conditions of fog or rain prevail or when the pavement surface or base shows signs of free moisture (film of water) or when the air and/or surface temperature is less than the temperature requirements contained in MassDOT Specifications Table 450.42-1. When the surface temperature of the underlying course is less than 50 degrees Fahrenheit the General Contractor shall determine the time available for compaction. The General Contractor shall also take extra precautions to control the temperature of the materials during placement. The time available for compaction shall be calculated based on the time, date, air temperature, average wind speed, sky conditions, latitude, mix type, PG grade, lift thickness, mix delivery temperature, existing surface type, existing moisture content of surface, existing state of moisture in surface, and surface temperature. The estimated time available for compaction can be calculated with computer programs, e.g., Pave Cool Tool. This program is available at the following web location: http://www.dot.state.mn.us/app/pavecool/
   3. The information regarding the air temperature, average wind speed, sky conditions, mix delivery temperature, and existing moisture conditions shall be evaluated by the Designer and the General Contractor's representative located at the paving operation. The estimated time available for compaction shall be provided by the General Contractor to the Designer. The Designer and the General Contractor shall determine if there is an adequate amount of time available to compact the mixture. Options can be explored to extend the time available for compaction. If there is an adequate amount of time available to compact the mixture, the temperature requirements may be waived by the Designer; however, all other requirements including compaction shall be met. The General Contractor assumes responsibility for constructing the pavement to meet compaction and specification requirements.
   4. The General Contractor shall not permit work to continue when overtaken by sudden storms until the pavement surface shows no signs of free moisture. The material in transit at the time of shutdown shall not be placed until the pavement surface shows no signs of free moisture, provided the mixture is within temperature limits as specified.

5. When the air temperature falls below 50 degrees Fahrenheit, extra precautions shall be taken in drying the aggregate, controlling the temperature of the materials, and placing and compacting the mixtures.
6. The construction of hot mix asphalt | bituminous concrete pavements shall terminate on November 15 and shall not be resumed prior to April 1 except as determined and directed in writing by the Designer.

1.07 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Installation Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs shall be allowed because of a lack of knowledge of existing conditions as indicated in the Construction Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the General Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.08 ADA AND MAAB COMPLIANCE

A. Comply with American with Disabilities Act (ADA) and the requirements of the Massachusetts Architectural Access Board (MAAB).
   1. Slopes: As defined by Section 22.1 of 521 CMR, shall be graded to a maximum of 4.5 percent. The cross-pitch (perpendicular to travel) for surfaces shall be constructed at 1.5 percent. The slopes of ramps and side slopes on handicap curb cuts as defined by Section 21.1 of 521 CMR shall be constructed at 7.6 percent maximum. Ramps as defined in Section 24.1 of 521 CMR, shall be constructed to a maximum slope of 7.6 percent.
   2. The General Contractor is to assume that sidewalk grades shall be verified and checked with a two foot long electronic ‘smart level’.
   3. A five-foot minimum level, 1.5 percent pitch, area shall be provided at entrances to buildings. Puddling or ponding of water at the entrances shall not be accepted.
   4. Handicap parking spaces and access aisles shall be graded level with the slope not to exceed 1.8 percent in any direction.
   5. The requirements specified hereinabove shall supersede the grades indicated on the Drawings. If these requirements cannot be met with the grades indicated on the Drawings, the Designer shall be notified immediately for direction.

PART 2 PRODUCTS

2.01 HOT MIX ASPHALT | BITUMINOUS CONCRETE

A. General
   1. Hot Mix Asphalt (HMA) | bituminous concrete paving shall conform to MassDOT Standard Sections 450.10, 450.30, and M 3.06.00. All HMA | bituminous concrete mixtures shall meet the requirements of the Superpave volumetric mix design system.
   2. Within the public Right-Of-Way, the local municipality’s HMA | bituminous concrete product requirements shall govern, if applicable.
   3. HMA | bituminous concrete designs shall meet the requirements of MassDOT Standard Specification Section 450.30
      a. Each HMA | bituminous concrete pavement course placed shall be comprised of one of the mixtures listed in MassDOT Standard Specifications Table 450.10-1: HMA | Bituminous Concrete Pavement Courses & Mixture Types
   4. Asphalt | bituminous concrete mixtures shall be composed of the following:
      a. Mineral aggregate
      b. Mineral filler (if required)
      c. Performance Graded Asphalt Binder (PGAB)

1) All mixes shall be PG 64-28

5. The use of recycled materials shall be in accordance with MassDOT Standard Section M3.06.00. As permitted, recycled materials shall be limited to Recycled Asphalt Pavement (RAP). Maximum amount of RAP allowed shall be per MassDOT Standard Table M3.06.2-1.

6. Warm Mix Asphalt | bituminous concrete. Warm Mix Asphalt | bituminous concrete shall be HMA | bituminous concrete modified using a Warm Mix Asphalt | bituminous concrete Additive. WMA shall be per MassDOT Standard Specifications Section M3.01.4.
   a. Shall meet the requirements of AASHTO R 25 Appendix X2: Special Mixture Design Considerations and Practices for Warm Mix Asphalt (WMA) | bituminous concrete.
   b. Laboratory mixing and compaction temperatures shall be reduced per the WMA Manufacturer's recommendations.
   c. WMA additive equipment shall be fully automated and integrated into the HMA | bituminous concrete plant controls. No WMA foaming technology which requires the mechanical injection of steam or water into the liquid asphalt shall be permitted.

2.02 AUXILIARY MATERIALS

A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.

B. Detectable Warning Panels
   1. As specified in Section 32 17 16 "DETECTABLE WARNING SURFACE".

2.03 SEALCOAT

A. Asphalt emulsion sealcoat shall conform to the requirements of the Asphalt Institute for seal coating. Non-volatile solids shall be 40 to70 percent. No additional water shall be added. The emulsion shall be produced using a colloid mill to ensure homogeneity and appropriate size of the particles in suspension.

B. Sand shall be washed and graded silica sand, or crushed, washed, and graded slag, free of all contaminants, and conforming within a 40 to 70 mesh gradation range. The addition of sand shall target three pounds to four pounds per gallon.

C. Sand shall be slowly added into the emulsion with the mixer engaged during the addition of the sand to ensure uniform dispersion and to prevent overloading of the mixing device. No additional water shall be added.

D. Slow mixing shall be continuous from the time all materials are placed into the mixer until the pavement sealer mix is applied to the pavement by the application equipment. During the entire mixing process, no breaking, segregating, or hardening of the emulsion, and no balling or lumping of the aggregate shall be permitted.

E. Shall submit a certified analysis of the proposed asphalt bulk emulsion, non- volatiles content, and ash content.

2.04 ASPHALT EMULSION FOR TACK COAT

A. Asphalt emulsion materials shall be homogeneous and shall show no separation after mixing within 30 days after deliveries. They shall conform to the requirements of AASHTO M 140. Anionic emulsion used for tack coat shall be grade RS-1h.

2.05 HOT POURED JOINT SEALER

A. The joint sealer shall meet the requirements under ASTN D6690 Type II. Products shall be evaluated by the National Transportation Product Evaluation Program (NTPEP) as an HMA | bituminous concrete Crack Sealer (CS) and be listed on the MassDOT Qualified Construction Materials List (QCML).

PART 3 EXECUTION

3.01 GENERAL

A. Subbase under paving shall be compacted as described in Section 31 00 00 "EARTH MOVING" Add material meeting the requirements of ordinary borrow to bring the subgrade to the required grade before placing base course.

B. Furnish, set, and maintain all line and grade stakes necessary to guide the automated grade control equipment. Where required these control stakes shall be maintained and used throughout the operations, from the grading of the subbase material up to and including the final layers of the pavement.

C. The gravel base course shall be spread in layers upon the prepared subgrade conforming to the required line and grade. Gravel shall be placed in compacted layers not more than four inches thick compacted to not less than 95 percent of the maximum dry density of the material. Any stone greater than three inches in size shall be removed. Compaction shall continue until the surface is even and true to line and grade.

D. Gravel base course shall be placed on backfilled and compacted trenches to proper grade before placement of pavement.

E. The edges of existing pavement that is to remain shall be sawcut to an even, straight edge using a power-driver rotary saw; use of a jackhammer is unacceptable. This includes road, parking lot, sidewalk, and utility trench edges.

1. The pavement shall be sawcut through its full depth at all joints between existing and proposed pavements, and at all utility trenches, to provide a uniform, smooth vertical surface.
2. Sawcut edges which become broken, ragged or undermined as a result of the operations shall be re-cut prior to the placement of abutting proposed pavement at no additional cost to the Owner.
3. Sawcut surfaces in asphalt | bituminous concrete pavements shall be sprayed or painted with a uniform, thin coat of asphalt emulsion tack coat immediately before placement of hot mix asphalt | bituminous concrete against the cut surface.

F. Asphalt | bituminous concrete courses shall be spread and compacted to the finished thicknesses as shown on the Contract Drawings. A smooth even surface shall be produced.

G. Any joints at junctions of old and new pavements shall be sealed with hot poured joint sealer and covered with sand.

3.02 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.03 QUALITY CONTROL OF HMA | BITUMINOUS CONCRETE PAVEMENT

A. General. Quality Control (QC) shall be in conformance with MassDOT Standard Specifications Section 450.60 through 450.68 and required as indicated. The General Contractor assumes responsibility of the quality for all materials and construction incorporated into the work and shall control all the processes leading to the final result through this function. The QC system addresses all elements which affect the quality of the pavement including, but not limited to:

1. Mix Design
2. Aggregate Grading
3. Quality of Materials
4. Stockpile Management
5. Proportioning

6. Mixing and Transportation
7. Placing and Finishing
8. Joints
9. Compaction
10. Surface smoothness and uniformity
11. Thickness and grade

B. Independent Testing Agency. The General Contractor shall cooperate with the Independent Testing Agency engaged by Owner for field quality control activities for the Work of this Section. Refer also to Section 01 40 00 – "QUALITY REQUIREMENTS".

C. The General Contractor shall be prepared to discuss and present, at the pre-paving conference, their understanding of quality control for this contract.

D. Field Quality Control.

1. HMA | bituminous concrete material placed in the field shall be tested for both joint and mat density on a completed street or public facility basis. The Independent Testing Agency may conduct any necessary testing to monitor that the specified density, uniformity and smoothness is being achieved. A properly correlated nuclear gauge may be used to monitor the pavement density in accordance with ASTM D2950.
    a. Sampling: Samples shall be neatly cut with a core drill. The cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be four inches. The minimum diameter of the base samples shall be six inches. Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. Cores shall be taken within 48 hours of placement of the HMA | bituminous concrete.
    b. The General Contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored pavement. Pavement cores shall be taken upon project pavement completion to determine the average percent density. Cores shall be taken randomly by the Independent Testing Agency based on five cores for mat density and three cores for longitudinal joint density per 1000 tons of material placed. A minimum of five core samples for mat and three core samples for joint density shall be removed from each course and construction phase or 40,000 square feet of paving. The average density of the core samples shall be used to determine the density of the pavement course. The removal and patching of cores shall be paid for by the Owner. Cored holes shall be filled in a manner acceptable to the Owner's Representative and/or Designer and within one day after sampling. Resampling of pavement shall be in accordance with applicable provisions of the Northeast Transportation Training and Certificate Program (NETTCP) Quality Assurance Technologist Manual, latest edition.
    c. Testing: The bulk specific gravity of each cored sample will be measured by the Independent Testing Agency in accordance with AASHTO T 166 or AASHTO T 275, whichever is applicable. The theoretical maximum specific gravity shall be the average maximum specific gravity for the project pavement in accordance with the plant-produced material section. The theoretical value used for the percent density of the core samples shall be the average of the measurements for maximum specific gravity for the project pavement course. The percent density of each sample will be determined in accordance with AASHTO T 269, using the bulk specific gravity of each sample and the average theoretical maximum specific gravity. Retesting of pavement shall be in accordance with applicable provisions of the NETTCP Quality Assurance Technologist Manual, latest edition.

d. Mat Density: Core locations will be determined by the Independent Testing Agency on a random basis in accordance with procedures contained in ASTM D3665. Cores shall not be taken closer than one foot from a longitudinal joint and 10 feet from a transverse joint.
e. In place density shall be measured during paving operations by a density gauge. Testing shall be performed randomly throughout the paving operation.
f. Joint Density: Three six-inch diameter cores of finished longitudinal joint, will be taken by the Independent Testing Agency from each course and construction phase. Core locations will be determined by the Independent Testing Agency on a random basis over the joint, not adjacent to the joint.

2. Surface Smoothness.
   a. The finished surfaces of the pavement shall be uniform in appearance, free from irregularities in contour and texture and shall present a smooth-riding surface. Smoothness evaluation applies to all hot mix asphalt | bituminous concrete roadways and walkways receiving 1.5 inches or more in plan (compacted) thickness of HMA | bituminous concrete pavement.
   b. Carefully apply the straight edge immediately after the first compaction by rolling, and from then on as may be necessary until and after the final compaction of the material in place. Hold the straightedge in successive positions parallel to the road centerline and in contact with the road surface; check the entire area from one side of the pavement to the other.
      1) Tests for conformity with the specified crown and grade shall be made immediately after initial compaction. Any variation shall be corrected by the removal or addition of materials and by continuous rolling.
      2) The finished surface of the pavement, when measured with a 10-foot straightedge, shall not vary more than 1/4 inch for the surface course and 3/8 inch for the intermediate course measured perpendicular and parallel to the centerline.
      3) After the completion of final rolling, the smoothness of the course shall again be tested.
   c. Humps or depressions exceeding the specified tolerances shall be immediately corrected by removing the defective work and replacing with new material. This shall be done at the General Contractor's expense.
   d. Skin patching will not be permitted.
   e. When profile corrections are required, use one or more of the following corrective methods:
      1) Removing and replacing the entire pavement thickness.
      2) Diamond grinding or micro milling.
      3) Overlaying (not patching) with the specified surface course.
      4) Removing the surface by milling and applying a lift(s) of the specified course(s).
      5) Use of other methods that will provide the desired results.
   f. The corrective method(s) chosen by the General Contractor shall be performed at the Installation Contractor’s expense, including all necessary equipment and traffic control.
      1) Areas of removal and replacement shall be removed the full width of the lane or paver pass. The removal areas shall begin and end with a transverse butt joint which shall be constructed with a transverse sawcut perpendicular to the centerline or paver pass.
      2) Replacement materials shall be placed in sufficient quantity, so the finished surface will conform to grade and smoothness requirements. The corrective area shall conform to all material and density specification requirements.
      3) When the corrective work consists of an overlay, the overlay shall cover the full width of the pavement including shoulders or the paver passes sufficient to correct

the defective work. The area overlaid shall begin and end with a transverse butt joint which shall be constructed with a transverse sawcut and asphalt | bituminous concrete removal.

4) All materials shall meet contract requirements. The overlay shall be placed so the finished surface will conform to grade and smoothness requirements. The overlaid area shall be compacted to the specified density.

g. The Owner's Representative and/or Designer can have the Independent Testing Agency retest any sections where corrections were made to verify that the corrections produced a surface that conforms to the grade and smoothness requirements.

3. Uniformity.
   a. The HMA | bituminous concrete mat shall be smooth, dense, and uniform. Uniformity is generally affected by Thermal and/or Aggregate segregation.
   b. If segregation is evident and discernable by either the General Contractor or the Owner's Representative/Designer, the Installation Contractor shall immediately cease production and take steps to correct and eliminate the cause(s) of the segregation.
   c. The Installation Contractor shall review all potential causes of segregation as it relates to its operation, including but not limited to HMA | bituminous concrete Plant issues, loading and transportation issues, placement issues, thermal segregation, and hand work. Employ additional investigation methods and make the necessary changes in their operation such that segregation is eliminated, and mat uniformity is acceptable.
4. Thickness.
   a. The thickness requirements contained herein shall apply only when each pavement layer is specified to be a uniform compacted thickness of one inch or greater. Thickness shall be evaluated for acceptance by the Owner's Representative and/or Designer to the requirements shown on the plans. Measurements of thickness may be checked periodically by the General Contractor in following their QC system for field operations. Measurements of thickness for acceptance shall be made by the Independent Testing Agency using four-inch minimum diameter pavement cores removed also for subsequent density measurement.
   b. The finished surfaces of each HMA | bituminous concrete pavement course shall not vary from that specified or cross sections shown on the contract drawings by more than 1/4 inch. The General Contractor shall correct pavement areas varying more than this amount by removing and replacing the defective work or as ordered by the Owner's Representative and/or Designer. Skin patching will not be permitted.
5. Grade.
   a. The finished surface of the pavement shall not vary from the gradeline elevations as shown on the plans by more than 1/2 inch. Remove deficient areas and replace with new material. Sufficient material shall be removed to allow at least 1 1/2 inches of hot mix asphalt | bituminous concrete to be placed. Skin patching for correcting low areas shall not be permitted. High points may be ground off.
6. Rejection of Inferior HMA | bituminous concrete.
   a. The Owner's Representative and/or Designer may at any time, notwithstanding previous acceptance, reject and require the General Contractor to dispose of any batch of hot mix asphalt | bituminous concrete which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. Similarly, the Owner's Representative and/or Designer may at any time, notwithstanding field acceptance for mat density, reject and require the Installation Contractor to correct any HMA | bituminous concrete pavement that was

placed with unacceptable mat uniformity or paving joints due to low density, segregation, improper elevation, or tearing. In the event of such rejection, the General Contractor and the Owner's Representative and/or Designer may take random split samples of the area(s) in question, and if it can demonstrate in the laboratory, in the presence of the Owner's Representative and/or Designer, that such material/pavement was erroneously rejected, payment will be made for the material at the contract unit price.

3.04 PATCHING

A. Areas of existing HMA | bituminous concrete pavement courses that are significantly distressed or unsound shall be removed and replaced with patches using new HMA | bituminous concrete. The location and limits of patching shall be as identified in the plans.

B. Each existing pavement course determined to be unsound shall be removed to the full depth of the pavement course within a rectangular area. For each patch location equal to or greater than 50 square feet (and having a minimum dimension of four feet) where the existing pavement courses are removed down to subbase, the subbase shall be compacted by mechanical means to not less than 95 percent of the maximum dry density of the subbase material as determined by AASHTO T 99 Method Cat optimum moisture content. Each edge of the patch area shall be sawcut or otherwise neatly cut by mechanical means to provide a clean and sound vertical face. The vertical face of each edge shall be thoroughly coated with a hot poured joint sealer immediately prior to placing the HMA | bituminous concrete patching mixture.

C. Delaminated areas of existing pavement courses resulting from pavement milling shall be cut back neatly by mechanical means to the limits of any unsound material. After removing all unsound material, the underlying pavement surface within the patch limits shall receive a thorough tack coat at a rate of application in accordance Section 3.7 prior to placing the HMA | bituminous concrete patching mixture.

D. HMA | bituminous concrete patching mixture shall be the same mixture type as the existing pavement course being patched or as specified on the plans. The lift thickness of the patching mixture shall not exceed four times the nominal maximum aggregate size of the mixture. The patching mixture shall be placed by hand or by mechanical means and shall match the thickness, grade, and cross-slope of the surrounding pavement. The HMA | bituminous concrete patching mixture shall be compacted using a steel wheel roller. For patch areas not large enough to permit use of a roller, compaction shall be accomplished using a mechanical tamper capable of achieving the required in-place density. The in- place density of the HMA | bituminous concrete patching mixture shall be not less than 90 percent of the maximum theoretical density of the mixture as determined by AASHTO T 209 (Method A). When the General Contractor and Owner's Representative and/or Designer elect to test the in-place density of a patched area using a calibrated density gauge, the test data for the patched area shall be recorded on NETTCP TRFs.

3.05 SURFACE PREPARATION

A. General: Immediately before placing asphalt | bituminous concrete materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving. The General Contractor shall ensure that it is in conformance with the required grade, cross-section, and in- place density. The compacted subbase shall not be frozen or have standing water.

B. Proof roll prepared base material surface, if applicable, to identify areas requiring removal and re-compaction, and to provide a uniform degree of compaction over the entire pavement area.

C. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

D. Do not begin paving work until deficient base material areas and utility trenches have been corrected and are ready to receive paving. Paving shall not be applied until the Designer inspects and accepts the finished base.

E. When an existing surface or new base upon which the bottom course is to be placed contains unsatisfactory irregularities, in the Designer's judgment, such irregularities may be eliminated by an adequate placing and compaction of HMA | bituminous concrete mixture to furnish a surface with true contour and grade before placing any specified course of mixture.

F. When indicated on the plans, existing HMA | bituminous concrete pavement courses shall be milled and removed from the project in accordance with Section 415 of the MassDOT Standard Specifications for Pavement Milling. Adjustments to milling depth shall be accepted by the Designer and shall be used for consideration of the HMA | bituminous concrete pavement thickness measurements. Each vertical face of the milled pavement that meets new/existing pavement shall be thorough coats with a hot poured joint sealer.

G. Check all frames, covers, grates, water valve boxes and other miscellaneous castings that are located in the proposed pavement areas to ensure that all have been correctly positioned and set to the proper slope and elevation. All covers and grates shall be set flush with the required finished surface. All adjustments shall be made prior to placement of the surface course. No depressions or mounds shall be permitted in the pavement to accommodate inaccuracies in the setting of castings. Hand placement of HMA | bituminous concrete along curbs, edging, or utilities after placement and compaction of the surface course shall not be permitted.

H. Leveling Course. Any HMA | bituminous concrete used for truing and leveling shall meet the requirements of the mix design methods and the requirements of MassDOT Standard Section 450.10 for the applicable mixtures. Leveling courses shall not be subject to density requirements. The thickness of the Leveling Course shall be measured off the interface with the existing milled or un-milled pavement surface. The leveling course shall be compacted with the same effort used to achieve placement and density of the test section. The truing and leveling course shall not exceed a nominal thickness of 1.5 inches.

I. Immediately before placing the hot mix asphalt | bituminous concrete, the underlying course shall be thoroughly cleaned of all dust and debris by a self-propelled sweeper. Areas inaccessible by power sweepers shall be broom swept until the pavement surface is clean. Extra care shall be required during fall leaf fall.

J. Tack Coat. Apply uniformly to surfaces to be paved.

1. Contact surfaces of manholes, structures, and vertical pavement edges shall be painted with a thin, uniform tack coat just before the material is placed against them.
2. Tack coat is required on all surfaces to be paved; this includes leveling, base, or intermediate layers of HMA | bituminous concrete. Particular attention should be made during the application that the longitudinal joint areas be treated with no bare spots. Missing areas on the longitudinal joint area shall require either re-application or localized hand work application. The existing surface shall be swept clean of all foreign matter and loose material using a mechanical sweeper and shall be dry before the tack coat is applied.
3. Tack Coat shall be applied by a pressure distributor. All nozzles on the distributor shall be open and functioning. All nozzles shall be turned at the same angle to the spray bar. The nozzles shall be offset at an angle from the spray bar to prevent the fan from one nozzle from interfering with the fan from another. Proper nozzle angle shall be as determined by the Manufacturer of the distributor spray bar. The spray bar shall be adjusted so that it is at the proper height above the pavement surface to provide a triple overlap spray for a

uniform coverage of the pavement surface. A triple lap application requires that the nozzle spray patterns overlap one another such that every portion of the pavement receives spray from exactly three nozzles.

4. The tack distributor system shall be equipped with the following to control and monitor the application:
   a. System for heating the asphalt emulsion uniformly to specified temperature.
   b. Thermometer for measuring the asphalt emulsion temperature.
   c. Adjustable full circulation spray bar.
   d. Positive controls including tachometer, pressure gauge, and volume measuring device.
5. Tack coat application rates for specific surface conditions shall be in accordance with the following:
   a. On a new HMA | bituminous concrete surface, not opened to traffic, the emulsion application rate shall equal 0.06 to 0.08 gallons per square yard.
   b. On an existing tight smooth pavement, the emulsion application rate shall equal 0.06 to 0.08 gallons per square yard.
   c. On a milled surface the emulsion application rate shall equal 0.07 to 0.09 gallons per square yard.
   d. On cement concrete base course, the emulsion application rate shall be equal to spray application for adjacent surface.
   e. On new HMA | bituminous concrete patches the emulsion application rate shall equal 0.06 to 0.09 gallons per square yard. Allow tack coat to cure undisturbed before applying hot-mix asphalt | bituminous concrete paving.
6. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
7. Tack Coat shall be applied to cover a minimum of 95 percent of the pavement surface.

3.06 HOT-MIX ASPHALT | BITUMINOUS CONCRETE TRANSPORTING, PLACING AND FINISHING

A. The trucks used to transport HMA | bituminous concrete to the field placement site shall have tight, clean, smooth metal beds. When necessary to maintain the required HMA | bituminous concrete temperature, trucks shall be equipped with insulated beds. The truck beds shall be evenly and lightly coated with an approved release agent meeting the requirements of MassDOT Standard Specification Section M3.01.6. Truck beds shall be free of kerosene, gasoline, fuel oil, solvent, or any other materials negatively impacting the HMA | bituminous concrete. The HMA | bituminous concrete shall be protected from foreign debris during transport.

B. Machine place hot-mix asphalt | bituminous concrete on prepared surface, spread uniformly, and strike off. Place asphalt | bituminous concrete mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

C. HMA | bituminous concrete deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver.

D. Upon arrival, the mixture shall be placed to the full width by a hot mix asphalt | bituminous concrete paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the hot mix asphalt | bituminous concrete mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of 10 feet except where edge lanes require less width to complete the area. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least six inches.

However, the joint in the top layer shall be at the centerline of the pavement. Transverse joints in one layer shall be offset by at least two feet from transverse joints in the previous layer. The placement of the material along the longitudinal joint may be performed by setting the screed to overlap the first mat. The elevation of the screed above the surface of the first mat should be equal to the amount of roll- down expected during compaction of the new mat. The overlapped material shall be bumped by the lutes, if necessary, to optimize the density along the longitudinal joint. Under no circumstances should the overlapped material be broadcast across the mat. Excess material should be removed by hand. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet.

E. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt | bituminous concrete to prevent segregation of mix; use suitable hand tools to smooth surface.
F. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.
G. When hand spreading is permitted, the mixture shall be distributed into place by means of hot shovels and spread with lutes in a loose layer of uniform density and correct depth. The use of rakes to spread the hot mix asphalt | bituminous concrete shall not be permitted. Loads shall not be dumped any faster than they can be properly handled by the shovelers and the shovelers shall not distribute the dumped load any faster than it can properly be handled by the luters. The luting shall be carefully and skillfully done to avoid segregation and so that, after the first passage of the roller over the luted mixture, no back patching shall be necessary. Compaction shall immediately follow hand spreading such that specification density is achieved while the mixture temperature is above the manufacturers recommended compaction temperature for the performance graded binder.
H. The mixtures shall be placed and compacted only at such times as to permit the proper inspection and checking by the Owner’s Independent Testing Agency.
I. The mixtures shall only be placed in the work when they can be efficiently and satisfactorily placed, compacted, smoothed, and made uniform in accordance with these specifications. Unless otherwise permitted by the Owner’s Representative and/or Designer for special particular conditions, only machine methods of placing shall be used.
J. No mixture shall be placed unless the breakdown, and intermediate rolling can be completed by the time the material has cooled to 195 degrees Fahrenheit, or that minimum compaction temperature specified by the binder manufacturer and provided that the density and uniformity of the completed pavement attains specification compliance.
K. No traffic of any kind shall be permitted on the HMA | bituminous concrete intermediate or HMA | bituminous concrete base when dirt or any other foreign substance may be tracked thereon.
L. Immediately after any course is screeded and before roller compaction is started, the surface shall be checked, any irregularities adjusted, any accumulation from the screed removed by rake or lute, and all fat spots in any course removed and replaced with satisfactory materials. Irregularities in alignment and grade along outside edges shall be corrected by the addition or removal of mixture before the edges are rolled. Indiscriminate casting of mix on the new screeded surface, where irregularities are not evident, shall not be permitted.
M. All hot mix shall be placed and compacted in such a manner as to ensure a continuous bond between the tacked hot mix pavement surfaces and obtain the required density.
N. No vehicular traffic or loads shall be permitted on newly completed HMA | bituminous concrete until adequate stability has be attained and the material has cooled to a temperature of 140 degrees Fahrenheit or less.

3.07 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections and to obtain the required density. Construct joints free of depressions, with same texture, smoothness and grade as other sections of hot-mix asphalt | bituminous concrete course. When abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure.

1. Clean contact surfaces and apply hot poured joint sealer to joints.
2. Longitudinal Joints.
    a. All longitudinal joints shall be constructed with the first paver pass in a neat straight line. Deviation from trueness shall negate the ability to form a properly compacted longitudinal joint.
    b. The paver screed may be equipped with a Longitudinal Notched - Wedge Joint or Straight Wedge Joint paver attachment and screed mounted roller attachment when placing HMA | bituminous concrete pavement courses. Use the Notched Wedge Joint for thicknesses of
    c. 1.5 inches or greater and use the Straight Wedge Joint for thicknesses less than 1.5 inches. The notched wedge joint shall include a variable notched vertical edge (the notch vertical height to be equal to the mixture's maximum aggregate size). The sloped surface of the diagonal wedge joint shall not exceed a 6:1 slope. Prior to placing the adjacent paver pass, all joint contact surfaces shall be given a coat of hot poured joint sealer prior to placing any fresh mixture against the joint. Hot applied joint filler shall not be applied when a wedge joint is used. A tack coat shall be applied to the entire surface of the wedge joint.
    d. Vertical butt joints which are not constructed straight, are not constructed with an edge restraining device (either a commercial paver screed attachment or by dropping the end gate down to the surface) or are damaged (or otherwise defective) shall be cut back three inches to expose a clean, sound surface for the full depth of the
    e. course and all contact surfaces shall be given a coat of hot poured joint sealant prior to placing any fresh mixture against the joint.
    f. Offset longitudinal joints, in successive courses, a minimum of 12 inches.
    g. All longitudinal joint edges on surface courses shall be treated with hot applied joint filler, regardless of location.
    h. When longitudinal joints abut edges such as curbs, gutters, and manholes, a tack coat surface shall be applied over the entire joint.
3. Transverse Joints.
    a. The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course, in which case the edge shall be cut back to its full depth and width on a straight line to expose a vertical face. In both methods, all contact surfaces shall be given a coat of hot poured joint sealer before placing any fresh mixture against the joint.
    b. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Longitudinal and transverse joints shall have an in-place density when measured by the average of three six-inch cores of between 90 percent to 98 percent of maximum theoretical.
5. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

6. At the start/end of new HMA | bituminous concrete meeting existing HMA | bituminous concrete, the existing pavement shall be sawcut. Sawcut faces shall be coated with hot applied joint sealer prior to HMA | bituminous concrete placement.
7. If traffic is to be carried over any traverse joints before HMA | bituminous concrete completion, a temporary pavement joint of a maximum 12:1 slope shall be constructed. Reheating of the joint shall not be permitted.

3.08 COMPACTION

A. The mixture shall be thoroughly and uniformly compacted by rolling. Equipment may include steel wheeled rollers, vibratory rollers, oscillation rollers, or pneumatic-tired rollers. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Installation Contractor so that the required compaction and surface texture are consistently attained while the mixture is in a workable condition. When possible, the Installation Contractor is encouraged to use pneumatic or oscillation rollers. Rolling shall be initiated with the drive roll or wheel towards the paving machine. When rolling on steep grades, the previous procedure may need to be altered. The General Contractor shall provide the proper number of rollers to achieve the target in-place density and course thickness.

B. The speed of the roller shall, at all times, be sufficiently slow and of uniform speed to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring because of reversing the direction of the roller, or from any other cause, shall be corrected at once. Rollers shall not be permitted to stop on the mat except to reverse direction or refill water.

C. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. The number of rollers and passes required shall be governed by the compaction results; however, at least two rollers shall be provided for each paver employed on the paving operation. Each roller shall be operated by a competent, experienced roller operator and shall be kept in as nearly continuous operation as practicable while work is underway. A plate shall be attached to each roller showing the ballasted and unballasted weight per length-width of tread.

D. To prevent adhesion of the mixture to the steel roller, the drums or shall be kept properly moistened, cocoa mats kept clean and scrapers used, but excessive water shall not be permitted. Pneumatic rollers shall be operated on adjacent pavement surfaces to get the tires warm to hot from friction, then moved to the fresh mat.

E. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers and vibratory plate compactors.

F. Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Installation Contractor’s expense. Skin patching shall not be allowed.

G. Along any adjoining edge such as curb, gutter, or an adjoining pavement, and after the HMA | bituminous concrete is placed by the paver, just enough of the hot HMA | bituminous concrete shall be placed by hand method to fill any space left open. These joints shall be properly ‘set up’ with the back of a lute at the proper height and level to receive the maximum compaction. Any areas where the rollers cannot access shall be hand tamped or plate compacted.

H. Breakdown Rolling. Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

I. Intermediate Rolling. Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt | bituminous concrete is still hot enough to achieve specified density. Continue

rolling until hot-mix asphalt | bituminous concrete course has been uniformly compacted to the required field density.

J. Finish Rolling. Finish roll paved surfaces to remove roller marks while hot-mix asphalt | bituminous concrete is still warm.

K. Edge Shaping. While the surface is being compacted and finished, the Installation Contractor shall carefully trim the outside edges of the pavement to the proper alignment. Edges so formed shall be beveled while still hot with the back of a lute or smoothing iron and thoroughly compacted by tampers or by other satisfactory methods.

L. Protection. After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

M. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.09 HOT MIX ASPHALT | BITUMINOUS CONCRETE SURFACES

A. Hot mix asphalt | bituminous concrete shall meet the relevant requirements of hot mix asphalt | bituminous concrete Superpave materials in this specification.

B. The hot mix asphalt | bituminous concrete surface shall be laid in two courses to a depth after rolling as indicated in the Contract Drawings. Each course shall be one-half the total depth of pavement. The bottom course surface after rolling shall be parallel to the proposed grade of the finished surfaces. The top course surface after rolling shall be at the finished grade as indicated on the Contract Drawings.

1. The hot mix asphalt | bituminous concrete shall be placed to the full width and shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grades and surface contour required.
2. The hot mix asphalt | bituminous concrete may be spread and luted by hand tools. When hand spreading is permitted, the mixture shall be distributed into place from wheelbarrows by means of hot shovels and spread with lutes in a loose layer of uniform density and correct depth. The use of rakes to spread the hot mix asphalt | bituminous concrete shall not be permitted. Loads shall not be dumped any faster than they can be properly handled by the shovelers and the shovelers shall not distribute the dumped load any faster than it can properly be handled by the luters. The luting shall be carefully and skillfully done to avoid segregation and so that, after the first passage of the roller over the luted mixture, no back patching shall be necessary. Compaction shall immediately follow hand spreading such that specification density is achieved while the mixture temperature is above the manufacturers recommended compaction temperature for the performance graded binder.
3. Rolling. The surface shall be rolled with a self-propelled tandem roller weighing not less than 1-1/2 tons and not more than five tons. In places not accessible to a power roller, compaction shall be obtained by means of mechanical rammers or by hand tampers weighing not less than 50 pounds and having a tamping face not exceeding 100 square inches.

C. The dimensions, cross slope, grades and tolerances of the surface shall be in conformance with the standard construction details.

D. The cross slope of the finished surface shall not exceed 1.5 percent.

3.10 SEALCOATING

A. Installation Contractor shall provide all tools and equipment necessary to perform the work, including but not limited to brushes, hand squeegees, pumps and hose equipment, storage tanks, mixing tanks, water distributors, power sweepers, blowers, barricades, and applicator equipment.

1. Spray equipment used on the job shall have full sweep mechanical agitators incorporated in their construction to assure homogeneous mixing of the asphalt emulsion sealer, sand,

and water (if required). The pumping system shall be adequate to apply a uniform coating at the specified rates of application. Equipment requiring pressurization of the mixing tank for distribution shall not be used.

2. Motorized squeegee application equipment used on the job shall have two or more devices such as squeegees and/or drag broom assemblies to assure even distribution of the asphalt emulsion sealer. A full sweep mechanical agitator shall be incorporated into the construction of the applicator to assure homogeneous mixing of the emulsion.
3. Mixing or agitating equipment may be either portable powered or a tank-type power mixer. In any case, mixers shall be of sufficient capacity to assure homogeneous mixing of the emulsion and to maintain complete suspension of mineral aggregate until the emulsion is applied to the pavement. All storage tanks shall be equipped with mechanical agitators sufficient to keep the asphalt emulsion homogeneous during storage.

B. The Installation Contractor shall coordinate their activities with each other to ensure the availability of the work area to avoid delaying the execution of the project, to maintain traffic flow, and to minimize activities that might be detrimental to the work in progress, other customer or construction traffic.

C. Surface to receive sealcoat shall be free of all foreign material and dry immediately prior to application of sealer.

D. Remove oil and grease spots that have not permanently damaged or softened the pavement by scrubbing with a detergent and flushing with water until a water-break-free surface is obtained. Oil and grease spots with deeper penetration shall be treated by burning with handheld propane torch and then coating the spot with an approved oil spot primer compatible with the sealer. If the oil spot is so severe as to cause permanent deterioration of the pavement, or if the pavement has failed due to other causes, the pavement shall be removed to the full depth of the damage and replaced with new asphalt | bituminous concrete pavement.

E. Existing pavement markings shall be blackened with black epoxy or black acrylic coatings. Excessive buildup of old lines should be abraded before any prime coats of emulsion are applied.

F. Cracks in excess of 1/4 inches, but less than one inch in width shall be crack filled prior to application.

G. Pavement shall be cleaned by air blowing, vacuum, or mechanical sweeper.

H. Asphalt sealcoat shall not be placed on new asphalt | bituminous concrete until a 30-day cure time has occurred.

I. Application of asphalt sealcoat shall be by mechanical means using rubber faced squeegees, brooms, distributor bar/wand in combination. Two coat application.

1. The coating shall be applied uniformly over the entire pavement surface and free of voids and pinholes. Subsequent coats shall be applied only after the previous coat is dried, preferably after 24 hours of cure time, but after no less than four hours under ideal conditions. Ideal conditions are temperatures in excess of 70 degrees Fahrenheit, sunshine, and less than 60-percent relative humidity. Marginal conditions can require curing times greater than 24 hours. Subsequent coats shall be applied at right angles to the previous coat, if possible.
2. First coat mechanical squeegee self−propelled is recommended, but wand application is allowed. Second coat by spray wand to lock down exposed aggregate and to return the parking lot to a proper aesthetic appearance free of streaks and marks.
3. Application rate for each coat shall be 13 to 17 gallons per 1,000 square feet as recommended by the Asphalt Sealcoat Manufacturers Association. Alternative application rates maybe allowed if accepted by the Owner’s Representative.

4. Sealer shall not be applied unless the temperature is a minimum 50 degrees Fahrenheit and rising and pavement temperature is 60 degrees Fahrenheit and rising. Work shall be completed so that there is a minimum of three hours of sunlight remaining after completing the day's work. Sealer shall not be applied under rainy or wet conditions such as an overcast sky with high humidity. UNDER NO CIRCUMSTANCES shall work, be performed under cold and/or wet conditions, nor shall emulsion be used that has been subjected to freezing weather.
5. In hot weather application 80 degrees Fahrenheit or higher (pavement temperatures are in excess of 120 degrees Fahrenheit) fog spraying of pavement with potable water shall be used to achieve better bond and even spreading of material. Properly applied fog spray shall dampen pavement without leaving puddles. Seal coat application shall not commence until it is determined there is no standing water to prevent even application and drying of the asphalt sealer.
6. Striping for parking and traffic flow should be done only after the sealcoat has dried completely to accept specified traffic paint.

J. PAVEMENT CLEANING AND PROTECTION
1. The pavement surface and all work areas shall be left in a clean condition.
2. Vehicular traffic shall not be permitted on the pavement that has been sealed during the dry period. The General Contractor shall supply all temporary traffic control devices (barricades, cones, signing) to protect the sealant. Any damage to uncured sealant shall be repaired at the General Contractor’s expense.

3.11 INSTALLATION TOLERANCES

A. Accessibility: Comply with requirements of Massachusetts Architectural Access Board and ADAAG requirements. Remove and replace paving that does not meet required tolerances when measured with a two-foot straight edge.

B. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
1. Base Course: Plus or minus 3/8 inch.
2. Surface Course: Plus 1/4 inch, no minus.

C. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within MassDOT Standard Specification tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas.

3.12 PEDESTRIAN TRAFFIC OPENING

A. No pedestrian traffic or loads shall be permitted on the newly completed pavement until all of the following conditions are met:
1. Adequate stability has been attained.
2. The material has cooled sufficiently to prevent distortion or loss of fines.
3. The pavement has cooled sufficiently to an internal temperature of 140 degrees Fahrenheit or less.

B. If the climatic or other conditions warrant, or if the PGAB manufacturer recommends, the period of time before opening to traffic may be extended at the discretion of the Owner’s Representative and/or Designer.

3.13 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from the Project site, and legally dispose of them in an EPA-approved landfill.

END OF SECTION

SECTION 32 12 16.36
ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT PAVING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes:
   1. Sport Court Paving.

B. Hot-mix asphalt (HMA) | bituminous concrete sport court paving.
   1. Hot-mix asphalt | bituminous concrete shall be composed of mineral aggregate and asphalt | bituminous concrete binder, mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and conformance to the lines, grades, thickness and typical cross sections shown on the plans.
   2. Each course shall be constructed to the depth, typical section, or elevation required by the contract and/or plans and shall be rolled, finished, and accepted before the placement of the next course. Each course shall be placed to a smooth, dense, and uniform appearance.
      a. Sawcutting existing pavements.
      b. Asphalt Emulsion for Tack Coat.

C. Acceptance: The acceptance of plant produced material for gradation, asphalt content, and air voids shall be determined by the Designer in accordance with the requirements of the section on acceptance criteria, herein specified.

D. Related Work: The following items are not included in this Section and shall be performed under the designated Sections:
   1. Section 02 41 00 "DEMOLITION" for demolition and removal of existing asphalt | bituminous concrete pavement.
   2. Section 04 43 00 “STONE MASONRY” for granite curbing.
   3. Section Section 31 00 00 "EARTH MOVING" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
   4. Section 32 12 16.13 “ASPHALT | BITUMINOUS CONCRETE PAVING (PEDESTRIAN)” for adjacent asphalt | bituminous concrete paving construction.
   5. Section 32 13 13.13 "CONCRETE PAVING (SITE)" for installation of cement concrete paving for plazas and walkways.
   6. Section 32 18 10 “COURT SURFACING” for multiuse sport court sealcoat surfacing.
   7. Section 32 18 23.43 “RECREATIONAL PAVEMENT MARKINGS” for play line stripe.

1.03 ACTION SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
   1. Proof of a State or local municipality Department of Transportation’s pre-approved Job Mix Formula (JMF).
   2. Tack Coat.

C. Material Certificates: For each paving material, from manufacturer.
   1. Submit certified test reports signed by the material producer certifying that materials comply with, or exceed, the specification requirements.

D. LEED
1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
   a. Include statement indicating costs for each product having recycled content.
2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
3. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paver is 29 or greater.
4. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.04 REFERENCES

A. The following Standards shall apply to the Work of this Section:
1. Commonwealth of Massachusetts Department of Transportation (MassDOT) Highway Division Specifications: Standard Specifications for Highways and Bridges; latest edition.
2. AASHTO: American Association of State Highway and Transportation Officials:
   Standard Size of Coarse Aggregate for Highway Construction: M43.
   Emulsified Asphalt: M140.
   Cationic Emulsified Asphalt: M208.
3. ANSI | ASTM: American Society for Testing and Materials:
   Specification of Concrete Aggregates: C33.
   Test method for Softening Point of Bitumen (Ring and Bell Apparatus): D36.
   Test method for Ductility of Bituminous Materials: D113.
   Penetration-Graded Asphalt Cement for Use in Pavement Construction: D946
   Test Method for laboratory Compaction Characteristics of Soil using Modified Effort [56,000 ft-lbf/ft3 (2,700 kN-m/m3)]: D1557.
   Specification for Viscosity-Graded Asphalt Cement for use in Pavement Construction: D3381.
4. ACI: American Concrete Institute.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by MassDOT, Highway Division.

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of MassDOT, Highway Division for hot mix asphalt | bituminous concrete paving work.
1. Comply with requirements of MassDOT, Highway Division, Standard Specifications for Highways and Bridges, including supplemental specifications and special provisions.
2. Comply with requirements of the Americans with Disabilities Act (ADA) and the Massachusetts Architectural Access Board (MAAB). If these requirements cannot be met with the grades and slopes indicated on the plans, notify the Designer immediately.
3. Comply with the requirements of the local authority having jurisdiction concerning the location and construction of accessible curb cuts.
4. Coordination. The General Contractor shall coordinate and schedule the Work under this specification with all other work, including underground utility improvement construction, to avoid covering up incomplete, unfinished, and/or uninspected work. Any repaving required

due to uncoordinated and/or improper scheduling shall be done by the General Contractor at no cost to Owner.

1.06 PROJECT CONDITIONS

A. Weather Limitations.

1. HMA | bituminous concrete shall only be placed on dry, unfrozen surfaces. The underlaying surface shall be accepted by the Owner's Representative and/or Designer prior to placement of any HMA | bituminous concrete. Underlaying surfaces shall be cleaned of any foreign materials.
2. The HMA | bituminous concrete shall not be placed when weather conditions of fog or rain prevail or when the pavement surface or base shows signs of free moisture (film of water) or when the air and/or surface temperature is less than the temperature requirements contained in MassDOT Specifications Table 450.42-1. When the surface temperature of the underlying course is less than 50 degrees Fahrenheit the General Contractor shall determine the time available for compaction. The General Contractor shall also take extra precautions to control the temperature of the materials during placement. The time available for compaction shall be calculated based on the time, date, air temperature, average wind speed, sky conditions, latitude, mix type, PG grade, lift thickness, mix delivery temperature, existing surface type, existing moisture content of surface, existing state of moisture in surface, and surface temperature. The estimated time available for compaction can be calculated with computer programs, e.g., Pave Cool Tool. This program is available at the following web location: http://www.dot.state.mn.us/app/pavecool/
3. The information regarding the air temperature, average wind speed, sky conditions, mix delivery temperature, and existing moisture conditions shall be evaluated by the Designer and the General Contractor's representative located at the paving operation. The estimated time available for compaction shall be provided by the General Contractor to the Designer. The Designer and the General Contractor shall determine if there is an adequate amount of time available to compact the mixture. Options can be explored to extend the time available for compaction. If there is an adequate amount of time available to compact the mixture, the temperature requirements may be waived by the Designer; however, all other requirements including compaction shall be met. The General Contractor assumes responsibility for constructing the pavement to meet compaction and specification requirements.
4. The General Contractor shall not permit work to continue when overtaken by sudden storms until the pavement surface shows no signs of free moisture. The material in transit at the time of shutdown shall not be placed until the pavement surface shows no signs of free moisture, provided the mixture is within temperature limits as specified.
5. When the air temperature falls below 50 degrees Fahrenheit, extra precautions shall be taken in drying the aggregate, controlling the temperature of the materials, and placing and compacting the mixtures.
6. The construction of hot mix asphalt | bituminous concrete pavements shall terminate on November 15 and shall not be resumed prior to April 1 except as determined and directed in writing by the Designer.

1.07 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Installation Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs shall be allowed because of a lack of knowledge of existing conditions as indicated in the Construction Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the General Contractor shall have examined them for himself during

the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.08 ADA AND MAAB COMPLIANCE

A. Comply with American with Disabilities Act (ADA) and the requirements of the Massachusetts Architectural Access Board (MAAB).
   1. Slopes: Walkways as defined by Section 22.1 of 521 CMR, shall be graded to a maximum of 4.5 percent. The cross-pitch (perpendicular to travel) for walkways and paths shall be constructed at 1.5 percent.
   2. The requirements specified hereinabove shall supersede the grades indicated on the Drawings. If these requirements cannot be met with the grades indicated on the Drawings, the Designer shall be notified immediately for direction.

PART 2 PRODUCTS

2.01 HOT MIX ASPHALT | BITUMINOUS CONCRETE

A. General
   1. Hot Mix Asphalt (HMA) | bituminous concrete paving shall conform to MassDOT Standard Sections 450.10, 450.30, and M 3.06.00. All HMA | bituminous concrete mixtures shall meet the requirements of the Superpave volumetric mix design system.
   2. Within the public Right-Of-Way, the local municipality's HMA | bituminous concrete product requirements shall govern, if applicable.
   3. HMA | bituminous concrete designs shall meet the requirements of MassDOT Standard Specification Section 450.30
      a. Each HMA | bituminous concrete pavement course placed shall be comprised of one of the mixtures listed in MassDOT Standard Specifications Table 450.10-1: HMA | Bituminous Concrete Pavement Courses & Mixture Types
   4. Asphalt | bituminous concrete mixtures shall be composed of the following:
      a. Mineral aggregate
      b. Mineral filler (if required)
      c. Performance Graded Asphalt Binder (PGAB)
         1) All mixes shall be PG 64-28

2.02 ASPHALT EMULSION FOR TACK COAT

A. Asphalt emulsion materials shall be homogeneous and shall show no separation after mixing within 30 days after deliveries. They shall conform to the requirements of AASHTO M 140. Anionic emulsion used for tack coat shall be grade RS-1h.

2.03 SPORT COURT SURFACING

A. Refer to Section 32 18 10 "COURT SURFACING" for athletic sealcoat on athletic asphalt | bituminous concrete sport court paving.

2.04 RECREATIONAL PAVEMENT MARKINGS

A. Refer to Section 32 18 23.43 "RECREATIONAL PAVEMENT MARKINGS" for line striping on athletic asphalt | bituminous concrete sport court paving.

PART 3 EXECUTION

3.01 GENERAL

A. Subbase under paving shall be compacted as described in Section 31 00 00 "EARTH MOVING" Add material meeting the requirements of ordinary borrow to bring the subgrade to the required grade before placing base course.

B. Furnish, set, and maintain all line and grade stakes necessary to guide the automated grade control equipment. Where required these control stakes shall be maintained and used throughout the operations, from the grading of the subbase material up to and including the final layers of the pavement.

C. The gravel base course shall be spread in layers upon the prepared subgrade conforming to the required line and grade. Gravel shall be placed in compacted layers not more than four inches thick compacted to not less than 95 percent of the maximum dry density of the material. Any stone greater than three inches in size shall be removed. Compaction shall continue until the surface is even and true to line and grade.

D. Gravel base course shall be placed on backfilled and compacted trenches to proper grade before placement of pavement.

E. The edges of existing pavement that is to remain shall be sawcut to an even, straight edge using a power-driver rotary saw; use of a jackhammer is unacceptable.

1. The pavement shall be sawcut through its full depth at all joints between existing and proposed pavements to provide a uniform, smooth vertical surface.
2. Sawcut edges which become broken, ragged or undermined as a result of the operations shall be re-cut prior to the placement of abutting proposed pavement at no additional cost to the Owner.
3. Sawcut surfaces in asphalt | bituminous concrete pavements shall be sprayed or painted with a uniform, thin coat of asphalt emulsion tack coat immediately before placement of hot mix asphalt | bituminous concrete against the cut surface.

F. Asphalt | bituminous concrete courses shall be spread and compacted to the finished thicknesses as shown on the Contract Drawings. A smooth even surface shall be produced.

G. Any joints at junctions of old and new pavements shall be sealed with hot poured joint sealer and covered with sand.

3.02 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.03 QUALITY CONTROL OF HMA | BITUMINOUS CONCRETE PAVEMENT

A. General. Quality Control (QC) shall be in conformance with MassDOT Standard Specifications Section 450.60 through 450.68 and required as indicated. The General Contractor assumes responsibility of the quality for all materials and construction incorporated into the work and shall control all the processes leading to the final result through this function. The QC system addresses all elements which affect the quality of the pavement including, but not limited to:

1. Mix Design
2. Aggregate Grading
3. Quality of Materials
4. Stockpile Management
5. Proportioning
6. Mixing and Transportation
7. Placing and Finishing
8. Joints
9. Compaction
10. Surface smoothness and uniformity
11. Thickness and grade

B. The General Contractor shall be prepared to discuss and present, at the pre-paving conference, their understanding of quality control for this contract.

1. Surface Smoothness.
   a. The finished surfaces of the pavement shall be uniform in appearance, free from irregularities in contour and texture and shall present a smooth-riding surface.

Smoothness evaluation applies to all hot mix asphalt | bituminous concrete roadways and walkways receiving 1.5 inches or more in plan (compacted) thickness of HMA | bituminous concrete pavement.

b. Carefully apply the straight edge immediately after the first compaction by rolling, and from then on as may be necessary until and after the final compaction of the material in place. Hold the straightedge in successive positions parallel to the road centerline and in contact with the road surface; check the entire area from one side of the pavement to the other.
    1) Tests for conformity with the specified crown and grade shall be made immediately after initial compaction. Any variation shall be corrected by the removal or addition of materials and by continuous rolling.
    2) The finished surface of the pavement, when measured with a 10-foot straightedge, shall not vary more than 1/4 inch for the surface course and 3/8 inch for the intermediate course measured perpendicular and parallel to the centerline.
    3) After the completion of final rolling, the smoothness of the course shall again be tested.
c. Humps or depressions exceeding the specified tolerances shall be immediately corrected by removing the defective work and replacing with new material. This shall be done at the General Contractor's expense.
d. Skin patching will not be permitted.
e. When profile corrections are required, use one or more of the following corrective methods:
    1) Removing and replacing the entire pavement thickness.
    2) Diamond grinding or micro milling.
    3) Overlaying (not patching) with the specified surface course.
    4) Removing the surface by milling and applying a lift(s) of the specified course(s).
    5) Use of other methods that will provide the desired results.
f. The corrective method(s) chosen shall be performed at the Installation Contractor’s expense, including all necessary equipment and traffic control.
    1) Areas of removal and replacement shall be removed the full width of the lane or paver pass. The removal areas shall begin and end with a transverse butt joint which shall be constructed with a transverse sawcut perpendicular to the centerline or paver pass.
    2) Replacement materials shall be placed in sufficient quantity, so the finished surface will conform to grade and smoothness requirements. The corrective area shall conform to all material and density specification requirements.
    3) When the corrective work consists of an overlay, the overlay shall cover the full width of the pavement including shoulders or the paver passes sufficient to correct the defective work. The area overlaid shall begin and end with a transverse butt joint which shall be constructed with a transverse sawcut and asphalt | bituminous concrete removal.
    4) All materials shall meet contract requirements. The overlay shall be placed so the finished surface will conform to grade and smoothness requirements. The overlaid area shall be compacted to the specified density.
g. The Owner’s Representative and/or Designer can have the Independent Testing Agency retest any sections where corrections were made to verify that the corrections produced a surface that conforms to the grade and smoothness requirements.

2. Uniformity.
    a. The HMA | bituminous concrete mat shall be smooth, dense, and uniform. Uniformity is generally affected by Thermal and/or Aggregate segregation.

b. If segregation is evident and discernable by either the General Contractor or the Owner's Representative/Designer, the Installation Contractor shall immediately cease production and take steps to correct and eliminate the cause(s) of the segregation.
c. The Installation Contractor shall review all potential causes of segregation as it relates to its operation, including but not limited to HMA | bituminous concrete Plant issues, loading and transportation issues, placement issues, thermal segregation, and hand work. The General Contractor shall employ additional investigation methods and make the necessary changes in their operation such that segregation is eliminated, and mat uniformity is acceptable.

3. Thickness.
   a. The thickness requirements contained herein shall apply only when each pavement layer is specified to be a uniform compacted thickness of one inch or greater. Thickness shall be evaluated for acceptance by the Owner's Representative and/or Designer to the requirements shown on the plans. Measurements of thickness may be checked periodically by the Installation Contractor in following their QC system for field operations. Measurements of thickness for acceptance shall be made by the Independent Testing Agency using four-inch minimum diameter pavement cores removed also for subsequent density measurement.
   b. The finished surfaces of each HMA | bituminous concrete pavement course shall not vary from that specified or cross sections shown on the contract drawings by more than 1/4 inch. The Installation Contractor shall correct pavement areas varying more than this amount by removing and replacing the defective work or as ordered by the Owner's Representative and/or Designer. Skin patching will not be permitted.
4. Grade.
   a. The finished surface of the pavement shall not vary from the gradeline elevations as shown on the plans by more than 1/2 inch. Remove deficient areas and replace with new material. Sufficient material shall be removed to allow at least 1 1/2 inches of hot mix asphalt | bituminous concrete to be placed. Skin patching for correcting low areas shall not be permitted. High points may be ground off.
5. Rejection of Inferior HMA | bituminous concrete.
   a. The Owner's Representative and/or Designer may at any time, notwithstanding previous acceptance, reject and require the General Contractor to dispose of any batch of hot mix asphalt | bituminous concrete which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. Similarly, the Owner's Representative and/or Designer may at any time, notwithstanding field acceptance for mat density, reject and require the Installation Contractor to correct any HMA | bituminous concrete pavement that was placed with unacceptable mat uniformity or paving joints due to low density, segregation, improper elevation, or tearing. In the event of such rejection, the General Contractor and the Owner's Representative and/or Designer may take random split samples of the area(s) in question, and if it can demonstrate in the laboratory, in the presence of the Owner's Representative and/or Designer, that such material/pavement was erroneously rejected, payment will be made for the material at the contract unit price.

C. General: Immediately before placing asphalt | bituminous concrete materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving. The General Contractor shall ensure that it is in conformance with the required

grade, cross-section, and in- place density. The compacted subbase shall not be frozen or have standing water.

D. Proof roll prepared base material surface, if applicable, to identify areas requiring removal and re-compaction, and to provide a uniform degree of compaction over the entire pavement area.

E. Do not begin paving work until deficient base material areas and utility trenches have been corrected and are ready to receive paving. Paving shall not be applied until the Designer inspects and accepts the finished base.

F. When an existing surface or new base upon which the bottom course is to be placed contains unsatisfactory irregularities, in the Designer's judgment, such irregularities may be eliminated by an adequate placing and compaction of HMA | bituminous concrete mixture to furnish a surface with true contour and grade before placing any specified course of mixture.

G. Check all frames, covers, grates, water valve boxes and other miscellaneous castings that are located in the proposed pavement areas to ensure that all have been correctly positioned and set to the proper slope and elevation. All covers and grates shall be set flush with the required finished surface. All adjustments shall be made prior to placement of the surface course. No depressions or mounds shall be permitted in the pavement to accommodate inaccuracies in the setting of castings. Hand placement of HMA | bituminous concrete along curbs, edging, or utilities after placement and compaction of the surface course shall not be permitted.

H. Leveling Course. Any HMA | bituminous concrete used for truing and leveling shall meet the requirements of the mix design methods and the requirements of MassDOT Standard Section 450.10 for the applicable mixtures. Leveling courses shall not be subject to density requirements. The thickness of the Leveling Course shall be measured off the interface with the existing milled or un-milled pavement surface. The leveling course shall be compacted with the same effort used to achieve placement and density of the test section. The truing and leveling course shall not exceed a nominal thickness of 1.5 inches.

I. Immediately before placing the hot mix asphalt | bituminous concrete, the underlying course shall be thoroughly cleaned of all dust and debris by a self-propelled sweeper. Areas inaccessible by power sweepers shall be broom swept until the pavement surface is clean. Extra care shall be required during fall leaf fall.

J. Tack Coat. Apply uniformly to surfaces to be paved.

1. Contact surfaces of manholes, structures, and vertical pavement edges shall be painted with a thin, uniform tack coat just before the material is placed against them.
2. Tack coat is required on all surfaces to be paved; this includes leveling, base, or intermediate layers of HMA | bituminous concrete. Particular attention should be made during the application that the longitudinal joint areas be treated with no bare spots. Missing areas on the longitudinal joint area shall require either re-application or localized hand work application. The existing surface shall be swept clean of all foreign matter and loose material using a mechanical sweeper and shall be dry before the tack coat is applied.
3. Tack Coat shall be applied by a pressure distributor. All nozzles on the distributor shall be open and functioning. All nozzles shall be turned at the same angle to the spray bar. The nozzles shall be offset at an angle from the spray bar to prevent the fan from one nozzle from interfering with the fan from another. Proper nozzle angle shall be as determined by the Manufacturer of the distributor spray bar. The spray bar shall be adjusted so that it is at the proper height above the pavement surface to provide a triple overlap spray for a uniform coverage of the pavement surface. A triple lap application requires that the nozzle spray patterns overlap one another such that every portion of the pavement receives spray from exactly three nozzles.
4. The tack distributor system shall be equipped with the following to control and monitor the application:

a. System for heating the asphalt emulsion uniformly to specified temperature.
b. Thermometer for measuring the asphalt emulsion temperature.
c. Adjustable full circulation spray bar.
d. Positive controls including tachometer, pressure gauge, and volume measuring device.

5. Tack coat application rates for specific surface conditions shall be in accordance with the following:
   a. On a new HMA | bituminous concrete surface, not opened to traffic, the emulsion application rate shall equal 0.06 to 0.08 gallons per square yard
   b. On an existing tight smooth pavement, the emulsion application rate shall equal 0.06 to 0.08 gallons per square yard.
   c. On a milled surface the emulsion application rate shall equal 0.07 to 0.09 gallons per square yard.
   d. On cement concrete base course, the emulsion application rate shall be equal to spray application for adjacent surface.
   e. On new HMA | bituminous concrete patches the emulsion application rate shall equal 0.06 to 0.09 gallons per square yard. Allow tack coat to cure undisturbed before applying hot-mix asphalt | bituminous concrete paving.
6. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
7. Tack Coat shall be applied to cover a minimum of 95 percent of the pavement surface.

3.04 HOT-MIX ASPHALT | BITUMINOUS CONCRETE TRANSPORTING, PLACING AND FINISHING

A. The trucks used to transport HMA | bituminous concrete to the field placement site shall have tight, clean, smooth metal beds. When necessary to maintain the required HMA | bituminous concrete temperature, trucks shall be equipped with insulated beds. The truck beds shall be evenly and lightly coated with an approved release agent meeting the requirements of MassDOT Standard Specification Section M3.01.6. Truck beds shall be free of kerosene, gasoline, fuel oil, solvent, or any other materials negatively impacting the HMA | bituminous concrete. The HMA | bituminous concrete shall be protected from foreign debris during transport.

B. Machine place hot-mix asphalt | bituminous concrete on prepared surface, spread uniformly, and strike off. Place asphalt | bituminous concrete mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

C. HMA | bituminous concrete deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver.

D. Upon arrival, the mixture shall be placed to the full width by a hot mix asphalt | bituminous concrete paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the hot mix asphalt | bituminous concrete mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of 10 feet except where edge lanes require less width to complete the area. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least six inches. However, the joint in the top layer shall be at the centerline of the pavement. Transverse joints in one layer shall be offset by at least two feet from transverse joints in the previous layer. The placement of the material along the longitudinal joint may be performed by setting the screed to overlap the first mat. The elevation of the screed above the surface of the first mat should be equal to the amount of roll- down expected during compaction of the new mat. The

overlapped material shall be bumped by the lutes, if necessary, to optimize the density along the longitudinal joint. Under no circumstances should the overlapped material be broadcast across the mat. Excess material should be removed by hand. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet.

E. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt | bituminous concrete to prevent segregation of mix; use suitable hand tools to smooth surface.

F. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.

G. When hand spreading is permitted, the mixture shall be distributed into place by means of hot shovels and spread with lutes in a loose layer of uniform density and correct depth. The use of rakes to spread the hot mix asphalt | bituminous concrete shall not be permitted. Loads shall not be dumped any faster than they can be properly handled by the shovelers and the shovelers shall not distribute the dumped load any faster than it can properly be handled by the luters. The luting shall be carefully and skillfully done to avoid segregation and so that, after the first passage of the roller over the luted mixture, no back patching shall be necessary. Compaction shall immediately follow hand spreading such that specification density is achieved while the mixture temperature is above the manufacturers recommended compaction temperature for the performance graded binder.

H. The mixtures shall only be placed in the work when they can be efficiently and satisfactorily placed, compacted, smoothed, and made uniform in accordance with these specifications. Unless otherwise permitted by the Owner's Representative and/or Designer for special particular conditions, only machine methods of placing shall be used.

I. No mixture shall be placed unless the breakdown, and intermediate rolling can be completed by the time the material has cooled to 195 degrees Fahrenheit, or that minimum compaction temperature specified by the binder manufacturer and provided that the density and uniformity of the completed pavement attains specification compliance.

J. No traffic of any kind shall be permitted on the HMA | bituminous concrete intermediate or HMA | bituminous concrete base when dirt or any other foreign substance may be tracked thereon.

K. Immediately after any course is screeded and before roller compaction is started, the surface shall be checked, any irregularities adjusted, any accumulation from the screed removed by rake or lute, and all fat spots in any course removed and replaced with satisfactory materials. Irregularities in alignment and grade along outside edges shall be corrected by the addition or removal of mixture before the edges are rolled. Indiscriminate casting of mix on the new screeded surface, where irregularities are not evident, shall not be permitted.

L. All hot mix shall be placed and compacted in such a manner as to ensure a continuous bond between the tacked hot mix pavement surfaces and obtain the required density.

M. No vehicular traffic or loads shall be permitted on newly completed HMA | bituminous concrete until adequate stability has be attained and the material has cooled to a temperature of 140 degrees Fahrenheit or less.

3.05 COMPACTION

A. The mixture shall be thoroughly and uniformly compacted by rolling. Equipment may include steel wheeled rollers, vibratory rollers, oscillation rollers, or pneumatic-tired rollers. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Installation Contractor so that the required compaction and surface texture are consistently attained while the mixture is in a workable condition. When possible, use pneumatic or oscillation rollers. Rolling shall be initiated with the drive roll or wheel towards the paving machine. When rolling

on steep grades, the previous procedure may need to be altered. The Installation Contractor shall provide the proper number of rollers to achieve the target in-place density and course thickness.

B. The speed of the roller shall, at all times, be sufficiently slow and of uniform speed to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring because of reversing the direction of the roller, or from any other cause, shall be corrected at once. Rollers shall not be permitted to stop on the mat except to reverse direction or refill water.

C. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. The number of rollers and passes required shall be governed by the compaction results; however, at least two rollers shall be provided for each paver employed on the paving operation. Each roller shall be operated by a competent, experienced roller operator and shall be kept in nearly continuous operation as practicable while work is underway. A plate shall be attached to each roller showing the ballasted and unballasted weight per length-width of tread.

D. To prevent adhesion of the mixture to the steel roller, the drums or shall be kept properly moistened, cocoa mats kept clean and scrapers used, but excessive water shall not be permitted. Pneumatic rollers shall be operated on adjacent pavement surfaces to get the tires warm to hot from friction, then moved to the fresh mat.

E. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers and vibratory plate compactors.

F. Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Installation Contractor’s expense. Skin patching shall not be allowed.

G. Breakdown Rolling. Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

H. Intermediate Rolling. Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt | bituminous concrete is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt | bituminous concrete course has been uniformly compacted to the required field density.

I. Finish Rolling. Finish roll paved surfaces to remove roller marks while hot-mix asphalt | bituminous concrete is still warm.

J. Edge Shaping. While the surface is being compacted and finished, the Installation Contractor shall carefully trim the outside edges of the pavement to the proper alignment. Edges so formed shall be beveled while still hot with the back of a lute or smoothing iron and thoroughly compacted by tampers or by other satisfactory methods.

K. Protection. After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

L. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

M. PAVEMENT CLEANING AND PROTECTION

1. The pavement surface and all work areas shall be left in a clean condition.
2. Vehicular traffic shall not be permitted on the pavement that has been sealed during the dry period. The General Contractor shall supply all temporary traffic control devices (barricades, cones, signing) to protect the sealant. Any damage to uncured sealant shall be repaired at the Installation Contractor’s expense.

3.06 INSTALLATION TOLERANCES

A. Accessibility: Comply with requirements of Massachusetts Architectural Access Board and ADAAG requirements. Remove and replace paving that does not meet required tolerances when measured with a two-foot straight edge.

B. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
   1. Base Course: Plus or minus 3/8 inch.
   2. Surface Course: Plus 1/4 inch, no minus.

C. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within MassDOT Standard Specification tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas.

3.07 SPORT COURT SURFACING

A. Refer to Section 32 18 10 “COURT SURFACING” for athletic sealcoat on athletic asphalt | bituminous concrete sport court paving.

3.08 RECREATIONAL PAVEMENT MARKINGS

A. Refer to Section 32 18 23.43 “RECREATIONAL PAVEMENT MARKINGS” for line striping on athletic asphalt | bituminous concrete sport court paving.

3.09 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from the Project site, and legally dispose of them in an EPA-approved landfill.

END OF SECTION

SECTION 32 13 13.13
CONCRETE PAVING (SITE)

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Concrete sidewalk and plazas.

B. Related Sections:
   1. Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for general building applications of concrete.
   2. Section 31 00 00 "EARTH MOVING" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
   3. Section 32 12 16 “ASPHALT PAVING” for adjacent asphalt | bituminous concrete paving construction.
   4. Section 32 12 16.13 “ASPHALT | BITUMINOUS CONCRETE PAVING (PEDESTRIAN)” for adjacent asphalt | bituminous concrete paving construction.
   5. Section 32 12 16.36 “ATHLETIC ASPHALT-BIT CONC SPORT COURT PAVING” for court paving.
   6. Section 32 13 73 "CONCRETE PAVING JOINT SEALANTS" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.
   7. Section 32 14 13 “UNIT PAVING ON BITUMINOUS SETTING BED” for precast concrete paving units.
   8. Section 32 17 26 “DETECTABLE WARNING SURFACE” for cast iron detectable warning strip set in concrete setting bed.

1.03 REFERENCES

A. The following Standards shall apply to the Work of this Section:
   1. ACI: American Concrete Institute:
      Guide for Measuring, Mixing, Transporting and Placing Concrete: 304R.
      Hot Weather Concreting: 305R.
      Standard Specifications for Cold Weather Concreting: 306.1.
      Standard Practice for Curing Concrete: 308.
      Building Code Requirements for Structural Concrete and Commentary: 318.
      Detailing Manual: SP-66.
   2. ASTM: American Society for testing and Materials:
      Specification of Concrete Aggregates: C33.
      Ready-Mixed Concrete: C94.
      Portland Cement: C150.
      Air Entraining Admixture for Concrete: C260.
      Chemical Admixtures for Concrete: C494.
      Blended Hydraulic Cements (Metric): C595M.
      Chemical Admixtures for Use in Producing Flowing Concrete: C1017.
      Packaged Dry, Hydraulic Cement Grout (Nonshrink): C1107.
      Preformed Expansion Joint Filler for Concrete (Bituminous Type): D994.
      Concrete Joint Sealer, Hot-Poured Elastic Type: D1190.

Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types): D1751.

Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction: D1752.

1.04 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.05 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Indicate pavement Control / Contraction and Expansion joint layout plan for review and acceptance by Owner's Representative.

C. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

D. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups of full-thickness sections of concrete paving to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.
2. Build mockups of concrete paving in the location and of the size indicated or, if not indicated, build mockups where required by Owner's Representative and not less than 96 inches (2400 millimeters) by 96 inches (2400 millimeters).
3. Accepted mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

E. Submit Product Certificates: Signed by manufacturers of joint sealants certifying that products furnished comply with requirements and are suitable for the use indicated.

F. Submit Qualification Data: For firms and persona specified in "Quality Assurance" article to demonstrate their capabilities and experiences. Include lists of completed projects with project names and addresses of architects and owners, and other information specified.

G. Submit Preconstruction Field Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on preconstruction testing specified in "Quality Assurance" Article.

H. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to concrete paving, including but not limited to, the following:
   a. Concrete mixture design.
   b. Quality control of concrete materials and concrete paving construction practices.
   c. Pavement Joints.

I. LEED

1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
   a. Include statement indicating costs for each product having recycled content.
2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
3. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paver is 29 or greater.

4. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.06 INFORMATIONAL SUBMITTALS

A. Material Certificates: For each of the following, signed by manufacturers:
   1. Cementitious materials.
   2. Admixtures.
   3. Form materials and form-release agents.
   4. Steel reinforcement and accessories.
   5. Semi-rigid joint filler.
   6. Joint-filler strips.
   7. Repair materials.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: Engage and experienced installer who has completed pavement work similar in material, design, and extent to that indicated for this project and with a record of successful in-service performances.

B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

C. Source Limitations: Obtain each type of class of cementitious material of the same brand from the same manufacturer's plant and each aggregate from one source.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.

1.09 ADA AND MAAB COMPLIANCE

A. Special attention is to be given to compliance with the American with Disabilities Act (ADA) and the requirements of the Massachusetts Architectural Access Board (MAAB).
   1. Slopes: All Walkways as defined by Section 22.1 of 521 CMR shall be graded to a maximum 4.5 percent. The cross pitch (perpendicular to travel) for all walkways and paths shall be constructed at 1.5 percent (1.9 percent maximum). All Plazas as defined by Section 22.3.2 of 521 CMR shall be graded to a maximum two percent in any direction. The slope of sidewalks ramps and handicap curb cuts as defined by Section 21.1 of 521 CMR shall be constructed at 7.6 percent maximum. Ramps as defined by Section 24.1 of 521 CMR shall be constructed to a maximum slope of 7.6 percent and shall have code compliant handrails.
   2. The General Contractor is to assume that all grades in pedestrian paths of travel shall be verified/checked with a four-foot electronic "Smart Level".
   3. A five-foot minimum level (1.5 percent pitch, 1.9 percent maximum) area shall be provided at all flush entrances to buildings. Puddling of water at the entrances will not be allowed.

B. The above requirements shall supersede the grades shown on the Drawings. If these requirements cannot be met with the grades as shown on the Drawings, the Owner's Representative shall be notified immediately.

1.10 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 PRODUCTS

2.01 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other accepted panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves with a radius of 100 feet (30.5 meters) or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.02 STEEL REINFORCEMENT

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, fabricated from steel wire into flat sheets.

C. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars, cut true to length with ends square and free of burrs.

2.03 CONCRETE MATERIALS

A. Cement: Shall be American-made Portland Cement; and conform to chemical and physical requirements of ASTM C150/C 150M for Type I for exposed concrete and Type II, low alkali, standard gray color for all other work.

B. A maximum of 15 percent fly ash or 30 percent slag is to be used to comply with the requirements of LEED v4 BD+C.

C. Use set retarding admixtures during hot weather only when accepted by Owner's Representative.

D. Prepare design mixtures, proportioned according to ACI 211.IR-91 and ACI 304 and ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trail mixes or field experience.

1. Use a qualified independent testing agency for prepping and reporting proposed concrete mixture designs for the trail batch method.
2. Total Cementitious Content: 705-pounds per cubic yard, maximum.
    a. If a low-alkali cement is used to address potential aggregate reactivity, its effectiveness shall be demonstrated by testing according to ASTM C1567.
    b. Limit use of fly ash in concrete exposed to deicing chemicals in service to not exceed 25 percent of cement content by weight. If fly ash contents above 25 percent are required for reactive aggregate mitigation, provide ASTM C666 testing results indicating satisfactory performance.
    c. Limit use of slag in concrete exposed to deicing chemicals in service to not exceed 50 percent of cement content by weight. If fly ash contents above 25 percent are required for reactive aggregate mitigation, provide ASTM C666 and ASTM C672 testing results indicating satisfactory performance.

E. Limit water-soluble, chloride ion content in hardened concrete to 0.15-percent by weight of cement.

F. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength 28-days:
    a. F3 (freezing and thawing with exposure to water and deicing chemicals) = 5,000 pounds per square inch (34.4 Megapascals), i.e., exposed paving.
2. Water/Cement Ratio (maximum): 0.45-percent by weight (mass).
3. Slump Limit: Maximum three-inches (16.2 millimeters) to five-inches (125 millimeters) a time of placement.

G. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: six percent, plus or minus 1.5 percent at point of delivery for 3/4-inch nominal maximum aggregates size (applies to footings and foundation walls and all other concrete exposed to freeze/thaw action).

H. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

I. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement according to ACI 301 requirements, only as authorized by the Owner in writing as follows:
   1. Fly Ash or Pozzolan: 25 percent.

J. Color Pigment: No Color Pigment should be added to concrete mixture.

K. Water: ASTM C 94/C 94M and potable.

L. Concrete Transit Mixers: Mix concrete materials in transit mixers, complying with requirements of ASTM C 94.
   1. At ambient temperatures of 85 to 90 degrees Fahrenheit, reduce mixing and delivery time to 75 minutes.
   2. At ambient temperatures above 90 degrees Fahrenheit, reduce mixing and delivery time to 60 minutes.

2.04 CURING MATERIALS

A. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

B. Water: Potable.

2.05 JOINT MATERIALS, GENERAL

A. Compatibility: Provide joint backings and other related materials that are compatible with one and other and with products provided under Section 32 13 73 "CONCRETE PAVING JOINT SEALANTS".

B. Location of joints shall comply with plans. Submit layout of joints for review and accepted prior to proceeding with the work.

2.06 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber; 1/2-inch (12.7 millimeters), unless otherwise indicated.

B. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

C. Non-Shrink Grout: ASTM C1107; premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents, capable of developing minimum compressive strength of 2,400 pounds per square inch (16.5 Megapascals) in 48-hours, and 7,000 pounds per square inch (48.2 Megapascals) in 28-days.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

3.02 SUBBASE

A. Prepare subbase in accordance with Section 31 00 00 "EARTH MOVING".

B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
   1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to three miles per hour (five kilometers per hour).
   2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).

3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch (13 millimeters) according to requirements in Section 31 00 00 "EARTH MOVING".

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.04 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.05 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.06 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Provide tie bars at sides of paving strips where indicated.
3. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
4. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Expansion Joints: Form expansion joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Extend joint fillers full width and depth of joint.
2. Terminate joint filler not less than 1/2 inch (13 millimeters) or more than one inch (25 millimeters) below finished surface if joint sealant is indicated.
3. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
4. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
5. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
   1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch (3.2 millimeters). Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
   2. Sawed Joints (only upon Client Acceptance): Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (three millimeters) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
      a. Tolerance: Ensure that sawed joints are within three inches (75 millimeters) either way from centers of dowels.

3.07 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.
C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
D. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.
E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
G. Consolidate concrete according to ACI 301 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
   1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels and joint devices.
H. Screed paving surface with a straightedge and strike off.
I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.
K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
   1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.
L. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
   1. When air temperature has fallen to or is expected to fall below 40 degrees Fahrenheit (4.4 degrees Celsius), uniformly heat water and aggregates before mixing to obtain a concrete

mixture temperature of not less than 50 degrees Fahrenheit (10 degrees Celsius) and not more than 80 degrees Fahrenheit (27 degrees Celsius) at point of placement.

2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

M. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 degrees Fahrenheit (32 degrees Celsius) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is General Contractor's option.
2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.08 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to three millimeters) deep with a stiff-bristled broom, perpendicular to line of traffic.

3.09 DETECTABLE WARNINGS

A. Blockouts: Form blockouts in concrete for installation of detectable paving units specified in Section 32 17 26 “DETECTABLE WARNING SURFACE”.

1. Tolerance for Opening Size: Plus 1/4 inch (six millimeters), no minus.

3.10 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 pounds per square foot by height (one kilograms per square meter by height) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by a combination of these as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
   a. Water.

b. Continuous water-fog spray.
c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-millimeters) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 millimeters) and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period using cover material and waterproof tape.
3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during the curing period.

3.11 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:
1. Elevation: 3/4 inch (19 millimeters).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (six millimeters).
3. Surface: Gap below 10-foot- (three meters) long, unleveled straightedge not to exceed 1/2 inch (13 millimeters).
4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches (13 millimeters per 300 millimeters) of tie bar.
5. Lateral Alignment and Spacing of Dowels: one inch (25 millimeters).
6. Vertical Alignment of Dowels: 1/4 inch (six millimeters).
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches (six millimeters per 300 millimeters) of dowel.
8. Joint Spacing: three inches (75 millimeters).
9. Contraction Joint Depth: Plus 1/4 inch (six millimeters), no minus.
10. Joint Width: Plus 1/8 inch (three millimeters), no minus.

3.12 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with the Owner’s Representative.
B. Allow concrete paving to cure for a minimum of 28 days and be dry before starting pavement marking.
C. Sweep and clean the surface to eliminate loose material and dust.
D. Apply paint with mechanical equipment to produce markings of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils (0.4 millimeters).
1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to concrete surface. Mask an extended area beyond edges of each stencil to prevent paint application beyond stencil. Apply paint so that it cannot run beneath stencil.
2. Broadcast glass beads uniformly into wet markings at a rate of six pounds per gallon (0.72 kilograms per liter).

3.13 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
1. Testing Frequency: Obtain at least one composite sample for each 100 cubic yards (76 cubic meters) or fraction thereof of each concrete mixture placed each day.

a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 degrees Fahrenheit (4.4 degrees Celsius) and below and when it is 80 degrees Fahrenheit (27 degrees Celsius) and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
   a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 pounds per square inch (3.4 Megapascals).

D. Test results shall be reported in writing to Owner's Representative, concrete manufacturer, and General Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both seven- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Owner's Representative but shall not be used as a sole basis for acceptance or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at the General Contractor's expense, shall be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

3.14 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise accepted by Owner's Representative.

B. Drill test cores, where required by Owner's Representative, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign materials. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

SECTION 32 13 73
CONCRETE PAVING JOINT SEALANTS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Cold-applied joint sealants.
   2. Hot-applied joint sealants.

B. Related Sections:
   1. Section 07 92 00 "JOINT SEALANTS" for sealing nontraffic and traffic joints in locations not specified in this Section.
   2. Section 32 12 16 “ASPHALT PAVING” for adjacent asphalt | bituminous concrete paving construction.
   3. Section 32 12 16.13 "ASPHALT | BITUMINOUS CONCRETE PAVING (PEDESTRIAN)" for constructing joints between concrete and asphalt pavement.
   4. Section 32 12 16.36 “ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT PAVING" for court paving.
   5. Section 32 13 13.13 "CONCRETE PAVING (SITE)" for constructing joints in concrete pavement.
   6. Section 32 14 13 “UNIT PAVING ON BITUMINOUS SETTING BED” for precast concrete paving units.
   7. Section 32 18 23.43 “RECREATIONAL PAVEMENT MARKINGS” for court line stripe.

1.03 PRECONSTRUCTION TESTING

A. Preconstruction Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers, for testing indicated below, Samples of materials that will contact or affect joint sealants.
   1. Use manufacturer's standard test method to determine whether priming and other specific joint-preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
   2. Submit no fewer than eight pieces of each type of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.
   3. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
   4. For materials failing tests, obtain joint-sealant manufacturer's written instructions for corrective measures including use of specially formulated primers.
   5. Testing will not be required if joint-sealant manufacturers submit joint-preparation data that are based on previous testing, not older than 24 months, of sealant products for compatibility with and adhesion to joint substrates and other materials matching those submitted.

1.04 ACTION SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

B. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch (13 millimeters) wide joints formed between two six-inch- (150-millimeters) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

C. Pavement-Joint-Sealant Schedule: Include the following information:
   1. Joint-sealant application, joint location, and designation.
   2. Joint-sealant manufacturer and product name.

3. Joint-sealant formulation.
4. Joint-sealant color.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.
B. Product Certificates: For each type of joint sealant and accessory, from manufacturer.
C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for joint sealants.
D. Preconstruction Compatibility and Adhesion Test Reports: From joint-sealant manufacturer, indicating the following:
   1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility with and adhesion to joint sealants.
   2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
B. Source Limitations: Obtain each type of joint sealant from single source from single manufacturer.
C. Product Testing: Test joint sealants using a qualified testing agency.
   1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.
D. Preinstallation Conference: Conduct conference at Project site.

1.07 PROJECT CONDITIONS

A. Do not proceed with the installation of joint sealants under the following conditions:
   1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 degrees Fahrenheit (five degrees Celsius).
   2. When joint substrates are wet.
   3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
   4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 PRODUCTS

2.01 MATERIALS

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.
B. Colors of Exposed Joint Sealants: Shall match as closely as possible the color of the surrounding materials and selected by Owner's Representative from Manufacturer's full range.

2.02 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant for Concrete: ASTM D 5893, Type NS.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Sika Corporation; 728 NS.
      b. Crafco Inc., an ERGON company; RoadSaver Silicone.
      c. Dow Corning Corporation; 888.
      d. Pecora Corporation; 301 NS.
B. Single-Component, Self-Leveling, Silicone Joint Sealant for Concrete: ASTM D 5893, Type SL.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Sika Corporation; 728 SL.
   b. Crafco Inc., an ERGON company; RoadSaver Silicone.
   c. Dow Corning Corporation; 890-SL.
   d. Pecora Corporation; 300 SL.

2.03 HOT-APPLIED JOINT SEALANTS

A. Hot-Applied, Single-Component Joint Sealant for Concrete: ASTM D 3406.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Crafco Inc., an ERGON company; Superseal 402/117.

B. Hot-Applied, Single-Component Joint Sealant for Concrete and Asphalt: ASTM D 6690, Types I, II, and III.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Meadows, W. R., Inc.; Sealtight Hi-Spec.
      b. Right Pointe; D-3405 Hot Applied Sealant.

2.04 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.

B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.05 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.03 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install joint-sealant backings of kind indicated to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backings.
   2. Do not stretch, twist, puncture, or tear joint-sealant backings.
   3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:
   1. Place joint sealants so they directly contact and fully wet joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
   1. Remove excess joint sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.04 CLEANING

A. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.05 PROTECTION

A. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

3.06 PAVEMENT-JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Joints within cement concrete pavement.
   1. Joint Location:
      a. Expansion and isolation joints in cast-in-place concrete pavement.
      b. Contraction joints in cast-in-place concrete slabs.
      c. Other joints as indicated.
   2. Silicone Joint Sealant for Concrete: Single component, nonsag.
   3. Urethane Joint Sealant for Concrete: Multicomponent, pourable, traffic-grade.
   4. Hot-Applied Joint Sealant for Concrete: Single component.
   5. Joint-Sealant Color: Shall match as closely as possible the color of the surrounding materials and be selected by Owner’s Representative from manufacturer's full range.

B. Joint-Sealant Application: Joints between cement concrete and asphalt pavement.
   1. Joint Location:
      a. Joints between concrete and asphalt pavement.
      b. Joints between concrete curbs and asphalt pavement.
      c. Other joints as indicated.
   2. Hot-Applied Joint Sealant for Concrete and Asphalt: Single component.
   3. Joint-Sealant Color: Shall match as closely as possible the color of the surrounding materials and be selected by Owner’s Representative from manufacturer's full range.

END OF SECTION

SECTION 32 14 13
UNIT PAVING ON BITUMEN SETTING BED

PART 1 GENERAL

1.01 GENERAL PROVISIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes the following:
   1. Concrete Pavers
   2. Joint Sand
   3. Bitumen Setting Bed
   4. Asphalt Tack Coat
   5. Aluminum edge restraints.
   6. Edge curb restraints.

B. Related Sections:
   1. Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for cast-in-place concrete base under unit pavers and curbs that serve as edge restraints for paving.
   2. Section 04 43 00 “STONE MASONRY” for stone landscape curb serving as edge restraints for pavers
   3. Section 31 00 00 "EARTH MOVING" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
   4. Section 31 50 00 "EXCAVATION SUPPORT AND PROTECTION" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
   5. Section 32 13 73 "CONCRETE PAVING JOINT SEALANTS" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt | bituminous concrete paving or adjacent construction.
   6. Section 32 13 13.13 “CONCRETE PAVING (SITE)” for concrete pavement and walks that edge the pavers.
   7. Section 32 92 00 “TURF AND GRASSES” for turf planted in permeable | porous paving.
   8. Section 32 93 00 "PLANTS" for ground cover planted in permeable | porous paving.

1.03 REFERENCES

A. ASTM International, latest edition:

Standard Specification for Concrete Aggregates: C 33.
Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates; C 136.
Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units; C 140.
Standard Specifications for Aggregate for Masonry Mortar; C 144.
Standard Classification for Sizes of Aggregate for Road and Bridge Construction; D 448.
Standard Specification for Solid Concrete Interlocking Paving Units; C 936.
Standard Specification for Pigments for Integrally Colored Concrete; C 979.
Test Methods for Moisture Density Relations of Soil and Soil Aggregate Mixtures Using a 5.5 lb (24.4 N) Rammer and 12 in. (305 mm) drop; D 698.
Standard Specification for Emulsified Asphalt; D 977.
Test Methods for Moisture Density Relations of Soil and Soil Aggregate Mixtures Using a 10-lb (44.5 N) Rammer and 18 in. (457 mm) drop; 1D 1557.
Standard Test Method for Freeze-thaw and De-icing Salt Durability of Solid Concrete Interlocking Paving Units; C1645.
Standard Specification for Viscosity-Graded Asphalt Cement for Use in Pavement

Construction; D 3381.

B. U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) Building Design + Construction, latest edition

1.04 SUBMITTALS

A. Concrete Pavers:
   1. Samples for verification: Three representative full-size samples of each paver type, thickness, color and finish that indicate the range of color variation and texture expected upon project completion.
   2. Accepted samples become the standard of acceptance for the product produced.
   3. Test results from an independent testing laboratory for compliance of concrete pavers with ASTM C 936.
   4. Manufacturer's catalog product data, installation instructions, and material safety data sheets for the safe handling of the specified materials and products.

B. Joint Sand:
   1. Provide three representative one-pound samples in containers of Joint Sand materials.
   2. Provide three representative one-pound samples in containers of Setting Bed Sand materials.
   3. Test results from an independent testing laboratory for sieve analysis per ASTM C 136 conforming to the grading requirements of ASTM C 144.

C. Polymeric Joint Sand:
   1. Test results from an independent testing laboratory for sieve analysis per ASTM C 136 conforming to the grading requirements of ASTM C 144.
   2. Samples for Initial Selection: Provide three representative samples in containers of Polymeric Joint Sand material, cured and dried, for color selection.
   3. Samples for Verification: Provide three one-pound samples in containers of Polymeric Joint Sand.

D. Neoprene modified asphalt adhesive product catalog sheets with specifications.

E. Bitumen Setting Bed: asphalt cement mix design to be used in the Bitumen Setting Bed conforming to ASTM D 3381.

F. Sieve analysis per ASTM C 136 for sand mixed with bitumen and sand for joints between concrete pavers.

G. Cast-in-Place Concrete Underlayment: Per Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)".

H. Paving Installation Contractor:
   1. Job references from a minimum of three projects similar in size and complexity. Provide Owner/Client/General Contractor names, postal address, phone, fax, and email address.

I. LEED:
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
   3. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paver is 29 or greater.

4. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.05 QUALITY ASSURANCE

A. Utilize a Manufacturer having at least ten years of experience manufacturing concrete pavers on projects of similar nature or project size.

B. Source Limitations:
   1. Obtain Concrete Pavers from one source location with the resources to provide products of consistent quality in appearance and physical properties.
   2. Obtain Joint Sands from one source with the resources to provide materials and products of consistent quality in appearance and physical properties.
   3. Obtain Polymeric Joint Sand from one source with the resources to provide materials and products of consistent quality in appearance and physical properties.

C. Paving Contractor Qualifications:
   1. Utilize an installer having successfully completed concrete paver installation similar in design, material, and extent indicated on this project.

D. Mockups:
   1. Install a five feet by five feet paver area per each paving pattern.
   2. Use this area to determine surcharge of the Setting Bed Sand layer, joint sizes, lines, laying pattern(s) and levelness. This area will serve as the standard by which the workmanship will be judged.
   3. Subject to acceptance by owner, mock-up may be retained as part of finished work.
   4. If mock-up is not retained, remove and dispose legally.

1.06 DELIVERY, STORAGE & HANDLING

A. In accordance with Conditions of the Contract and Division 1 Product Requirement Section.

B. Deliver Concrete Pavers in manufacturer's original, unopened and undamaged container packaging with identification labels intact.
   1. Coordinate delivery and paving schedule to minimize interference with normal use of streets and sidewalks adjacent to paver installation.
   2. Deliver Concrete Pavers to the site in steel banded, plastic banded or plastic wrapped packaging capable of transfer by forklift or clamp lift.
   3. Unload Concrete Pavers at job site in such a manner that no damage occurs to the product or adjacent surfaces.

C. Store and protect materials free from mud, dirt and other foreign materials.

D. Prevent Joint from exposure to rainfall or removal by wind with secure, waterproof covering.

E. Store Polymeric Joint Sand on elevated platforms, under a cover and/or in a dry location.

1.07 PROJECT/SITE CONDITIONS

A. Environmental Requirements:
   1. Install Concrete Pavers only on unfrozen Bitumen Setting Bed.
   2. Install the Neoprene Tack Coat only to unfrozen Bitumen Setting Bed or when the temperature is within the manufacturer's recommended temperature range.
   3. Install Bitumen Setting Bed materials only when the temperature is above freezing.
   4. Install Bitumen Setting Bed materials only when there is no heaving rain or snowfall.
   5. Install Setting Bed Sand or Concrete Pavers only when there is no heavy rain or snowfall.

B. Weather Limitations for Polymeric Jointing Sand:
   1. Install Polymeric Joint Sand only when ambient temperature is above 40 degrees Fahrenheit (five degrees Celsius), under dry conditions with no rain forecast for 24 hours and when surface of pavement is completely dry.

1.08 CONCRETE PAVER OVERAGE AND ATTIC STOCK

A. Provide a minimum of five percent additional material for overage to be used during construction.

B. General Contractor to provide 100 square feet of each product and size used to owner for maintenance and repair. Furnish Pavers from the same production run as installed materials.

C. Manufacture to supply maintenance and reinstatement manuals for Concrete Paver units.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:

1. Unilock New York, New England Division; 35 Commerce Drive; Uxbridge, MA 01569; Telephone: 508.278-6700; Website: www.unilock.com; Daniel Neviackas Massachusetts Sales Representative; Telephone: 508.341 4306 or your local Territory Manager.
2. Techo-Bloc Group; 70 East Brookfield Road, North Brookfield, MA 01535; Telephone: 774.449.8400; Website: www.techo-bloc.com; Rich Brown; Sales Representative; Telephone: 857.286.9828; Email: rich.brown@techo-bloc.com.
3. Hanover Architectural Products, 5000 Hanover Road, Hanover, PA 17331; Telephone: 800.426.4242; Fax: 717.637.7145; E-mail: info@hanoverpavers.com; Website: www.hanoverpavers.com.
4. Glen-Gery; 445 5th Avenue, New York, New York; Telephone: 914.215.7844; Website: www.glengery.com
5. Belgard, Oldcastle APG New England, 46 Spring Street, Holbrook, MA 02343; Telephone: 781.767.2202; Website: www.belgardcommercial.com; Chip George; Sales Representative; Telephone: 603.340.4337.
6. Whitacre Greer, 1400 S. Mahoning Avenue, Alliance, OH 44601; Telephone: 330.823.1610; Website: www.wgpaver.com; Jaquelyn Cox Regional Representative, Telephone: 423.802.7645; E-mail: jcox@wgpaver.com.

B. Any manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is not a proprietary specification, and it should be noted that "or equivalent" applies to all products denoted herein. It is understood that all manufacturers will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equivalent. It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that can supply similar products.

C. Other manufacturer’s products accepted by the Awarding Authority as equal to the specified products in terms of construction, quality, durability, performance, and or appearance. Submit as substitutions: see Section 012500 “SUBSTITUTION PROCEDURES”.

2.02 CONCRETE PAVERS

A. Basis-of-Design Product: The Concrete Paver shapes are based on:

1. Unilock: To Be Determined; See Plans.

B. Product requirements:

1. Concrete Paver Type One: insert product name
   a. Finish: To Be Determined; See Plans.
   b. Color: To Be Determined; See Plans.
   c. Edge: Chamfer, Rolled, Beveled, Zero-bevel, Micro-bevel.
   d. Size: Manufacture the sizes indicated with a maximum tolerance of plus or minus 1/16 inch for length and width. Maximum height tolerance of plus or minus 1/8 inch.
      1) To Be Determined; See Plans.

Note: Imperial dimensions are nominal equivalents to the metric dimensions.

C. Provide pavers meeting the minimum material and physical properties set forth in ASTM C 936, Standard Specification for Interlocking Concrete Paving Units. Efflorescence is not a cause for rejection.
   1. Average compressive strength 8,000 pounds per square inch (55Megapascals) with no individual unit under 7,200 pounds per square inch (50 Megapascals).
   2. Average absorption of five percent with no unit greater than seven percent when tested according to ASTM C 140.
   3. Conforming to ASTM C 1645 when tested for freeze-thaw requirements.
   4. Height tolerances +/- 3.2 millimeters (1/8 inches).

D. Accept only pigments in concrete pavers conforming to ASTM C 979.

2.03 JOINT SAND

A. Provide natural Joint Sand as follows:
   1. Washed, clean, non-plastic, free from deleterious or foreign matter, symmetrically shaped, natural or manufactured from crushed rock.
   2. Reject limestone screenings, stone dust, or sand for the Joint Sand material that does not conform to conform to the grading requirements of ASTM C 33.
   3. Utilize sands that are as hard as practically available where concrete pavers are subject to vehicular traffic.
   4. Gradation as shown in Table 1 below:

TABLE 1 – JOINT SAND
GRADATION REQUIREMENTS FOR JOINT SAND

ASTM C 144		
Sieve Size	**Natural Sand Percent Passing**	**Manufactured Sand Percent Passing**
No. 4 (4.75 mm)	100	100
No. 8 (2.36 mm)	95 to 100	95 to 100
No. 16 (1.18 mm)	70 to 100	70 to 100
No. 30 (0.600 mm)	40 to 75	40 to 75
No. 50 (0.300 mm)	10 to 30	20 to 40
No. 100 (0.150 mm)	2 to 15	10 to 25
No. 200 (0.075)	0 to 1	0 to 10

2.04 POLYMERIC JOINT SAND

A. Provide Polymeric Joint Sand as manufactured by:
   1. Alliance Gator G2
      a. Product Type: Dry mix, contains polymeric binding agent, activated with water.
      b. Color: To Be Determined.
   2. Unicare HP Polymeric Max Sand
      a. Product Type: Dry mix, contains polymeric binding agent, activated with water.
      b. Color: To Be Determined.
   3. Techniseal HP Next Gel
      a. Product Type: Dry mix, contains polymeric binding agent, activated with water.
      b. Color: Grey, or custom.

B. Provide Polymeric Joint Sand meeting the minimum material and physical properties as follows:

1. Compression Strength: proven resistance to compression of 550 pounds per square inch after drying for seven days under controlled conditions (73degrees Fahrenheit (23 degrees Celsius) at 50 percent humidity).
   a. Test sand sample shape: cylinder (two-inch (five centimeters) diameters by four inches (10 centimeters) high).
2. Gradation as shown Table 1 above.

2.05 NEOPRENE TACK COAT

A. Neoprene modified asphalt adhesive:
   1. Karnak 230 2% neo-asphalt paving block adhesive.
   2. Note: Only apply enough Neoprene Tack Coat to completely cover the Bitumen Setting Bed. Applying an excessive amount of Neoprene Tack Coat can cause the material to expand during summer months and ooze up through the paver joint damaging the paver surface.

2.06 BITUMEN SETTING BED MATERIALS

A. Sand for asphalt bed:
   1. Clean, non-plastic, free from deleterious or foreign matter, symmetrically shaped, natural or manufactured from crushed rock.
   2. Graded according to ASTM C 136.
   3. Bedding Sand Material Requirements: Conform to the grading requirements of ASTM C 33 with modifications as shown in Table 2.

TABLE 2 – BITUMEN SETTING BED
GRADATION REQUIREMENTS FOR BITUMEN SETTING BED

ASTM C 33	
Sieve Size	**Percent Passing**
No. 4 (4.75 mm)	100
No. 8 (2.36 mm)	85 to 100
No. 16 (1.18 mm)	50 to 85
No. 30 (0.600 mm)	25 to 60
No. 50 (0.300 mm)	10 to 30
No. 100 (0.150 mm)	2 to 10
No. 200 (0.075)	2 to 10

B. Asphalt Cement:
   1. Provide Asphalt Cement used in the bituminous setting bed conforming to ASTM D 946 with a penetration at 77 degrees Fahrenheit 100G., five sec of minimum 85 millimetres and a maximum of 100 millimetres.
   2. Combine the dried fine aggregate with hot asphalt cement and heat the mix to approximately 300 degrees Fahrenheit (150 degrees Celsius), at an asphalt plant. Mix the approximated proportion of materials including seven percent asphalt cement and 93 percent fine aggregate. Proportioned by weight each ton of the batch in the approximate ratio of 145 pounds (66 kilograms) asphalt to 1,855 pounds (840 kilograms) sand.

C. Primer for base:
   1. Anionic asphalt emulsion SS-1h, per ASTM D 977.

2.07 EDGE RESTRAINTS

A. Aluminum Edging: Standard-profile extruded-aluminum edging, ASTM B 221, Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Permaloc Corporation.
      b. Curv-Rite, Inc.
      c. Sure-Loc Edging Corporation.
   2. Edging Size: 3/16 inches (4.8 millimeters) wide by four-inches (102 millimeters) deep by 16-feet (4.8 meters) long.
   3. Stakes: Aluminum, 12- inches (305 millimeters) long, stakes to interlock in section hoops.
   4. Finish: Black Anodized.

B. Aluminum L-Shaped Edge Restraints: Standard-profile extruded-aluminum edging, ASTM B 221, Alloy 6063-T6, fabricated in standard lengths with interlocking sections; paver restraint edging for straight-line and curvilinear applications in corrugated L-shaped profile, Horizontal base shall have holes spaced 4 inches (102 millimeters) apart along its length to receive spikes.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Permaloc Corporation.
      b. Curv-Rite, Inc.
      c. Sure-Loc Edging Corporation.
   2. Edging Size: 3/16-inch (4.8 millimeters) wide by 2 1/4-inches (102 millimeters) deep by eight-feet (2.4 meters) long.
   3. Spikes: Steel spiral spike, 3/8-inch (9.5 millimeters) by 10-inches (254 millimeters). In hardened surfaces (concrete, masonry) use 3/16-inch (4.8 millimeters) by 1 1/2-inch (38 millimeters) concrete nail or drive pin fastener equal to Hilti DX 40 powder actuated pin.
   4. Finish: Black Anodized.

C. Job-Built Concrete Edge Curb Restraints: Comply with requirements in Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 5000 pounds per square inch (34 Megapascals).

D. Stone Edge Curb Restraints: Comply with requirements in Section 04 43 00 "STONE SITE MASONRY" for stone curbing in shapes and sizes indicated.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas indicated to receive paving for compliance with requirements for installation tolerances and other conditions affecting performance for the following items before placing the Concrete Pavers.
   1. Verify that Cast-in-Place Concrete Underlayment strength, thickness, surface tolerances and elevations conform to specified requirements.
   2. Verify that the Bitumen Setting Bed materials, thickness, compacted density, surface tolerances and elevations conform to specified requirements.
   3. Verify location, type, and elevations of edge restraints, concrete curbing, concrete collars around utility structures, and drainage inlets.
   4. Verify location of two inches (50 millimeters) diameter weep holes at 20 feet (seven meters) centers and at lowest elevations against curbs, walls, or other permanent structures or as

indicated on the drawings. Verify holes filled with IDOT CA-16. Provide temporary plugs for holes to prevent ingress of sand-asphalt setting bed or neoprene adhesive during construction. Remove plugs when paving adjacent to drain holes.

5. Verify that concrete surfaces to receive the bitumen bedding material are free of dust, oil, grease, paint, wax, curing compounds, primer, sealers, form release agents, from cracks over 3/16 inches (five millimeters) in width, or any deleterious substances and debris which may prevent or reduce bonding.
6. Conduct moisture tests to verify that concrete surfaces are cured, free from hydrostatic pressure and having a moisture content of less than five percent.
7. Verify location, type, and elevations of edge restraints, concrete collars around utility structures, and drainage inlets.
8. Do not proceed with installation of Bitumen Setting Bed or Concrete Pavers until base conditions are corrected by the General Contractor or designated subcontractor.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
   1. Beginning of Bitumen Setting Bed and Concrete Paver installation signifies acceptance of Cast-in-Place Concrete Underlayment.

3.02 PREPARATION

A. Verify that Cast-in-Place Concrete Underlayment is clean, dry, and ready to accept Primer, Bitumen Setting Bed, Tack Coat, Concrete Pavers, and imposed loads.
B. Stockpile Joint Sand materials such that they are free from standing water, uniformly graded, free of any organic material or sediment, debris, and ready for placement.
C. Remove any excess thickness of soil applied over the excavated soil subgrade to trap sediment from adjacent construction activities before placing the Aggregate Base.
D. Keep area where pavement is to be constructed free from sediment during entire job. Remove and replace all Joint Sand contaminated with sediment with clean materials.
E. Complete all subdrainage of underground services within the pavement area in conjunction with subgrade preparation and before the commencement of Cast-in-Place Concrete Underlayment construction.
F. Prevent damage to underdrain pipes, overflow pipes, observation wells, or inlets and other drainage appurtenances during installation. Report all damage immediately.
G. Compact soil subgrade uniformly to at least 95 percent of Standard Proctor Density per ASTM D 698 for pedestrian areas. Compact soil subgrade uniformly to at least 98 percent Modified Proctor per ASTM D 1557 for vehicular areas. Stabilization of the subgrade may be necessary with weak or saturated subgrade soils.
H. Backfill all service trenches within the pavement area to the subgrade level with approved material placed in uniform lifts not exceeding four inches (100 millimeters) loose thickness. Compact each lift to at least 100 percent Standard Proctor Density as specified in ASTM D 698.
I. Trim the subgrade to within zero to 1/2 inch (zero to 13 millimeters) of the specified grades. Do not deviate the surface of the prepared subgrade by more than 3/8 inch (10 millimeters) from the bottom edge of a 39 inches (one meter) straight edge laid in any direction.
J. Do not proceed with further pavement construction, under any circumstances, until the subgrade has been inspected by the Architect/Engineer.

3.03 EDGE RESTRAINTS

A. Provide edge restraints as indicated.
B. Install edge restraints before placing unit pavers.
   1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after unit paver installation.

2. For metal edge restraints with top edge exposed, drive stakes at least one inch (25 millimeters) below top edge.
3. Install job-built concrete edge curb restraints to comply with requirements in Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)".
4. Install stone edge curb restraints to comply with requirements in Section 04 43 00 "STONE SITE MASONRY".
5. Where pavers set in mortar bed are indicated as edge restraints for pavers set in aggregate setting bed, install pavers set in mortar and allow mortar to cure before placing aggregate setting bed and remainder of pavers. Cut off mortar bed at a steep angle so it will not interfere with aggregate setting bed.
6. Where pavers embedded in concrete are indicated as edge restraints for pavers set in aggregate setting bed, install pavers embedded in concrete and allow concrete to cure before placing aggregate setting bed and remainder of pavers. Hold top of concrete below aggregate setting bed.

C. Provide steps made of pavers as indicated. Install paver steps before installing adjacent pavers.
1. Where pavers set in mortar bed are indicated for steps constructed adjacent to pavers set in aggregate setting bed, install steps and allow mortar to cure before placing aggregate setting bed and remainder of pavers. Cut off mortar bed at a steep angle so it will not interfere with aggregate setting bed.

3.04 INSTALLATION

A. CONCRETE BASE PREPARATION:
1. Fill any cracks under 3/16 inches (five millimeters) wide with mortar.
2. Sweep the surface clean.

B. ASPHALT PRIMER:
1. Apply Bitumen Setting Bed Asphalt primer to Cast-in-Place Concrete Underlayment to bond the bituminous bedding material to the concrete base.
2. Apply according to manufacturer's recommendation at a rate.
Note: Utilize Cut Back Asphalt Specification (Rapid Curing Type), per ASTM D 2028-97 (2004) and AASHTO M-81.

C. BITUMEN SETTING BED:
1. Place in panels between 3/4 inches (20 millimeters) high screed rails spaced approximately 12 feet (four meters). Set the depth screed rails carefully to bring the Bitumen Bedding material to proper grade, to ensure proper Concrete Paver finished height. Place Bitumen Bedding material between the parallel screed rails. Rake and screed smooth with strike board. Fill any depressions with fresh bituminous material to produce a smooth, firm and even setting bed after each pass.
2. Use screed rails to achieve a level setting bed conforming to elevations and slope shown on the drawings. After one panel is completed, advance screed rails to the next position in readiness for screeding adjacent panels with strike board. Fill depressions left from removed screed rails and smooth to height consistent with panel.
3. Place an area in size that will remain at least 270 degrees Fahrenheit (130 degrees Celsius) during compaction.
4. Compact the Bitumen Setting Bed with a powered roller compactor to an even, nominal thickness of 3/4 inch (20 millimeters) after compaction while still hot. Adjusted the Bitumen Setting Bed to accommodate the required finished grade of the Concrete Pavers. Proper attention to elevations during the construction of the concrete base material to insure maintaining the required nominal 3/4-inch-thick Bitumen Setting Bed.
5. Re-heat, fill, and compact low areas with Bitumen Setting Bed materials to conform to slope and elevation shown on the drawings.

6. Re-heat, remove, level, and compact Bitumen Setting Bed in high areas to conform to slope and elevation shown on the drawings.
7. Correct irregularities or evenness in the grade of the concrete base surface with Setting Bed materials only.

D. NEOPRENE MODIFIED ASPHALT ADHESIVE:
1. Apply to cold asphalt setting bed with notched trowel with serrations not exceeding 1/16 inch (two millimeters). Do not apply pavers to adhesive until dry skin forms on surface of adhesive, approximately two to three hours depending on air temperature.

E. CONCRETE PAVERS
1. Replace Concrete Pavers with chips, cracks, voids, discolorations, and other defects that might be visible in finished work.
2. Mix Concrete Pavers from a minimum of three bundles simultaneously drawing the paver vertically rather than horizontally, as they are placed, to produce uniform blend of colors and textures. (Color variation occurs with all concrete products. This phenomenon is influenced by a variety of factors, e.g. moisture content, curing conditions, different aggregates and, most commonly, from different production runs. By installing from a minimum of three bundles simultaneously, variation in color is dispersed and blended throughout the project).
3. Exercise care in handling face mix concrete pavers to prevent surfaces from contacting backs or edges of other units.
4. Place Concrete Pavers using laying pattern as indicated. Adjust laying pattern at pavement edges such that cutting of edge pavers is minimized. Cut all pavers exposed to vehicular tires no smaller than one-third of a whole paver.
5. Use string lines or chalk lines on Setting Bed Sand to hold all pattern lines true.
6. Set surface elevation of pavers 1/8 inch (three millimeters) above adjacent drainage inlets, concrete collars or channels.
7. Place units hand tight against spacer bars. Adjust horizontal placement of laid pavers to align straight.
8. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.
9. Provide space between paver units of 1/32 inch (one millimeters) wide to achieve straight bond lines.
10. Prevent joint (bond) lines from shifting more than ±1/2 inch (±13 millimeters) over 50 feet (15 meters) from string lines.
11. Fill gaps between units or at edges of the paved area that exceed 3/8 inch (10 millimeters) with pieces cut to fit from full-size unit pavers.
12. Cut Concrete Pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
13. Prevent all traffic on installed Concrete Pavers until Joint Sand has been vibrated into joints. Keep skid steer and forklift equipment off newly laid Concrete Pavers that have not received initial compaction and Joint Sand material.
14. Vibrate Concrete Pavers into leveling course with a low-amplitude plate vibrator capable of a to 5000-pound force (22-kilo-newton) compaction force at 80 to 90 Hertz. Perform at least three passes across paving with vibrator. Vibrate under the following conditions:
    a. After edge pavers are installed and there is a completed surface or before surface is exposed to rain.
    b. Compact installed Concrete Pavers to within six feet (two meters) of the laying face before ending each day's work. Cover Concrete Pavers that have not been compacted

and leveling course on which pavers have not been placed, with nonstaining plastic sheets to prevent Setting Bed Sand from becoming disturbed.

15. Protect face mix Concrete Paver surface from scuffing during compaction by utilizing a urethane pad.
16. Remove any cracked or structurally damaged Concrete Pavers and replace with new units prior to installing Joint Sand material.

F. JOINT SAND
   1. Provide, spread and sweep dry Joint Sand into joints immediately after vibrating pavers into Tack Coat and Bitumen Setting Bed course until full. Vibrate pavers and add Joint Sand material until joints are completely filled, then remove excess material. Perform a minimum of four passes with a plate compactor.
   2. Leave all work to within three feet (one meter) of the laying face fully compacted with sand-filled joints at the completion of each day.
   3. Remove excess Joint Sand broom clean from surface when installation is complete.
   4. Polymeric Joint Sand
      a. Install Polymeric Joint Sand per manufacturers recommended instructions.

3.05 FIELD QUALITY CONTROL

A. Verify final elevations for conformance to the drawings after sweeping the surface clean.
   1. Prevent final Concrete Paver finished grade elevations from deviating more than ±3/8 inch (±10 millimeters) under a 10 feet (three meters) straightedge or indicated slope, for finished surface of paving.

B. Lippage: Paver-to-Paver Lippage:
   1. No greater than three millimeters (1/8 inch) difference in height between adjacent pavers.

3.06 REPAIRING, CLEANING AND SEALING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

B. Cleaning: Remove excess dirt, debris, stains, and grit from exposed paver surfaces; wash and scrub clean.
   1. Clean Concrete Pavers in accordance with the manufacturer’s written recommendations.

C. Seal as indicated.
   1. Apply Sealer for Permeable Concrete Pavers in accordance with the sealer and paver manufacturer’s written recommendations.

3.07 PROTECTION

A. Protect completed work from damage due to subsequent construction activity on the site.

END OF SECTION

SECTION 32 16 14
PRECAST CONCRETE CURBS

PART 1 - GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. Earth Moving: Section 31 00 00.

1.02 RELATED DOCUMENTS

A. The Construction Manager, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section will also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.03 SUBMITTALS

A. Product Data: Catalog sheets, specifications, and installation instructions for precast curbs.

B. Quality Control Submittals:

1. Test Reports: Random freeze thaw tests will be conducted by the manufacturer. Test specimens will retain 60 percent of its initial modulus of elasticity after 300 cycles. Test results will be made available to the Director upon request.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Provide precast concrete curbs with a minimum compression strength of 5000 pounds per square inch. Castings will have plane smooth surfaces, true to line and face, free from defects, sharp arises, and with curved surfaces accurately reproduced. Overall dimensions for each casting will not vary more than 1/16 inch from those indicated.

B. Curb units will be cast at the manufacturers plant. Job site castings will not be permitted.

C. Curbing to be set on a radius of 100 feet or less will be cast to the curve required. Ends will be formed or sawed on radial lines.

D. Curb Foundation: One part of Portland cement to six parts No. 1A coarse aggregate dry mix.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set curb true to line and grade on a foundation of one cubic foot of dry concrete for each linear foot of curb installed. Ram all spaces under the curb so that it is completely supported throughout the entire length.

B. Butt joint curb sections together.

C. Install joint sealer where curb abuts existing walls, posts, buildings, and fixed structures or appurtenances.

3.02 RESETTING EXISTING CURBS

A. Remove mortar and concrete from existing curbs to be reused. Replace units damaged by the Construction Manager's negligence.

B. Reset existing curbs accepted for reuse by the Town of Wilmington.

3.03 FIELD QUALITY CONTROL

A. The Town of Wilmington may conduct additional tests at their discretion. Replace curb units taken for testing, not to exceed 10 linear feet for each 1000 feet or fraction thereof delivered to the project.

END OF SECTION

SECTION 32 12 40
GRANITE CURB

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The Construction Manager, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section will also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.02 WORK INCLUDED

A. The work includes furnishing all labor, materials, equipment, and supervision to construct the various types of granite curbing, in accordance with the Drawings and Specifications.

1.03 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:
   1. Section 01 40 00 - Quality Requirements; Inspection and testing.
   2. Provision of waste management: Section 01 74 19 - Construction Recycling Waste Management Plan.
   3. Section 03 30 00 - Cast-In-Place Concrete; Concrete curb; concrete for base.
   4. Section 31 00 00 - Earth Moving; Establishment of subgrade elevations and courses.
   5. Section 32 12 16 - Asphalt Paving.

1.04 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirements will govern.
   1. American Society for Testing and Materials (ASTM):
      a. ASTM C 131 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
      b. ASTM C 615 Structural Granite
   2. Commonwealth of Massachusetts Highway Department (MHD): Specifications Standard Specifications for Highway and Bridges

1.05 SUBMITTALS

A. Submit complete shop drawings of each curb type and size for Architect's acceptance.

1.06 SAMPLE SECTION

A. A sample curb section, full dimension, 6 feet long minimum, will be fabricated prior to start of granite curbing. The work will be inspected by the Architect. If the original sample is not acceptable, the Construction Manager will construct additional sample sections until an accepted sample is obtained. The accepted sections will become the standard for the entire job and will remain undisturbed until completion of all granite curbing.

1.07 QUALITY ASSURANCE

A. Unless otherwise indicated, granite curb materials and construction will conform to the applicable portions of the following:
   1. MHD Specifications Section 500, "Curb and Edging."

1.08 DELIVERY, STORAGE, AND HANDLING

A. Granite curb units will be delivered to the job adequately protected from damage during transit.

B. Curb will be protected against staining, chipping, and other damage. Cracked, badly chipped, or stained units will be rejected and will not be employed in the work.

PRODUCTS

2.01 BASE COURSE

A. Material for base course will be Dense Graded Crushed Stone, as specified in Section 31 00 00 - Earth Moving.

2.02 GRANITE CURB

A. Granite curb required to complete the work of this Section will be a structural granite conforming to ASTM C 615, Class I Engineering Grade, suitable for curbstone use.
   1. Curb will be light grey, free from seams which impair structural integrity, and with percentage of wear less than 32 percent, as determined by ASTM C 131.

B. Curb materials will conform to MHD Specifications Section M9.04.0 and will meet requirements specified in the subsection of Division III, Materials of the MHD Specifications:
   1. Item:
      a. Vertical Granite Curb.
      b. Transitional Granite Curb.
      c. Flush Granite Curb.

C. Provide sawn vertical faces on both sides for all curb sizes. Provide thermal finish on exposed pavement/paver side only.

2.03 CEMENT MORTAR

A. Mortar for pointing joints between curbstones will be a cement mortar composed of one-part Portland cement and two parts sand, by volume with sufficient water to form a workable, stiff mixture.

2.04 CONCRETE

A. Concrete for foundation at joints will conform to Section 03 30 00 - Cast-In-Place Concrete.

PART 3 - EXECUTION

3.01 GRADING

A. Areas to receive granite curb will be compacted and brought approximately to subgrade elevation under Section 31 00 00 - Earth Moving before work of this section is performed. Final fine grading, filling, and compaction of subgrade to receive curbing to form a firm, uniform, accurate, and unyielding subgrade at required elevations and to required lines, will be done under this Section.

B. Existing subgrade material which will not readily compact will be removed and replaced with satisfactory materials. Additional materials needed to bring subgrade to required line and grade and to replace unsuitable material removed will be material conforming to Section 31 00 00 - Earth Moving.

C. Subgrade of areas to receive curbing will be recompacted to bring top eight inch of material immediately below gravel base course to a compaction of at least 90 percent of maximum density, as determined by ASTM D 1557, Method D. Subgrade compaction will extend for a distance of at least one foot. beyond curb edge.

D. Excavation required in subgrade will be completed before fine grading and final compaction of subgrade are performed. Where excavation shall be performed in completed subgrade or subbase subsequent backfill and compaction will be performed as specified in Section 31 00 00 - Earth Moving. Completed subgrade after filling such areas will be uniformly and properly graded.

E. Areas being graded or compacted will be kept shaped and drained during construction. Ruts greater than or equal to two inch deep in subgrade, will be graded out, reshaped and recompacted before placing granite curb.

F. Materials will not be stored or stockpiled on subgrade.

G. Disposal of debris and other material excavated and/or stripped under this section, and material unsuitable for or in excess of requirements for completing work of this Section will be legally disposed of off-site.

H. Prepared subgrade will be inspected by the Architect. Subgrade will be accepted by the Architect before installation of aggregate base course. Disturbance to subgrade caused by inspection procedures will be repaired under this Section of the specification.

3.02 AGGREGATE BASE COURSE

A. Aggregate base course for paving and the spreading, grading, and compaction methods employed will conform to Section 31 00 00 - Earth Moving.

B. Subgrade and base course will be kept clean and uncontaminated. Less select materials will not be permitted to become mixed with gravel. Materials spilled outside pavement lines will be removed and area repaired.

C. Portions of subgrade or of construction above which become contaminated, softened, or dislodged by passing of traffic, or otherwise damaged, will be cleaned, replaced, and otherwise repaired to conform to the requirements of Section 31 00 00 - Earth Moving before proceeding with next operation.

3.03 SETTING CURB

A. Curb will be set in aggregate base with continuous concrete haunch foundation, with trench bottom at minimum six inches below bottom of curb. Excavation will be filled to required level with base course material as specified above.

B. Vertical face of vertical curb will be plumb, with curb top parallel to adjacent surface.

C. Curb will be set accurately to line and grade in continuous haunch. Curb units will be fitted together as closely as possible. Curb will not be field cut.

D. Joints, between curb units will be carefully filled with a cement mortar, and neatly pointed on the top and front exposed portions. After pointing, excess mortar will be cleaned from curb surface.

E. Backfill material on each side of curb will be as specified for adjacent surface and will be thoroughly compacted by means of power tampers. Extreme care will be taken not to destroy alignment. Curb sections disturbed during backfilling or otherwise will be reset to line and grade, and properly backfilled.

END OF SECTION

SECTION 32 17 00
LANDSCAPE PAVING SPECIALTIES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Stone drip strip.
   2. Aluminum edge restraints.
   3. Edge curb restraints
   4. Geotextiles.

B. Related Sections:
   1. Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for flush cast-in-place concrete edge curb restraints.
   2. Section 04 43 00 "STONE SITE MASONRY" for flush stone edge curb restraints.
   3. Section 31 00 00 "EARTH MOVING" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.

1.03 PERFORMANCE REQUIREMENTS

A. Perform gradation of decomposed granite material or 3/8-inch or 1/4-inch minus crushed aggregate in accordance with ASTM C 136 – Method for Sieve Analysis for Fine and Course Aggregates.

1.04 REFERENCES

A. The following Standards shall apply to the Work of this Section:
   1. ASTM: American Society for Testing and Materials:
      Specification of Concrete Aggregates: C33.
      Test Methods for Absorption and Bulk Specific Gravity of Dimensional Stone: C97.
      Test Methods for Modulus of Rupture of Dimension Stone: C99.
      Standard Terminology Relating to Dimension Stone: C119.
      Test Method for Sieve Analysis of Fine and Course Aggregates: C136.
      Test Method for Compressive Strength on Dimension Stone: C170.
      Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic: C241.
      Standard Specification for Granite Dimension Stone: C615.
      Test Method for Flexural Strength of Dimension Stone: C880.
      Specification for Solid Concrete Interlocking Paving units: C936.
      Test method for Softening Point of Bitumen (Ring and Bell Apparatus): D36.
      Test method for Ductility of Bituminous Materials: D113.
      Test Method for laboratory Compaction Characteristics of Soil using Modified Effort [56,000 ft-lbf/ft3 (2,700 kN-m/m3)]: D1557.
      Specification for Viscosity-Graded Asphalt Cement for use in Pavement Construction: D3381.

1.05 ACTION SUBMITTALS

A. Product Data: For materials other than water and aggregates.

B. Product Data: For the following:
   1. Stone drip strip materials.
   2. Edge restraints.
   3. Reinforcement.

C. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C 136.

D. Samples for Initial Selection: For the following:
   1. Each type of stone indicated.
   2. Exposed edge restraints involving color selection.
E. Samples for Verification:
   1. Stone drip strip; one quart bag; minimum
   2. Exposed edge restraints; 12-inches with one stake.
F. Maintenance Instructions: Submit copy(ies) of manufacturer's written maintenance instructions in accordance with Section 01 73 23 – "OPERATION AND MAINTENANCE DATA".
G. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
   3. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paving is 29 or greater.
   4. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.06 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of stone and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.
B. Compaction testing to be provided by General Contractor, one test per 2,000 square feet of base course.
C. Manufacturer's technical representative shall visit the site at the start of an installation to ensure the installer understands the correct installation methods to use.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store aggregates where grading and other required characteristics can be maintained, and contamination avoided.
B. Upon receipt at site, protect surfacing during storage and construction against erosion, soiling or contamination from earth and other materials.
   1. Cover surfacing with plastic or use other packaging materials to prevent damage and erosion
C. Delivered materials shall be identical to the previously acceptable sample and mock-up. Remove materials which are damaged or otherwise not suitable for installation for the job and replace with acceptable materials.
D. Any pavement delivered to the job site which exhibits flaws, imperfections, dimensional errors, improper tolerances or is not considered acceptable shall be rejected and such stone shall be removed from the job site and replaced so as not to delay job progress

1.08 PROJECT CONDITIONS

A. Field Measurements: Each bidder is required to visit the site of the Work to verify the existing conditions. No adjustments shall be made to the Contract Sum for variations in the existing conditions.
   1. Where surfacing is indicated to fit with other construction, verify dimensions of other construction by field measurements before proceeding with the work.

PART 2 PRODUCTS

2.01 AGGREGATE BASE COURSE

A. Graded Aggregate for Subbase: Sound, crushed stone or gravel complying requirements in Section 31 00 00 "EARTH MOVING" for subbase material.

B. Graded Aggregate for Base: Sound, crushed stone or gravel complying with requirements in Section 31 00 00 "EARTH MOVING" for base course.

2.02 STONE DRIP STRIP

A. Stone shall be hard, durable stone, washed free of loam, sand, clay and other foreign substances, of following type, size range and color:
   1. Type: Crushed Stone; Angular
   2. Size Range: 3/4-inch
   3. Match: Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects
   4. Color: Readily available natural gravel color range, provide sample for acceptance.

2.03 EDGE RESTRAINTS

A. Aluminum Edging: Standard-profile extruded-aluminum edging, ASTM B 221, Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Permaloc Corporation.
      b. Curv-Rite, Inc.
      c. Sure-Loc Edging Corporation.
   2. Edging Size: 3/16 inch (4.8 millimeters) wide by four-inches (102 millimeters) deep by 16-feet (4.8 meters) long.
   3. Stakes: Aluminum, 12- inches (305 millimeters) long, stakes to interlock in section hoops.
   4. Finish: Black Anodized.

B. Job-Built Concrete Edge Curb Restraints: Comply with requirements in Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 5000 pounds per square inch (34 Megapascals).

C. Stone Edge Curbs Restraints: Comply with requirements in Section 04 43 00 "STONE SITE MASONRY" for stone curbing in shapes and sizes indicated.

2.04 FILTER FABRIC FOR STONE DRIP STRIP

A. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications; made from polyolefins or polyesters, with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   1. Survivability: Class 2, AASHTO M 288.
   2. Apparent Opening Size: No. 60 (0.250-millimeters) sieve, maximum; ASTM D 4751.
   3. Permittivity: 0.02 per second, minimum; ASTM D 4491.
   4. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing pavement.

3.03 EDGE RESTRAINTS

A. Provide edge restraints as indicated.

B. Install edge restraints before placing stone surfacing.

1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after stone installation.
2. For metal edge restraints with top edge exposed, drive stakes at least one inch (25 millimeters) below top edge.
3. Install job-built concrete edge curb restraints to comply with requirements in Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)".
4. Install stone edge curb restraints to comply with requirements in Section 04 43 00 "STONE SITE MASONRY".

3.04 STONE DRIP STRIP AGGREGATE BASE COURSE

A. Compact soil subgrade uniformly to at least 100 percent of ASTM D 698 laboratory density.

B. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill.

C. For Drip strip, place separation geotextile over prepared subgrade, overlapping ends and edges at least 12 inches (300 millimeters).

D. For Drip strip, place drainage geotextile over compacted base course, overlapping ends and edges at least 12 inches (300 millimeters).

3.05 STONE DRIP STRIP SURFACING

A. Drip strip surfacing shall be placed only after planting, excavation and construction work that might injure the surfacing have been completed. Damage to edging, drip strip surfacing, adjacent grades or materials occurring during construction shall be repaired by the General Contractor before acceptance at no additional cost to the Owner.

B. Any stone with a dimension greater than that permitted for the type of aggregate specified shall be removed from the base before the stone is compacted. Compaction shall continue until the surface is even and true to the proposed lines and grades within a tolerance of 1/8-inch.

C. Any specific area of drips trip surfacing, which after being rolled, does not form satisfactory, solid, stable foundation shall be removed, replaced and re-compacted by the General Contractor without extra compensation.

3.06 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the General Contractor under requirements of the Contract Documents.

1. Premature wear and tear provided the material is maintained in accordance with manufacturer’s written maintenance instructions.
2. Failure of system to meet performance requirements.

B. Warranty Period: General Contractor shall provide warranty for performance of product. General Contractor shall warranty installation of product for the time of one year from completion.

END OF SECTION

SECTION 32 17 26
TACTILE WARNING SURFACES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 1 Specifications Section, apply to this Section.

1. Provision of waste management: Section 01 74 19, Construction of Waste Management Plan.
2. Section 32 13 13.13, CONCRETE PAVING (SITE)

1.02 DESCRIPTION

A. This Section specifies furnishing and installing Cast Iron Detectable/Tactile Warning Surface Indicator Plates where indicated.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's literature describing products, installation procedures and routine maintenance.

B. Samples for Verification Purposes: Submit one plate sample that shows dome size and spacing.

C. Shop drawings are required for products specified showing fabrication details, fastener and anchor locations, plans of plate placement including joints, and material to be used as well as outlining installation materials and procedure.

D. Material Test Reports: Submit complete test reports from qualified accredited independent testing laboratories to qualify that materials proposed for use are in compliance with requirements and meet or exceed the properties indicated on the specifications. All tests shall be conducted on a Cast Iron Detectable/Tactile Warning Surface Indicator Plate (or approved equal) as certified by a qualified independent testing laboratory.

E. Maintenance Instructions: Submit copies of manufacturer's specified installation and maintenance practices for each type of Detectable/Tactile Warning Surface Indicator Plate and accessory as required.

1.04 QUALITY ASSURANCE

A. Provide Cast Iron Detectable/Tactile Warning Surface Indicator Plates and accessories by a single supplier with a minimum of three (3) years' experience in the supply of Cast Iron Detectable/Tactile Warning Surface Indicator Plates.

B. Installer's Qualifications: Engage an experienced installer certified in writing by Cast Iron Detectable/Tactile Warning Surface Indicator Plate supplier as qualified for installation, who has successfully completed installations similar in material, design, and extent to that indicated for the project.

C. Provide Cast Iron Detectable/Tactile Warning Surface Indicator Plates which are in compliance with the following standards (or most recent):

1. Americans with Disabilities Act (Title III Regulations, 28 CFR Part 36 ADA STANDARDS FOR ACCESSIBLE DESIGN, Appendix A, Section 4.29.2 DETECTABLE WARNINGS ON WALKING SURFACES).

D. Gray Cast Iron Detectable/Tactile Warning Surface Indicator Plates shall be according to ASTM A 48M, Class 35B, and shall be bare and not coated with paint or other coatings or substances. Castings shall be sound, free from pouring faults, cracks, blowholes, and other defects.

E. Dimensions: The plate shall incorporate an in-line pattern of truncated domes measuring nominal 0.2" height, 0.90" base diameter, 0.45" top diameter spaced center-to-center 2.35" (+/- 0.05) For wheelchair safety the field area shall consist of a series of micro texture 0.06" high.

F. Product Data: Cast Iron Detectable/Tactile Warning Surface Indicator Plates shall meet or exceed the following test criteria:

ASTM A 327	Impact Resistance	No damage @ 54 J
ASTM A 48	Standard Specification for Gray Iron Castings	
ASTM D695	Compressive Strength	114,000 psi
ASTM D638	Tensile Strength	35,000 psi
ASTM C 501	Abrasive Wear Index	≥ 8800

1.05 DELIVERY, STORAGE AND HANDLING

A. Cast Iron Detectable/Tactile Warning Surface Indicator Plates shall be suitably packaged or crated to prevent damage in shipment and handling. Detectable/Tactile Warning Surface Indicator plate type shall be identified by part number.

B. Cast Iron Detectable/Tactile Warning Surface Indicator Plates shall be delivered to location at building site for storage prior to installation.

1.06 SITE CONDITIONS

A. Environmental Conditions and Protection: Maintain minimum temperature of 41°F in spaces to receive Cast Iron Detectable/Tactile Warning Surface Indicator Plates for at least 24 hours prior to installation, during installation, and for not less than 24 hours after installation.

B. The use of water for work, cleaning, or dust control, etc. shall be contained and controlled and shall not be allowed to come into contact with the general public. Provide barricades or screens to protect the general public.

1.07 MANUFACTURER'S WARRANTY

A. Cast Iron Detectable/Tactile Warning Surface Indicator Plates shall be warranted in writing for a period of ten (10) years from date of substantial completion. The warranty includes factory defects, breakage, and deformation.

1.08 INSTALLATION WARRANTY

A. Cast Iron Detectable/Tactile Warning Surface Indicator Plate installation shall be warranted in writing for a period of two (2) years. Alternate products approved during the tendering process must be guaranteed for an additional three (3) years. Product must be guaranteed from defective work.

PART 2 – PRODUCTS

2.01 MATERIALS

A. DETECTABLE WARNING SURFACE, Detectable warning panel shall be cast iron.

1. Tile shall have integral embedment flanges for complete anchoring system.
2. Shall be capable of sustaining dynamic vehicle loading, AASHTO HS20-44 wheel load test.
3. Tile shall be easily cut to conform to angled and radius ramps.
4. Sizes: shall be manufacturer's standard sizes, or as indicated on the Drawings
5. Color shall be homogeneous throughout the tile. Color to be confirmed by the Architect, with visual contrast with surrounding paving in accordance with ADA Guideline A4.29.2 "Detectable Warnings on Walking Surfaces".
6. Pattern shall consist of raised truncated domes of height and diameter as specified in ADA Guideline 4.29.2.

B. Anchoring Materials:

1. Color matched, flat head drive anchors 1/4 in. diameter x 1-1/2 in. long.
2. Adhesive as supplied by manufacturer.
3. Perimeter Sealant as supplied by manufacturer.

C. Detectable warning tiles as manufactured by the following:

1. Tuf-Tile
2. Duralast
3. Neenah Foundry
4. Or approved equal

PART 3 - EXECUTION

3.01 INSTALLATION

A. During all surface preparation and installation procedures, ensure adequate safety guidelines are in place and that they are in accordance with the applicable industry and government standards.

B. The specifications and related materials shall be in strict accordance with the contract documents and the guidelines set by their respective manufacturers. Contact manufacturer for asphalt applications.

C. Coordinate with the Contractor or Engineer to ensure that the surfaces being prepared and fabricated to receive the plates are constructed correctly and adequately for plate installation. Review manufacturer and contract drawings with the Contractor prior to the construction and refer any and all discrepancies to the Engineer.

D. The physical characteristics of the concrete shall be consistent with the contract specifications while maintaining a slump range of three to four inches to permit solid placement of the Cast Iron Detectable/Tactile Warning Surface Indicator Plates.

E. When preparing to set the plate, ensure that the area to receive the plates has been finished to its final elevation. The concrete shall be poured and finished true and smooth to the required dimensions and slope prior to the plate placement. Vents in the plate allow air and displaced concrete to escape during the installation process.

F. Lift the Detectable/Tactile Warning Surface Indicator plate and gently place into position onto the wet concrete. The plate shall be placed true and square to the curb edge in accordance with the contract drawings. Press into the concrete. The Cast Iron Detectable/Tactile Warning Surface Indicator Plates shall be tamped into the fresh concrete to ensure that the field level of the plate is flush to the adjacent concrete surface.

G. Immediately after placement, the plate elevation is to be checked to adjacent concrete, and the concrete around the perimeter of the tile should be finished. The elevation and slope should be set consistent with contract drawings to permit water drainage to curb as the design dictates. Ensure that the field surface of the plate is flush with the surrounding concrete and back of curb so that no ponding is possible on the plate at the back side of curb, and to eliminate tripping hazards between adjacent finishes.

H. While concrete is workable, create a 1/4” concrete-free recess around the perimeter of the plate. Use a 3/8” radius edging tool to create a finished edge of concrete, then a steel trowel shall be used to finish the concrete around the plate’s perimeter, flush to the field level of the plate.

I. Clean the surface of the tile of any concrete that has protruded from the vent holes.

J. During and after the Detectable/Tactile Warning Surface Indicator Plate installation and the concrete curing stage, it is imperative that there is no walking, leaning or external force placed on the plate that may rock the plate causing a void between the underside of Detectable/Tactile Warning Surface Indicator Plate and concrete.

K. Following Detectable/Tactile Warning Surface Indicator Plate placement, review installation tolerances to contract drawings and adjust plate before the concrete sets.

L. Following the concrete curing stage, a soft brass wire brush will clean the residue without damage to the plate surface.

3.02 PROTECTION AND MAINTENANCE

A. Protect plates against damage during construction period to comply with Detectable/Tactile Warning Surface Indicator plate manufacturer’s specification.

B. Protect plates against damage from rolling loads following installation by covering with plywood or hardwood.

C. Comply with manufacturer’s maintenance manual for cleaning and maintaining plate surface. It is recommended to perform annual inspections for safety and plate integrity.

END SECTION

SECTION 32 17 26. 13
DETECTABLE WARNING SURFACE - RADIAL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes:
   1. Furnishing and installing embedded Cast Iron Detectable Warning Surface Plates with an in-line truncated dome pattern embedded in concrete at radial pedestrian crossings.

B. Related Sections:
   1. Section 310000 "EARTH MOVING" for excavation for installing concrete paving.
   2. Section 033000.13 “CAST-IN-PLACE CONCRETE (SITE)” for concrete base under unit pavers.
   3. Section 044300 “STONE SITE MASONRY” for stone landscape curb serving as edge restraints for unit pavers.
   4. Section 321216.13 "ASPHALT | BITUMINOUS CONCRETE PAVING (PEDESTRIAN)" for asphalt base under unit pavers.
   5. Section 321400 “UNIT PAVING” for precast concrete paving units.
   6. Section 321413 “UNIT PAVING ON BITUMIN SETTING BED” for precast concrete paving units.
   7. Section 32 17 26 “DETECTABLE WARNING SURFACE” for cast iron detectable warning strip set in concrete setting bed at standard curb cuts (non-radial).

1.03 REFERENCES

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 1 Specifications Section, apply to this Section.
   1. Department of Justice ADA Standards (2010)
   2. Department of Transportation ADA Standards for Transportation Facilities (2006)
   3. Proposed Guidelines for Accessible Public Rights-of-Way (2011)
   4. California Title 24
   5. ISO 23599:2019-01 – Assistive products for blind and vision-impaired persons — Tactile walking surface indicators
   6. ISO 21542:2011 – Building Construction – Accessibility and Usability of the Built Environment
   7. ISO 9001 – Certificate No. 0502011, ISO 1409 and ISO/B 16949 Certified Manufacturing Facility located in Jefferson, Ohio.

1.04 SUBMITTALS

A. Product Data Sheet: Submit ADA Solutions literature describing products, installation procedures and routine maintenance.

B. Samples for Verification Purposes: Submit two detectable warning surface plate samples. Samples shall be properly labeled and shall contain the following information: Name of Project, Submitted By, Date of Submittal, and Manufacturer’s Name.

C. Shop Drawings: Submit the Standard Manufacturer Shop Drawings showing all pertinent characteristics of the Cast Iron Detectable Warning Surface Plates including profile, plate

surface profile, plans of plate placement including joints, and material to be used as well as outlining installation materials and procedures.

D. Material Test Reports: Submit all completed current test results from qualified, accredited independent testing laboratories by ASTM and UL/Canada guidelines and indicating that materials proposed for use follow specification requirements and meet or exceed the properties indicated on these specifications.

E. Maintenance Instructions: Submit copies of the manufacturer's specified installation and maintenance practices for each type of Detectable Warning Surface plates and accessories.

F. LEED

1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
   a. Include statement indicating costs for each product having recycled content.
2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
3. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paving is 29 or greater.
4. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.05 QUALITY ASSURANCE

A. Provide Radial Cast Iron Detectable Warning Surface Plates and accessories as produced by a single manufacturer with a minimum of five years of experience in manufacturing Cast-In-Place Detectable Warning Surface Products.

B. Installer's Qualifications: Engage an experienced installer certified in writing by Cast Iron Detectable Warning Surface Plates manufacturer as qualified for installation, who has completed installations similar in material, design, and extent to that indicated for the Contract.

C. Cast Iron Detectable Warning Surface Plates shall be compliant with ADAAG, PROWAG, and California Title 24 requirements.

D. Cast Iron Detectable Warning Surface Plates shall meet or exceed the following test criteria using the most current test methods:

Standard	Standard Description	Value
ASTM C 1028	Standard Test Method for Determining the Static Coefficient of Friction (Slip Resistance)	0.93 Dry, 0.91 Wet
ASTM A 48	Standard Specification for Gray Iron Castings	Complies Class 35B Gray Iron
ASTM A 159	Standard Specification for Automotive Gray Iron Castings	Complies
ASTM D 638	Tensile Strength	34,700 psi
AASHTO M105	Standard Specification for Gray Iron Castings	Complies Class 35B Gray Iron
ASTM D5420	Standard Test Method for Impact Resistance of by Means of a Striker Impacted by a Falling Weight (Gardner Impact)	600 in-lbs minimum
FM 5-594	Florida Method - Test for Wear Resistance of Surface Applied Detectable Warning Surfaces	0.00189 g/cm^3

E. Gray Iron Casting compliant with ASTM A 159 (G3000), ASTM A 48-03, and AASHTO M105-09 (Grade 35B).

F. Stamped concrete, polymer concrete, concrete pavers/tile, brick, or composite products are not acceptable for use on this project.

G. Plate body shall meet or exceed 0.20 inches (6.35 millimeters) thickness (not including truncated domes).

H. Plates shall have perimeter flange on all four sides with a minimum flange length of 0.38 inches (9.7 millimeters) long; 0.25 inches (6.35 millimeters) x 1.5 inches (38.1 millimeters) corrosion resistant metallic anchors with 0.25 inches (6.35 millimeters) x 1.25 inches (31.75 millimeters) stainless steel truss head bolts and washers.

I. Dimensions: Cast Iron Detectable Warning Surface Plates shall be held within the following dimensions and tolerances:

Part Number	No. of Anchors	Part Size	Part Weight
CI1224	4	Rectangular Plate 12” x 24” (305 mm x 610 mm)	19.30 lbs. (8.75 kg)
CI2424	6	Rectangular Plate 24” x 24” (610 mm x 610 mm)	34.25 lbs. (15.54 kg)
CI2430	8	Rectangular Plate 24” x 30” (610 mm x 762 mm)	43.35 lbs. (19.66 kg)
CI_15	-	15’ Radial Wedge Plate 24” x 5” (610 mm x 127 mm)	5.50 lbs. (2.49 kg)
CI_20	-	20’ Radial Wedge Plate 24” x 4” (610 mm x 101 mm)	5.50 lbs. (2.49 kg)
CI_25	-	25’ Radial Wedge Plate 24” x 4” (610 mm x 101 mm)	6.00 lbs. (2.72 kg)
CI_30	-	30’ Radial Wedge Plate 24” x 4” (610 mm x 101 mm)	6.00 lbs. (2.72 kg)

1.06 DELIVERY, STORAGE AND HANDLING

A. Cast Iron Detectable Warning Surface Plates shall be suitably packaged or crated to prevent damage in shipment and handling. Finished surfaces shall be protected by sturdy plastic wrappings to protect the plate from concrete residue during installation.

B. Cast Iron Detectable Warning Surface Plates shall be delivered to a location at the building site for storage before installation. Store plates in an area so that the plates are maintained in a clean, dry condition to prevent contamination or damage to the plates.

1.07 SITE CONDITIONS

A. Environmental Conditions and Protection: Maintain a minimum temperature of 40 degrees Fahrenheit (4 degrees Celsius) in spaces to receive Cast Iron Detectable Warning Surface Plates for at least 24 hours before installation, during installation, and for not less than 24 hours after installation.

B. The use of water for work, cleaning, and/or dust control shall be contained and controlled and shall not be allowed to come into contact with the general public. Provide barricades or screens to protect pedestrians.

1.08 MANUFACTURER’S WARRANTY

A. Cast Iron Detectable Warning Surface Plates shall be guaranteed in writing for a period of 15 years from date of Contract’s final completion. The guarantee includes manufacturing defects, breakage, and deformation.

1.09 INSTALLATION WARRANTY

A. Cast Iron Detectable Warning Surface Plates installation shall be warranted in writing for two years by the installer. Products shall be guaranteed from defective work and loosening of plates.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:
   1. ADA Solutions, 323 Andover Street; Suite 3, Wilmington, MA 01887; Telephone 844.339.5967; Fax: 978.262.9125; E-mail: sales@adatile.com; Website: www.adatile.com.
   2. Advantage Tactile Systems, 241 Main Street; Suite 100, Buffalo, NY 14203; Telephone: 1.800.679.4022; Website: www.advantagetactile.com.
   3. NEI/ Neenah Foundry, 2121 Brooks Avenue, Neenah, WI 54956; Telephone: 920.725.7000; E-mail: infrastructureSolutions@groupnei.com; Website: www.groupnei.com.

B. Any manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is not a proprietary specification, and it should be noted that "or equivalent" applies to all products denoted herein. It is understood that all manufacturers shall have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equivalent. It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that can supply similar products.

C. Other manufacturer’s products accepted by the Awarding Authority as equal to the specified products in terms of construction, quality, durability, performance, and or appearance. Submit as substitutions: see Section 012500 “SUBSTITUTION PROCEDURES”.

2.02 CAST IRON DETECTABLE WARNING SURFACE PLATES

A. Product: IRON DOME® Cast Iron Plates manufactured by ADA Solutions.

B. Plate Sizes
   1. Standard Rectangular Plates
      a. 12 inches by 24 inches (304.8 x 609.6 millimeters)
      b. 24 inches by 24 inches (609.6 x 609.6 millimeters)
      c. 24 inches by 30 inches (609.6 x 762 millimeters)
   2. Radius Wedge Plates (to be used in conjunction with rectangular plates)
      a. 24 inches by four inches or five inches (609.6 x 101.6 or 127 millimeters)
      b. Radius: four feet (1.2 meters) minimum to 150 feet (45.7 meters)

C. Existing engineered and field-tested products, which have been in successful service for five years are subject to specification compliance, may be incorporated in the project and shall meet or exceed the specified test criteria and characteristics. Requests for Approved Equal status must be submitted and accepted by the Owner before the Tender Phase of the project.

D. Color: Color shall be Dark Gray #36118.

E. Domes: Raised truncated domes of 0.2 inches (5.0 millimeters) nominal height, base diameter of 0.9 inches (22.8 millimeters) and top diameter of 0.45 inches (11.4 millimeters). ADA Standards and Public Rights-of-Way Accessibility Guidelines require truncated dome spacing range of 1.6 inches to 2.4 inches (40.6-60.9 millimeters).

F. Dome Spacing:
   1. Standard Rectangular Plates: 2.4 inches (60.9 millimeters) dome spacing in square grid pattern
   2. Radius Wedge Plates: 1.67 inches to 2.4 inches (40.6-60.9 millimeters) dome spacing in radial pattern

G. The Specifications of the concrete, sealants, and related materials shall be in accordance with the Contract Documents and the guidelines set by their respective manufacturers.

PART 3 EXECUTION

3.01 PREPARATION

A. During all concrete pouring and detectable warning plate installation procedures, ensure adequate safety guidelines are in place and that they comply with the applicable industry and government standards.

B. Before installation, General Contractor to ensure all submittals have been reviewed and accepted by the contract Engineer/Architect. Detectable warning plates shall be installed as per manufacturer's instructions.

C. Before placement of the detectable warning plates, review manufacturer's instructions and contract drawings with the Paving Contractor before the construction and refer all discrepancies to Project Engineer/Manager.

D. The physical characteristics of the concrete shall be consistent with the Contract Specifications while maintaining a slump range of four-inches to seven inches (102 millimeters to 178 millimeters) to permit solid placement of the detectable warning plates. An overly wet concrete mix may cause the plates to float. Under these conditions, suitable weights such as two concrete blocks or sandbags 25 pounds (11.4 kilograms) shall be placed on each cast iron plate until the concrete sets.

E. The concrete shall be poured and finished, true and smooth using typical mason's tools to the required dimensions and slope before detectable warning plate placement. Immediately after finishing, use a four feet (1.2 meters) long level with electronic slope readout to level to the required specified slope is achieved. The plates shall be placed true and square to the curb edge, or by the contract drawings/specifications.

3.02 INSTALLATION

A. Maintain a four inch to seven-inch slump range, pour, and float the concrete and prepare for detectable warning plate installation.

B. Without removing any concrete, place plates on the curb ramp six inches to eight inches from the curb line.

C. Tamp the plates in grid pattern across the top face, embedding the plates into the concrete using a rubber mallet or vibrate into place using a vibrating mechanism fixed with a soft base such as wood.

D. Create an edge around the perimeter of the detectable warning plates using a 3/8-inch radius edging tool then float the concrete around plate perimeter using a steel trowel.

E. Using a smart level, make sure ramp and plates maintain compliance with ADA requirements and in accordance with contract documents.

F. Apply a broom-finish to the curb ramp and ensure face of tile is clean and free of any concrete debris.

G. When preparing to set the detectable warning plates, it is important that no concrete be removed from the area to accept the plates. It is recommended that the installation technique eliminate any air voids under the plates. Air holes at anchor locations allow air to escape during the installation process.

H. Detectable warning plates shall be tamped, vibrated, and cast into place to provide an adequate bond between the back side of the plate and the wet concrete; this shall ensure that the plate is flush to the adjacent concrete surface or as the drawings indicate to permit proper water drainage and eliminate tripping hazards between adjacent finishes. Care should be taken to avoid stepping on the plate while it is being set. Doing so shall result in the possible unevenness of the plates, creating an air void(s) under the surface.

I. Radius wedge plates are recommended to accommodate most radius conditions. Radius wedge plates are to be installed between rectangular plates.

J. Immediately after placement, the detectable warning plate elevation is to be checked to adjacent concrete. The elevation and slope should be set consistent with contract drawings to permit water drainage to curb as the design dictates. Ensure that the field surface of the plate is flush with the surrounding concrete and back of curb so that no ponding is possible on the plate at the back side of the curb.

K. While concrete is workable, create a 0.25 inches (6.35 millimeters) concrete-free recess around the perimeter of the plates. Use a 0.75 inches (9.5 millimeters) radius edging tool to create a finished edge of the concrete. Then a steel trowel shall be used to finish the concrete around the perimeter of the plate flush to the field level.

L. During and after the detectable warning plate installation and the concrete curing stage, it is imperative that there is no walking, leaning, or external force placed on the plate that may rock the plate causing a void between the underside of plate and the concrete. Use proper safety barriers or cones to keep the pedestrians away.

M. Following detectable warning plate placement, review installation tolerances to contract drawings and adjust plate before the concrete sets. Suitable weights of 25 pounds (11 kilogram) each may be required to be placed on each plate to ensure solid contact with the underside of the plate to concrete.

3.03 CLEANING AND PROTECTING

A. Protect detectable warning plates against damage during the construction period to comply with manufacturer’s specifications.

B. Protect plates against damage from rolling loads following installation by covering with plywood or hardwood.

C. Replace plates by the method specified by ADA Solutions.

D. If requested by the Project Manager, clean detectable warning plates not more than four days before the date scheduled for observation intended to establish the date of substantial completion in each area of the project. Clean the plates by the method specified by ADA Solutions.

E. Comply with ADA Solutions maintenance manual for cleaning and maintaining plate surface. It is recommended to perform annual inspections for safety and plate integrity.

END OF SECTION

SECTION 32 18 10
COURT SURFACING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Basketball sealcoat.
   2. Cleaning, Repair and Protection.

B. Related Requirements:
   1. Section 31 00 00 "EARTH MOVING" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
   2. Section 32 12 16.36 "ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT PAVING" for court paving.
   3. Section 32 18 23.43 “RECREATIONAL PAVEMENT MARKINGS” for court line stripe.

1.03 REFERENCES

A. The following Standards shall apply to the Work of this Section:
   1. National Federation of State High School Associations (NFSHSA).
   2. International Amateur Athletic Federation (IAAF).
   3. National Collegiate Athletic Association (NCAA).

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Color Sealcoat: The General Contractor shall submit catalog cuts, manufacturer’s specifications and color chips or charts.

B. Field Layout: For each area of color sealcoat.
   1. Field layout of color sealcoat shall be accepted by Owner’s Representative prior to installation.

C. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
   3. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paving is 29 or greater.
   4. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.05 QUALITY ASSURANCE

A. Delivery and Handling:
   1. Deliver materials and products and provide adequate protection against damage.
   2. Handle in strict compliance with manufacturer’s instructions and recommendations and store off the ground.

3. Protect from all possible damage including, but not limited to chipping, staining, cracking and other damage.
4. Sequence deliveries to avoid delays, but minimize on-site storage.

1.06 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt | bituminous concrete materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the ambient or base surface temperature is less than 40 degrees Fahrenheit (4.4 degrees Celsius), or if surface is wet or frozen.

B. Do not apply the color seal filler coats and finish coat in foggy or rainy weather, or when the ambient temperature is below 45 degrees Fahrenheit (7.2 degrees Celsius), or if such conditions are anticipated during the next 48-hours.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:
1. California Sports Surfaces, “Plexipave”, 150 Dascomb Road, Andover, MA 01810; Telephone: 978.623.9980; Fax: 978.623.9970; Website: www.californiasportsurfaces.com.
2. Nova Sports USA, Inc., “Novaplay”, 8 Commercial Way, Milford, MA 01757; Telephone: 508.473.6540; Fax: 508.473.4077; Website: www.novasports.com.
3. SportMaster Sport Surfaces, “Colorplus & Standard Court System”, P.O. Box 2277, Sandusky, OH 44870; Telephone: 800.395.7325; Fax: 419.626.5477; Website: www.sportmaster.net.

B. Any manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is not a proprietary specification, and it should be noted that "or equivalent" applies to all products denoted herein. It is understood that all manufacturers will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equivalent. It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that can supply similar products.

C. Other manufacturer’s products accepted by the Awarding Authority as equal to the specified products in terms of construction, quality, durability, performance, and or appearance. Submit as substitutions: see Section 01 25 00 “SUBSTITUTION PROCEDURES”.

2.02 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

2.03 ASPHALT | BITUMINOUS CONCRETE MATERIALS

A. Asphalt | bituminous concrete paving for basketball court, and four-square, construction shall be Class I, Type I-1 hot plant mix, conforming to the applicable sections of the MassDOT Highway Division Standard Specifications (for Highways and Bridges) and shall consist of two courses of asphalt | bituminous concrete with a minimum finished pavement thickness as shown on Drawings and specified in 32 12 16.36 "ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT PAVING".

2.04 COLOR SEALCOAT

A. The layout and design of color sealing shall be installed per Drawings.

B. Filler Coats: The two filler coats shall be “Plexipave” as manufactured by California Products Corporation, 169 Waverly Street, Cambridge, Massachusetts, or approved equal.
1. Color shall be as indicated on Drawings.
a. Basketball Court Color A: To Be Determined.

b. Basketball Court Color B: To Be Determined.
c. Final color selection to be determined by Shop Drawing.

2. The two “Plexipaver” filler coats shall be applied to the cleaned asphalt | bituminous concrete pavements as specified in 32 12 16.36 "ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT PAVING". It shall be non-flammable upon exposure to flame.
3. The filler coats shall contain a minimum of nine pounds/gallon of Silica, 100 percent passing through a 100 percent mesh as pre-mixed at the manufacturer’s plant. No sand or silica shall be added to the emulsion in the field. The asphalt shall cure for fourteen days prior to applying the Plexipave Acrylic Color System.

C. Water:
1. Water, if accepted, may be added to the “Plexipave” emulsion mixes.
2. In no case may the quantity of water in the filler coat emulsion mix exceed 33 percent of the emulsion volume (One part water: Two parts filler coat).
3. In no case may the quantity of water in the finish coat emulsion mix exceed 50 percent of the emulsion volume (One part water: One part finish coat).
4. Water shall be potable and its temperature above 40 degrees Fahrenheit (4.4 degrees Celsius) upon addition to the emulsions.

D. Color Emulsion Color: The color emulsion color shall be “Plexichrome” as manufactured by California Products Corporation, 169 Waverly Street, Cambridge, Massachusetts, or approved equal.
1. Colors shall match those of the “Plexipave” filler coats.
2. The “Plexichrome” shall be applied lengthwise of the court with a wide type push broom.

E. Finish Coat:
1. The base vehicle for the finish coat shall be an acrylic polymer dispersed in water, and which has the ability to withstand extremes in temperature and general weathering.
2. The film former shall provide a non-skid surface upon drying and under all weather conditions.
3. Pigment dispersions in the color coating are to be of the best quality chrome oxides so as to obtain a permanent true color. The coating shall contain no material that will cause cracking due to extremes in temperatures and is to be factory mixed and consistent in color.
4. The finish coat shall be one hundred percent acrylic emulsion containing no alkyds, butadiene styrene, or vinyls and shall be thinned with water. It shall not chalk or discolor any equipment.

F. The finished surface shall be smooth and uniform, true to required grade and cross section, and free of depressions, ridges, or other irregularities.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.
B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
C. Verify gradients and elevations of base are correct.
D. Proceed with paving only after unsatisfactory conditions have been corrected.

3.02 SUBBASE

A. Construct subbase in accordance with Drawings and Section 31 00 00 "EARTH MOVING".

3.03 ASPHALT | BITUMINOUS CONCRETE PAVING

A. Construct subbase in accordance with Drawings and 32 12 16.36 "ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT PAVING".

3.04 COLOR SEALCOAT

A. The asphalt | bituminous concrete pavement shall cure for 14 days prior to the applying of the Color Sealcoat System as indicated in the Drawings.

B. The General Contractor shall furnish and apply to the accepted asphalt | bituminous concrete pavements as designated in the Drawings: two filler coats and one finish coat of acrylic emulsion color coating.

C. Prior to application of the filler coats, all dirt, sand, dust, and other loose material shall be cleaned from the paved areas to be covered, by sweeping and pressure washing with water. All surfaces shall be dry prior to starting any color seal coating process.

D. The Paving Contractor shall take special precautions to assure that existing pavements are thoroughly cleaned and that all cracks or joints in existing pavements are repaired in conformance with 32 12 16.36 "ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT PAVING".

E. Limits or areas to be colored shall be taped with minimum two inches (51 millimeters) wide tape true as to alignment prior to application of the color coating material.

F. The entire system of two filler coats and one finish coat shall be applied with accepted squeegees and hair-type push brooms, respectively. The material shall be thoroughly mixed by mechanical agitation and all Work shall be done in a through manner. The emulsion shall be thoroughly stirred in its container as received by stationary bucket power mixer so that a creamy, smooth consistency of all emulsion in the container is assured for the ready application. The entire Work of color coat surfacing shall be done in accordance with the recommendations of the manufacturer's representative.

G. Special care shall be taken so as to allow none of the material to splatter or flow beyond the perimeter to be covered. The filler coats and finish coat shall not be applied in foggy or rainy weather, or when the ambient temperature is below 45 degrees Fahrenheit, nor shall they be applied if such conditions are anticipated during the next 48-hours.

H. The two filler coats shall be applied so that both coats are of a total quantity and with a uniform spread at the rate of one gallon per 100 square feet of surface area. Additional filler coating material is to be used to complete the court surfaces to be smooth and uniform. The first coat shall be applied lengthwise of the court, and the second coat cross-wise of the court.

I. After the filler coat applications have been completed and accepted by the Owner's Representative, apply one acrylic color emulsion coating to the properly prepared surfaces with a uniform spread at the rate of one gallon per 200 square feet of surface area. The acrylic color emulsion shall be applied lengthwise of the court with a wide type push broom.

J. The finished surface shall be smooth and uniform, true to required grade and cross section, and free of depressions, ridges, or other irregularities.

3.05 WARRANTY

A. The General Contractor shall provide the manufacturer's standard written warranty for each product within this specification. All of these warranties shall be in addition to, and not in lieu of, other liabilities that the General Contractor may have by law or other provisions of the Contract Documents.

B. The pavement and coatings shall be guaranteed against defects in workmanship or quality for a period of one year after final acceptance. The General Contractor shall replace, repair, recoat or otherwise make satisfactory to the Owner any unacceptable pavement and/or coating at no additional cost to the Owner.

3.06 CLEANING, REPAIR AND PROTECTION

A. Repair minor damage to eliminate all evidence of repair. Remove and replace Work that cannot be satisfactorily repaired.

B. Provide temporary protection to ensure that the Work will be without dirt, stains, damage or deterioration at the time of final acceptance. Clean up stains and spills as they occur. Remove protections and clean immediately before final acceptance.

C. Upon completion of the Work and before acceptance, the General Contractor shall remove and dispose of in an approved manner all surplus materials, and rubbish which the General Contractor may have accumulated during the course of the Work and shall leave the site in a clean and orderly condition. The General Contractor shall not abandon any materials at or near the site regardless of whether or not it has any value.

END OF SECTION

SECTION 32 18 13
SYNTHETIC TURF SURFACING ACTIVE USE – FALL ZONE

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:
   1. Synthetic turf surfacing, including artificial turf.
   2. Supplementary turf surfacing: high use, shock pad, and SBR layer at elevated mounds.
   3. Subbase preparation and placement of aggregate base course.
   4. Turf infill.
   5. Edge curb restraints

B. Related Information:
   1. Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for installing nailer board flush edge curb restraints.
   2. Section 31 00 00 "EARTH MOVING" for excavation for installing subbase.
   3. Section 32 13 13.13 "CONCRETE PAVING (SITE)" for installing nailer board into concrete paving.
   4. Section 32 90 00 - UNDERDRAIN SYSTEM for piping and drainage course serving as subbase for synthetic turf surfacing.

1.03 REFERENCES

A. ASTM International (ASTM): www.astm.org:
   1. ASTM D1335 - Test Method for Tuft Bind of Pile Yarn Floor Coverings.
   2. ASTM D2859 - Standard Test Method for Ignition Characteristics of Finished Textile Floor Covering Materials.
   3. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
   4. ASTM E108 - Standard Test Methods for Fire Tests of Roof Coverings.
   5. ASTM E648 - Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source.
   6. ASTM F1015 - Standard Test Method for Relative Abrasiveness of Synthetic Turf Playing Surfaces.
   7. ASTM F1292 - Standard Specification for Impact Attenuation of Surfacing Materials Within the Use Zone of Playground Equipment.
   8. ASTM F1951 - Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment.

B. International Play Equipment Manufacturers Association (IPEMA): www.ipema.org:

1.04 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Conference: Conduct conference at Project site following award of contract. Review methods and procedures related to synthetic turf surfacing installation including, but not limited to, the following:
   1. Review survey of subbase conditions.
   2. Review delivery, storage, and handling procedures.

1.05 ACTION SUBMITTALS

A. Product Data: For each type of product specified.

B. Shop Drawings: Provide installation details including roll and seaming layout, methods of attachment and details at penetrations and terminations
   1. Show layout of marking plan if any, indicating details for specified activity areas.

C. Samples: For each type of synthetic turf surfacing indicated.
   1. Minimum 12-by-12-inch- square sample of synthetic turf surface with tufted perimeter line and carpet seam.

D. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
   3. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paver is 29 or greater.
   4. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.06 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Installation Schedule: Showing planned commencement and completion dates for each portion of the Work; include critical dates indicated on Owner's project schedule.

C. Warranty: Sample warranty specified in this Section.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Seaming Materials: Sufficient quantity for 100 square feet.
   2. Synthetic Turf Fiber: Sufficient quantity for 100 square feet.
   3. Infill Material: Sufficient quantity for 100 square feet., in weatherproof bags.

1.08 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing synthetic turf surfacing materials similar to those specified for this project, with a record of successful service for a minimum of five years.

B. Installer Qualifications: An experienced Installer certified by the manufacturer, employing workers trained and approved by manufacturer, who has successfully installed work similar in design and extent to that required for the project, in not less than five projects of similar scope. Installer shall be STC Certified (Synthetic Turf Council).

C. Source Limitations: Obtain synthetic turf surfacing materials through one source from a single manufacturer.
   1. Provide secondary materials including adhesives, paint, thread, and repair materials of type and from source recommended by manufacturer of synthetic turf surfacing materials.

1.09 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit synthetic turf surfacing installation to be performed according to manufacturers' written instructions and warranty requirements.

1.10 COORDINATION

A. Coordinate installation of synthetic turf surfacing with installation of site paving, playground equipment, adjacent lawns, landscaping materials, site lighting, and related work.

1.11 WARRANTY

A. Manufacturer's Warranty: Submit manufacturer's standard published limited warranty form in which manufacturer agrees to repair or replace components of synthetic turf surfacing installation installed by manufacturer-certified Installer that fail in materials under normal use and maintenance, or provide other relief, within specified warranty period.
   1. Failures include ultraviolet degradation, backing integrity, more than 50 percent loss of face fiber, and loss of tuft bind strength.
   2. Warranty Period: Life of product.

B. Installer Project Warranty: Submit synthetic turf surfacing Installer's warranty, signed by Installer, covering the Work of this Section, including installation of all components of synthetic turf surfacing system, for the following warranty period:
   1. Warranty Period: Two years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:
   1. SYNLawn®; 2680 Abutment Road SE, Dalton, GA 30721. Telephone: 706.227.1128. Website: www.synlawn.com; Massachusetts Representative; 5 Fulton Street #100; Canton, MA 02021 Telephone: 781.821.0112; Website: www.newenglandturfstore.com.
   2. ForeverLawn; 8007 Beeson Street, Louisville, OH 44641; Telephone: 866.922.7876; Fax: 330.249.2170; Website: www.foreverlawn.com.
   3. Ideal Turf Solutions; 281 Middlesex Avenue, Medford, MA 02155; Telephone: 781.866.6161; E-mail: infoturfsolutions@gmail.com; Website: www.idealturfsolutions.com.

B. Any manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is not a proprietary specification, and it should be noted that "or equivalent" applies to all products denoted herein. It is understood that all manufacturers will have minor variations in configuration, appearance, and product specifications and such minor variations will not eliminate such manufacturers as an equivalent. It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that can supply similar products.

C. Other manufacturer’s products accepted by the Awarding Authority as equal to the specified products in terms of construction, quality, durability, performance, and or appearance. Submit as substitutions: see Section 01 25 00 “SUBSTITUTION PROCEDURES”.

D. Source Limitations: Obtain synthetic turf surfacing materials through one source from a single manufacturer.
   1. Provide secondary materials including adhesives, paint, thread, and repair materials of type and from source recommended by manufacturer of synthetic turf surfacing materials.

2.02 PERFORMANCE REQUIREMENTS

A. Environmental: Provide synthetic turf surfacing system with EN 71-3 Heavy Metal Analysis.

B. Fire-Test-Response Characteristics: Provide products with the critical radiant flux classification indicated in Part 2, as determined by testing identical products per ASTM E648 by an independent testing and inspecting agency acceptable to authorities having jurisdiction.

C. Exterior Fire-Test Exposure: Provide synthetic turf surfacing materials identical to those of assemblies tested for Class A fire resistance according to ASTM E108 or UL 790 by Underwriters Laboratories or another testing and inspecting agency acceptable to authorities having jurisdiction.

D. Accessibility Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and ICC A117.1 for recreation surfaces.

1. Provide synthetic turf system meeting requirements of ASTM F1951.

2.03 SYNTHETIC TURF SURFACING

A. Synthetic Turf Surfacing: Complete surfacing system, consisting of synthetic yarns bound to water-permeable primary and secondary backing and accessory materials.

B. Product Basis-of-Design: Synthetic Turf Surfacing: Complete surfacing system, consisting of delustered UV-stabilized antimicrobial synthetic yarns bound to water-permeable bio-based primary and secondary backing. IPEMA-certified. Non-abrasive blades with low surface temperature. Anti-Static and Ultraviolet reflective pigment enhanced.

1. Basis of Design Product: SYNLawn Play Platinum.
2. Artificial Turf Fiber and Construction Characteristics:
    a. Yarn, Turf Zone: Tufted polyethylene, high emissivity omega.
        1) Color: Field green + apple.
        2) Denier, ASTM D1577: 10,800/6.
        3) Antimicrobial Protection: Sanitized®
        4) Antistatic Protection: StatBlock™
        5) IR Reflective: DualChill™
    b. Yarn, Thatch Zone: Polyethylene.
        1) Color: Field Green + beige.
        2) Denier, ASTM D1577: 5,000/8.
    c. Finished Pile Height, ASTM D5823: 1-1/2 inch.
    d. Face Weight, ASTM D5848: 100 ounce per square yard.
    e. Tuft Machine Gauge: 3/8 inch.
    f. Backing, Primary: six ounce per square yard, 15/18 polypropylene, two layers with fiber-reinforcing core.
    g. Backing, Secondary: 22 ounce per square yard bio-based urethane.
        1) Enviroloc+™
            (a) Anti Fungi and Anti Algae blended into secondary backing.
    h. Total Fabric Weight: 128 ounce per square yard.
    i. Ballast: Silica sand ballast.
    j. Temperature-Reducing Ballast: Silica sand and moisture-retaining coated sand ballast.
3. Performance Characteristics:
    a. Tuft Bind, ASTM D1335: Not less than eight pounds.
    b. Grab tear strength, ASTM D5034: Not less than 200 pound-force.
    c. Elongation to break, ASTM D2256: Not less than 30 percent.
    d. Yarn breaking strength, ASTM D5793: Not less than 20 pound-force.
    e. Flammability, ASTM D2859: Pass.
    f. Fire Test Exposure, ASTM E108: Class A.
    g. Heavy Metal Analysis, EN71-3

2.04 SUPPLEMENTARY TURF SURFACING MATERIALS

A. High Use Area Package: High density, crush-resistant component, configured for easy replacement without disturbing surrounding turf surfacing.

1. Product: SYNLawn, TrampleZone.

B. Shock Pad:

1. Basis of Design: Subject to compliance with requirements, provide products by the following, or approved equal:
2. Brock USA LLC; 3090 Sterling Circle, Boulder, CO 80301; Telephone: (303) 544-5800; Fax: 866-850-9421; E-mail: sales@brockusa.com
3. Product: Brock PowerBase PLAY50
4. Product Number: PLB50

5. Pad Thickness: 1.97-inches (50 millimeters).
6. Material Type: Expanded Polypropylene.
7. Vertical Permeability: Greater than 250 inches per hour.
8. Product format: Edge locking panels.
9. Size: approximately 59.8 inches by 40.7 inches (1520 millimeters by 1030 millimeters) overall dimensions
10. Area: Net coverage per panel 16.89 square feet (1.57 square meters)
11. Panel Weight: approximately four pounds per panel

C. Exoanded Polystyrene (EPS) geofoam meeting the requirements of ASTM D6817.

D. Styrene-butadiene rubber, base layer (SBR): Cushion course beneath synthetic turf on mounded installations. Manufacturer's standard formulation of SBR particles and polyurethane, site mixed and applied. Rubber may not be recycled SBR rubber from tires, it shall be high quality rubber that is pre-consumer virgin product.
   1. SBR layer to extend a minimum of six feet outward from the toe of mound slope.

E. Turf Spikes: Manufacturer's approved fasteners.

F. Nailer Board: Manufacturer's approved nailer/edger board.

2.05 EDGE CURB RESTRAINTS

A. Job-Built Concrete Edge Curb Restraints: Comply with requirements in Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 5,000 pounds per square inch (34 Megapascals).

2.06 MATERIALS

A. Infill Material: Silica sand in manufacturer’s recommended formula for application to synthetic turf surfacing.
   1. Product: SYNLawn, Envirofill.
      a. Color: Green.

B. Glue, Seaming Fabric, and Thread: Manufacturer’s recommended product for application.

C. Aggregate Base: Refer to Section 31 00 00 "EARTH MOVING”.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine synthetic turf surfacing base and perimeter conditions, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.
   1. Verify substrate meets profile required.
   2. Confirm base material, compaction of substrate, permeability, and drainage system installation meets requirements.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 SUBBASE PREPARATION

A. Refer to Section 31 00 00 "EARTH MOVING" for requirements for preparing subbase for Work of this Section.

B. General: Prepare substrates to receive surfacing products according to synthetic turf surfacing manufacturer's written instructions. Verify that substrates are sound and without high spots, ridges, holes, and depressions. Remove organic debris. Grade soil subgrade level and compact.

C. Finish grade soil subgrade with slope between 1/2-percent and one percent toward path of site drainage.
   1. Compact subgrade in both directions with mechanical compacting equipment to achieve specified compaction at 90 percent standard Proctor.
   2. Prepare subgrade to tolerance of within 1/2-inch of design grade.
   3. Prepare subgrade within 1/4-inch in 10 feet in any direction from design grade over entire playing surface.

3.03 EDGE CURB RESTRAINTS

A. Provide edge restraints as indicated.

B. Install edge restraints before installing synthetic turf surfacing.

1. Install job-built concrete edge curb restraints to comply with requirements in Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)".

3.04 AGGREGATE COURSE INSTALLATION

A. Refer to Section 31 20 00 "EARTHWORK" for requirements for preparing aggregate course for Work of this Section.

B. Gravel for Synthetic Turf Dynamic Base shall consist of durable crushed rock or crushed gravel stone, free of ice, snow, sand, silt, clay, loam, shale, or other deleterious or organic matter; washed and graded. Fragmentation shall be at least 100 percent. No round stone or sand shall be accepted. It shall be graded within the following limits:

1. Base Stone:

U.S. Sieve Size	Percent Finer by Weight
1 inch	100
3/4 inch	85-100
1/2 inch	55-85
3/8 inch	40-75
1/4 inch	25-65
No. 4	5-35
No. 8	0-20
No. 16	0-10
No. 200	0-2

2. Finishing Stone:

U.S. Sieve Size	Percent Finer by Weight
1/2 inch	100
3/8 inch	85-100
1/4 inch	75-100
No. 4	60-90
No. 8	35-75
No. 16	10-55
No. 30	0-40
No. 50/60	0-15
No. 100	0-8
No. 200	0-2

C. Place aggregate base course, compact by tamping with plate vibrator to 90 percent of ASTM D 1557 maximum laboratory density, and screed to depth indicated. Install a four-inch base course unless otherwise indicated.

1. Slope base course between 1/2-percent and one percent, measured from the longitudinal center of the installation towards the edges. Grade base course to tolerance of within 1/2-inch of design grade, and with a maximum variation of 1/4-inch in 10 feet in any direction.

3.05 SYNTHETIC TURF INSTALLATION

A. General: Comply with synthetic turf surfacing manufacturer's written installation instructions. Install synthetic turf surfacing over area and in thickness indicated.

B. Shock Pad: Place fall pads tightly abutted over area to receive synthetic turf surfacing. Tape seams with pad seam tape to secure pads in position prior to installing synthetic turf.

C. Expanded Polystyrene (EPS) Geofoam: Use a high PSI geofoam to form the play mound. The forming shall be created using a hot knife, prior to installation of the Styrene-butadiene rubber, base layer.

D. Styrene-butadiene rubber, base layer (SBR): For mounded synthetic turf surfaces, use pointed steel trowel, lightly lubricated, to smooth the SBR evenly over the compacted gravel base. If any porous spots are found at this time they can be filled by adding more mixture. Keep the trowel lubricated to avoid re-separation of rubber particles.

E. Artificial Turf: Loose-lay artificial turf and allow fabric to relax for period recommended by manufacturer. Stretch carpet and attach at perimeter in accordance with accepted submittals.

F. Seaming: Form seams flat and snug, with no gaps or fraying. Remove yarns that are trapped within seams. Form seams per manufacturer's written instructions using manufacturers provided or recommended materials.

G. Attachment: Attach turf fabric to perimeter restraint system per manufacturer recommendations.

3.06 ACTIVITY LINES AND MARKERS

A. Install lines in accordance with accepted submittals.

B. Provide As-Built drawing including verification of field layout dimensions in accordance of with CONTRACT CLOSEOUT.

3.07 INSTALLATION, INFILL

A. Mix and install infill material components in accordance with manufacturer's requirements for accepted system. Groom material and leave surface ready for use.

B. Infill materials shall be uniformly filled to a depth which leaves no more than 1/2-inch of exposed pile after settlement. If the results of the infill depth test show an infill with more than 1/2-inch exposed, additional infill shall be installed to meet the specified infill heights. Additional G-Max, and Head Injury Criterion may be required once the installed infill heights meet the specified heights at no additional cost to the Owner.

3.08 PROTECTION

A. Protect completed installation from damage. Prevent traffic over system prior to acceptance by Owner.

3.09 CLOSE OUT

A. Infilled Synthetic Turf System Vendor shall provide the Owner's Representative with an electronic copy of the accepted Standard Warranty and Third Party Insured Warranty.

B. Infilled Synthetic Turf System Vendor shall train the Owner's designated personnel in the proper maintenance and care of the field and provide the Owner's Representative with an electronic copy of the Standard Maintenance Manual. Training shall at a minimum address:

1. Use and maintenance of equipment including when/how often to use the particular pieces of machinery, how fast/slow to operate machinery.
2. How to clean stains/markings from the field.
3. Snow removal (plow versus snowblowing)
4. What to do if a problem is encountered in the field – who to call/contact.
5. Any small repairs that can be done by the Owner (if any) without affecting the warranty.
6. How to inspect a field and what to look for as well as how often this should be done.
7. Maintenance Log Information – discuss the importance in respect to warranty.

END OF SECTION

SECTION 32 18 16.13
PLAYGROUND PROTECTIVE SURFACING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Unitary synthetic dual density Poured-in-Place Resilient Rubber Surfacing; bonded rubber seamless surface.
   2. Edge curb restraints.

B. Related Sections:
   1. Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for installing cast-in-place concrete edge restraints for playground surfacing.
   2. Section 04 43 00 “STONE MASONRY” for stone landscape curb serving as edge curb restraints for playground surfacing.
   3. Section 11 68 00 “PLAY EQUIPMENT AND STRUCTURES” for required critical fall height for each playground equipment piece per Appendix A.
   4. Section 31 00 00 "EARTH MOVING" for filling and grading and for drainage course drainage/separation geotextiles, and subbase courses.
   5. Section 32 90 00 “UNDERDRAIN SYSTEM” for underdrain connection to site storm drainage system.
   6. Section 33 41 00 “STORM UTILITY DRAINAGE PIPING” for playground subdrainage system.

1.03 DEFINITIONS

A. Critical Height: Standard measure of shock attenuation. According to CPSC No. 325, this means "the fall height below which a life-threatening head injury would not be expected to occur."

B. SBR: Styrene-butadiene rubber, base layer

C. TPV: Thermoplastic vulcanized rubber, top (wear) layer

D. EPDM Rubber: Ethylene Propylene Diene Monomer rubber, top (wear) layer

E. Polyurethane binders: Aromatic (tends to “yellow” with time) and Aliphatic (recommended for shades of blue, purple and gray colors)

1.04 PERFORMANCE REQUIREMENTS

A. Impact Attenuation: According to ASTM F 1292-17 or latest version.

B. Accessibility of Surface Systems: According to ASTM F 1951-14 or latest version.

C. International Playground Equipment Manufacturers Equipment IPEMA Certification

D. Inspection by Third party Certified Playground Safety Inspector CPSI with a minimum of 10 years’ experience in at least 15 playground surfacing inspections

E. Standard Guide for Specification, Purchase, Installation and Maintenance of Poured-In-Place Playground Surfacing: ASTM F2479-17. In addition, as supplied by manufacturer:
   1. ASTM D412 Standard Test Methods or Vulcanized Rubber, Thermoplastic Rubbers, and Thermoplastic Elastomers-Tension
   2. ASTM D624 Standard Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
   3. ASTM D2047 Standard Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as measured by the James Machine.

4. ASTM D2859 Standard Test Method for Flammability of Finished Textile Floor Covering Materials.
5. ASTM E303 Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester.

1.05 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each playground surface system, including materials, plans, cross sections, drainage, installation, penetration details, and edge termination. Include layout illustrating playground surfacing layout, patterns, graphics, typical banding, and direction. Show playground equipment with use zones and type and length of edging on each drawing to confirm compliance of playground safety surface materials.

C. Samples for Initial Selection: For each type of playground surface system indicated.
   1. Include similar Samples of playground surface system and accessories involving color selection.

D. Samples for Verification: For each type of playground surface system indicated.
   1. Minimum four-inch (101-millimeters) disk sample of synthetic rubber seamless surface.
   2. Minimum one-quart (0.95-liter) loose-fill surface sealed in a container.
   3. Minimum six-by-six-inch (150-by-150-millimeters) Sample of synthetic rubber seamless surface.
   4. Six-inch (150-millimeters) long by full-size cross section of border edging.
   5. Minimum 12-by-12-inch (300-by-300-millimeters) Sample of geosynthetic fabric.
   6. Minimum six-by-six-inch (150-by-150-millimeters) Sample of geosynthetic, molded-sheet drainage panel.
   7. Joint materials involving color selection.
   8. Exposed edge restraints; 12-inches (305-millimeters) in length with one stake.
   9. Edge curb restraints.

E. Product Schedule: For playground surface systems. Use same designations indicated on Drawings.

F. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
   3. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paver is 29 or greater.
   4. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.06 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans drawn to scale, on which the following items are shown and coordinated with each other, using input from CPSI Installers of the items involved:
   1. Extent of surface systems and use zones for equipment.
   2. Critical heights for playground surfaces and fall heights for equipment.

B. Qualification Data:

1. For qualified Installer / Installer Supervisor, Installation Contractor to submit current CPSI license number and proof / references demonstrating a minimum of five years of experience, having installed a minimum of 15 playground surfaces with varying fall zone depths.
2. Submit qualifications of testing agencies as listed or supplied by manufacturer.
3. Submit manufacturers' installation instructions for each play surface specified herein.

C. Material Certificates: For each type of playground surface system, from manufacturer.
D. Material Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each playground surface system.
E. Product Certificates: For each type of playground surface system, from manufacturer.
F. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each unitary synthetic playground surface system.
G. Field quality-control reports.
H. Warranty: Sample Warranty.

1.07 CLOSEOUT SUBMITTALS

A. Maintenance Data: For playground surface system to include in maintenance manuals.
B. Warranty documentation.
C. Material Certificates: Material certificates shall be filled out and signed by a specified manufacturer/supplier that specified materials were shipped and in proper amounts for square footage/thickness/color.
D. LEED documentation.

1.08 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Sample of each color combination of bounded Poured-in-Place Resilient Rubber surface, with annotated percentages and codes of each color combinations for Owner's quick reference.
   2. Termination Edge Units: three full-size units.

1.09 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer. Crew Chief shall be IPEMA Certified.
A. Source Limitations: Obtain playground surface system materials, including primers and binders, from single source from single manufacturer.
   1. Provide secondary materials including adhesives, primers, geosynthetics, and repair materials of type and from source recommended by manufacturer of playground surface system materials.
B. Standards and Guidelines: Comply with CPSC No. 325, "Handbook for Public Playground Safety"; ASTM F 1292-17; and ASTM F 1487.

1.10 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit playground surface system installation to be performed according to manufacturers' written instructions and warranty requirements. Temperature should be 50 degrees Fahrenheit and rising during the installation period. The installer shall have sole discretion based on their judgement to proceed or to halt the installation based on their judgement.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of playground surface system that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:

a. Failure for impact attenuation as per ASTM 1292-17 or latest version.
b. Deterioration of surface and other materials beyond normal weathering.
c. Loose or easily scraped rubber surface.
d. Excessive UV fade/Loss of color.
e. TRIAX 2015 GMAX/HIC testing, with accompanied certificate for compliance that this device meets the testing equipment specifications as stated in ASTM 1292-09.

2. Warranty Period: All safety surfacing shall be free of defects due to workmanship or material for a minimum of two years from the date of installation.
   a. A minimum of 10 years performance warranty is required for Poured-in-Place safety surfacing from the date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:
   1. “DuraTurf Poured in Place (PIP)” (TPV) as manufactured by Robertson Recreational Surfaces/Sport Surface Specialties (PlayCore, Inc.); New England Region Address; P.O. Box 577, East Aurora NY 14052; Tele: 716.652.2039 Fax: 716.805.1001; Web: www.sportsurface.net.
   2. “Playbound Poured-in-Place, Extreme-10” (EPDM) with aliphatic urethane, as manufactured by Surface America, Inc.(Ecore Co.), 505 Aero Drive; Suite 1, Cheektowaga, NY 14225; Tele: 800.999.0555, 716.632.8413; Fax: 716.632.8324; E-mail: info@surfaceamerica.com; Web: www.surfaceamerica.com.
   3. “Vitriturf; V-10 System” (EPDM Standard & Mirco), as manufactured by Hanover Specialties Inc., 35 Feldland Street, Bohemia, NY 11716; Tele: 631.231.1300; Fax: 631.231.1329; E-mail: stevenoskin@vitriturf.com; Web: www.vitriturf.com.

B. Any manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is not a proprietary specification, and it should be noted that "or equivalent" applies to all products denoted herein. It is understood that all manufacturers will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equivalent. It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that can supply similar products.

C. Other manufacturer’s products accepted by the Awarding Authority as equal to the specified products in terms of construction, quality, durability, performance, and or appearance. Submit as substitutions: see Section 012500 “SUBSTITUTION PROCEDURES”.

2.02 UNITARY SYNTHETIC DUAL-DENSITY SEAMLESS SURFACE (Poured-in-Place Resilient Rubber Surfacing; bonded rubber seamless surface or PIP)

A. Surface System: Poured-in-place, two-layer system with wearing course over cushion course. Provide manufacturer's standard thickness for each layer for overall thickness indicated, tested for impact attenuation according to ASTM F 1292-17 or latest version, and for accessibility according to ASTM F 1951-14 or latest version.
   1. Products: Subject to compliance with requirements, provide the following, or approved equal:
      a. “DuraTurf Poured in Place (PIP)” (**TPV**) as manufactured by Robertson Recreational Surfaces/Sport Surface Specialties (PlayCore, Inc.); New England Region Address; P.O. Box 577, East Aurora NY 14052; Telephone: 716.652.2039 Fax: (716)805.1001; Website: www.sportsurface.net

b. “Playbound Poured-in-Place, Extreme-10” (**EPDM**) with aliphatic urethane, as manufactured by Surface America, Inc.(Ecore Co.), 505 Aero Drive; Suite 1, Cheektowaga, NY 14225; Telephone: 800.999.0555, 716.632.8413; Fax: 716.632.8324; E-mail: info@surfaceamerica.com; Website: www.surfaceamerica.com
c. “Vitriturf; V-10 System” (**EPDM Standard & Micro**), as manufactured by Hanover Specialties Inc., 35 Feldland Street, Bohemia, NY 11716; Telephone: 631.231.1300; Fax: 631.231.1329; E-mail: stevenoskin@vitriturf.com; Website: www.vitriturf.com

2. Primer/Adhesive: Manufacturer’s standard primer and weather-resistant, moisture-cured aliphatic polyurethane adhesive suitable for unit, substrate, and location indicated.
3. Wearing Course: Formulation of TPV or EPDM rubber particles, as recommended by the manufacturer. All colors shall be UV stable for a minimum of five years. Polymer content shall be 25 percent minimum. Aliphatic grout or .5-to-1.5-millimeter granules shall be applied under all high impact areas. Tiles will not be allowed. Wear mats will not be allowed. Black rubber used in the wear course shall be pre consumer high quality virgin rubber.
4. Cushion Course: Manufacturer’s standard formulation of SBR particles and polyurethane, site mixed and applied. Rubber SBR mix may not contain wire, metal, or fabric.
5. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane complying with requirements of authorities having jurisdiction for nontoxic and low VOC content. No TDI urethanes will be permitted.
6. Cushion Course/Base Mat Thickness: The type of playground equipment determines the required cushion course/base mat thickness, and the cushion course/base mat thickness may be different at various locations on the playground site. Specify project requirements per individual equipment specifications supplied by play equipment manufacturer(s).
7. Critical Height: Choose a protective surfacing material that has a Critical Height Value of at least the height of the Highest Accessible Part/Fall Height of the adjacent equipment. (Ref. ASTM F1487.) Typical Fall Heights range between three feet (one meter) and 10 feet (three meter) depending on the equipment configuration. See individual equipment requirements as supplied by play equipment manufacturer(s).
8. Overall Thickness: Not less than the minimum fall height as indicated by the individual play equipment specifications per the manufacturer’s information and for critical height indicated on Drawings. Overall Thickness ranges from 1-1/2-inches (38 millimeters) to four-inches (100 millimeters). See individual equipment requirements as supplied by play equipment manufacturer(s).
9. Thickened High-use Wearing Course to be one-inch thick.
    a. Location: As indicated on Drawings.
10. Wearing Course Color(s): as selected by Owner’s Representative and indicated on the drawings from manufacturer's full range.
    a. Color and Pattern: As indicated on Drawings and in Specification.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by playground surface system manufacturer.

2.03 EDGE RESTRAINTS

A. Job-Built Concrete Edge Curb Restraints: Comply with requirements in Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 5,000 pounds per square inch (34 Megapascals).

B. Stone Edge Curb Restraints: Comply with requirements in Section 04 43 00 "STONE SITE MASONRY" for stone curbing in shapes and sizes indicated.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content, sub grade and substrate conditions, drainage, and other conditions affecting performance of the Work. Drainage at the low end of the site is of the utmost importance. Any brick or concrete walls or curbs at the low end of the area to receive the play surface shall have drainage access via weep holes. Weep holes shall extend a minimum of two inches above the top of the new concrete slab and a minimum of 1/8 inch below the top of the new concrete slab. The latter is necessary because the rubber surfacing system is porous and water to permeate (drain downward) to the concrete slab.

B. General Contractor shall coordinate other paving schedules to make sure playground surfacing has a clear, defined and well-structured edge prior to proceeding with installation.

C. Hard-Surface Substrates: Verify that substrates are satisfactory for unitary playground surface system installation and that substrate surfaces are dry, cured, and uniformly sloped to drain within recommended tolerances according to playground surface system manufacturer's written requirements for cross-section profile.

1. Crushed Stone: dense graded aggregate base shall be a homogeneous mixture of fine and medium stone (3/4-inch stone) applied in multiple layers and compacted using a mechanical compactor and/or roller to provide an even plane. The crushed stone base shall be tightly compacted and smooth to a Standard Proctor Compaction of 95 percent or greater (as per ASTM test). Depth of the dense graded aggregate base shall be between four and six inches to achieve Standard Proctor Compaction. Thickness shall not exceed ten inches. Crushed stone shall be contained. Use filter fabric when using rubber tiles, but not with PIP Resilient Rubber surfacing. This base is not acceptable for mounding areas. In this case the crushed stone base shall be skim-coated with concrete or asphalt to be stabilized.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. General: Prepare substrates to receive surfacing products according to playground surface system manufacturer's written instructions. Verify that substrates are sound and without high spots, ridges, holes, and depressions.

B. Crushed Stone Substrates: Provide sound surface free of laitance, efflorescence, curing compounds, and other contaminants incompatible with playground surface system.

1. Repair unsatisfactory surfaces and fill holes and depressions.
2. Mechanically scarify or otherwise prepare concrete substrates to achieve recommended degree of roughness.
3. Saw cut concrete for terminal edges of playground surface systems as indicated.
4. Treat control joints and other nonmoving substrate cracks to prevent telegraphing through playground surface system.
5. Provide 3/4-inch homogenous crushed stone per Section 31 00 00 "EARTH MOVING".
6. The crushed stone base shall be tightly compacted to a 95 percent Standard Proctor Compaction (per ASTM test) and smooth.
7. A two percent maximum (one percent minimum) slope is recommended.

3.03 INSTALLATION, GENERAL

A. General: Comply with playground surface system manufacturer's written installation instructions. Install playground surface system over area and in thickness indicated.

B. Tolerances: Do not exceed 1/32-inch (0.8-millimeters) unit-to-unit offset from flush (lippage) nor 1/8 inch in 10 feet (three millimeters in three meters) from level, or indicated slope, for finished surface of paving.

3.04 EDGE RESTRAINTS

A. Provide edge restraints as indicated

B. All edge restraints shall be flush to avoid any tripping hazards or dips that could cause differential settlement of surfacing, ponding of water and ultimately failure of safety surfacing.

C. Install edge restraints before placing safety surfacing.

1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after safety surfacing installation.
2. Install job-built concrete edge curb restraints to comply with requirements in Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)".
3. Install stone edge curb restraints to comply with requirements in Section 04 43 00 "STONE SITE MASONRY".

3.05 GEOSYNTHETIC INSTALLATION

A. General: Install geosynthetics according to playground surface system manufacturer's and geosynthetic manufacturer's written instructions.

1. Geotextiles: Completely cover area indicated, overlapping sides and edges a minimum of four inches (100 millimeters) with manufacturer's standard treatment for overlapping loosely laid seams.
   a. Perimeter: Adhere edges on all sides to top of perimeter curb or footing.

3.06 INSTALLATION OF UNITARY SYNTHETIC DUAL-SENSITY SEAMLESS PLAYGROUND SURFACE SYSTEMS (Poured-in-Place Resilient Rubber Surfacing; bonded rubber seamless surface or PIP).

A. Seamless Surface: Mix and apply components of playground surface system according to manufacturer's written instructions to produce a uniform, monolithic wearing surface and impact-attenuating system of total thickness indicated.

1. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
2. Poured Cushion Course: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation, with a minimum of cold joints. Thickness of cushion course should meet ASTM 1292-17 or latest version guidelines. Varying thickness is allowed to match fall height.
3. Intercoat Primer: Over cured cushion course, apply primer at manufacturer's standard spreading rate.
4. Wearing Course: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation and, except where color changes, with a minimum of cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.
   a. Where colored pattern is or graphics are indicated, place adjacent colored material as soon as placed colored material is sufficiently cured, using primer or adhesive if required by manufacturer's written instructions.
5. Lacquer Topcoat: Spray or roller applied at manufacturer's standard coating rate in one continuous operation. Apply two coats of aliphatic polyurethane binder to ensure bonding of rubber particles.
6. Edge Treatment: As indicated on the Drawings. Fully adhere edges to substrate with full coverage of substrate. Maintain fully cushioned thickness required to comply with safety performance requirements.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing and inspecting completed applications of the playground surface system shall take place according to ASTM F 1292-17 or latest version. The following testing reports shall be presented before substantial completion:
   1. Shock Attenuation (ASTM F 1292-17 or latest version).
   2. Gmax: Less than 150.
   3. Head Injury Criteria (HIC): Less than 850.
   4. Flammability (ASTM D 2859): Pass.
   5. Tensile Strength (ASTM D 412): 60 pounds per square inch (413 kilopascal).
   6. Tear Resistance (ASTM D624):140 percent.
   7. Water Permeability: 0.4 gallons per square yard per second.
   8. Accessibility: Compliant with requirements of ASTM F 1951.

C. Remove and replace applications of playground surface system where test results indicate that it does not comply with requirements.

D. Additional testing and inspecting, at General Contractor's expense, from a third-party CPSI certified inspector, will be performed to determine compliance of replaced or additional work with requirements.

3.08 PROTECTION

A. Tile Systems: Prevent traffic over the system for not less than 48 hours after installation. General Contractor shall utilize a temporary chain link mesh construction fence along all publicly accessible playground protective surface edges. Fence shall be closed and secured with a lock and/or meet structure walls flush without any gaps. Any vandalism or damage shall be repaired by the General Contractor and no extra cost to the Owner.

3.09 MAINTENANCE INSTRUCTIONS FOR OWNER:

A. For all types of surfacing: Visual Observation: Owner shall observe that the level of Playground Protective Surface does not fall below the design depth (refer to post line demarcations). For unitary bound surfacing, this observation should be carried out a minimum of two times a year, especially after installation, as there will be settling of material. Observations always depend on the frequency of use in addition to manufacturer’s recommendations.

B. Poured-in-place Rubber Surface
   1. In order to maintain the top TPV or EPDM surface in compliance, a roll coat of Polyurethane Binder Composition should be applied to the entire top surface every 18 months. This cost is not included in these Contract Documents; however, it is recommended by the manufacturers.
   2. Keeping the surface clean of debris is critical in maintaining the product and its optimal performance (impact attenuation properties). A minimum of biweekly cleaning is recommended by most manufacturers. Owner should refer to manufacturer’s instructions for approved cleaning products.

END OF SECTION

SECTION 32 18 23.43
RECREATIONAL PAVEMENT MARKINGS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes:
   1. Painted markings applied to asphalt basketball court pavement.
   2. Painted markings applied to asphalt four-square pavement.

B. Related Requirements:
   1. Section 03 30 00.13 “CAST-IN-PLACE CONCRETE (SITE)” for pavement and walks.
   2. Section 31 00 00 "EARTH MOVING" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
   3. Section 32 12 16.36 “ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT”.
   4. Section 32 18 10 “COURT SURFACING” for basketball, and four-square.

1.03 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to marking pavement including, but not limited to, the following:
      a. Pavement aging period before application of pavement markings.
      b. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include technical data and tested physical and performance properties.

B. Shop Drawings: For pavement markings.
   1. Indicate all basketball, and four-square, colors and dimensions to adjacent Work.

C. Samples: For each exposed product and for each color and texture specified.

D. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. Product Data for Credit IEQ 4.2: For interior, field-applied, pavement-marking paints, documentation including printed statement of VOC content.
   3. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
   4. LEED Sustainable Sites Credit 7.1, Non-roof: Submit letter from manufacturer certifying the solar reflectance index (SRI) of the paving is 29 or greater.
   5. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements for pavement-marking work.

B. Delivery and Handling:

1. Deliver materials and products and provide adequate protection against damage.
2. Handle in strict compliance with manufacturer's instructions and recommendations and store off the ground.
3. Protect from all possible damage including, but not limited to chipping, staining, cracking and other damage.
4. Sequence deliveries to avoid delays but minimize on-site storage.

1.06 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not apply asphalt | bituminous concrete materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the ambient or base surface temperature is less than 40 degrees Fahrenheit (4.4 degree Celsius), or if surface is wet or frozen.
2. Do not apply the pavement markings in foggy or rainy weather, or when the ambient temperature is below 45-degree Fahrenheit (7.2-degrees Celsius) for alkyd materials, below 55-degrees Fahrenheit (12.8-degrees Celsius) for water-based materials, and not exceeding 95-degrees Fahrenheit (35-degrees Celsius), or if such conditions are anticipated during the next 48-hours.

PART 2 PRODUCTS

2.01 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Graded Aggregate for Subbase and Base for court construction shall be sound, crushed stone or gravel complying with requirements in Section 31 00 00 "EARTH MOVING" for subbase material.

2.02 ASPHALT | BITUMINOUS CONCRETE MATERIALS

A. Asphalt | bituminous concrete paving for basketball court, and four-square construction shall be Class I, Type I-1 hot plant mix, conforming to the applicable sections of the MassDOT Highway Division Standard Specifications (for Highways and Bridges) and shall consist of two courses of asphalt | bituminous concrete with a minimum finished pavement thickness as shown on Drawings and specified in Section 32 12 16.36 "ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT PAVING".

2.03 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Latex-ite; Dalton Coatings.
2. Transpo Industries.
3. Aexcel Inc.
4. Benjamin Moore & Co.
5. Columbia Paint & Coatings.
6. Ennis Traffic Safety Solutions, Inc.
7. PPG Industries.
8. Sherwin-Williams Company (The).

2.04 BASKETBALL COURT-MARKING PAINT

A. Basketball Court- Marking Paint: Acrylic Latex line-marking paint.

B. The layout and design of color sealing shall be installed per Drawings.

C. Color:
   1. Line Markings on basketball court shall be white textured line paint.
   2. Apply all acrylic paint colors in two coats each.
   3. Basketball Court Color X: COLOR
   4. Basketball Court Color X: COLOR

2.05 FOUR SQUARE-MARKING PAINT

A. Four Square- Marking Paint: Acrylic Latex line-marking paint.
B. The layout and design of color sealing shall be installed per Drawings.
C. Color:
   1. Line Markings on four-square shall be white textured line paint.
   2. Apply all acrylic paint colors in two coats each.
   3. Four-Square Color X: COLOR
   4. Four-Square Color X: COLOR

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.
B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
C. Verify gradients and elevations of base are correct.
D. Proceed with paving only after unsatisfactory conditions have been corrected.

3.02 SUBBASE

A. Construct subbase in accordance with Drawings and Section 31 00 00 "EARTH MOVING".

3.03 ASPHALT | BITUMINOUS CONCRETE PAVING

A. Construct subbase in accordance with Drawings and 32 12 16.36 "ATHLETIC ASPHALT | BITUMINOUS CONCRETE SPORT COURT PAVING".

3.04 PAVEMENT AND COURT MARKING EXAMINATION

A. Verify that pavement is dry and in suitable condition to begin pavement marking according to manufacturer's written instructions.
B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

3.05 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Owner’s Representative.
B. Allow paving to age for a minimum of 30 days before starting pavement marking.
C. Sweep and clean surface to eliminate loose material and dust.
D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils (0.4 millimeters).
   1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to pavement. Mask an extended area beyond edges of each stencil to prevent paint application beyond the stencil. Apply paint so that it cannot run beneath the stencil.

3.06 COURT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Owner’s Representative.
B. Allow paving to age for a minimum of 30 days before starting pavement marking.
C. Sweep and clean surface to eliminate loose material and dust.
D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils (0.4 millimeters).

E. Marking Application:
   1. Basketball, and Four-Square lines shall be 100 percent acrylic line paint containing no alkyds, butadiene styrene or vinyls and shall be thinned with water only.
   2. The paint shall be suitable for application by brush, spray or roller using masking tape or templates. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to pavement. Mask an extended area beyond edges of each stencil to prevent paint application beyond the stencil. Apply paint so that it cannot run beneath the stencil.
   3. The paint shall be suitable for use over all types of asphalt surfaces and when applied over emulsified asphalt, it shall not cause lifting, crazing, peeling, or other damage to the base.
   4. Basketball, and Four-square lines shall be striped twice with complete court markings. The first markings shall be installed directly on the asphalt surface to allow the courts to be used prior to the installation of color surfacing. The second installation of court markings shall be performed after the color surfacing is installed and accepted by the Owner's Representative.

3.07 WARRANTY

A. The General Contractor shall provide the manufacturer's standard written warranty for each product within this specification. All of these warranties shall be in addition to, and not in lieu of, other liabilities that the General Contractor may have by law or other provisions of the Contract Documents.

B. The pavement and line striping shall be guaranteed against defects in workmanship or quality for a period of one year after final acceptance. The General Contractor shall replace, repair, recoat or otherwise make satisfactory to the Owner any unacceptable pavement and/or coating at no additional cost to the Owner.

3.08 CLEANING, REPAIR AND PROTECTION

A. Protect pavement markings from damage and wear during remainder of construction period.

B. Repair minor damage to eliminate all evidence of repair. Remove and replace Work that cannot be satisfactorily repaired.

C. Provide temporary protection to ensure that the Work shall be without dirt, stains, damage or deterioration at the time of final acceptance. Clean up stains and spills as they occur. Remove protections and clean immediately before final acceptance.

D. Upon completion of the Work and before acceptance, the General Contractor shall remove and dispose of in an accepted manner al surplus materials, and rubbish, which the General Contractor may have accumulated during the course of the Work and shall leave the site in a clean and orderly condition. The General Contractor shall not abandon any materials at or near the site regardless of whether or not it has any value.

END OF SECTION

SECTION 32 31 00
SELF-LATCHING GATE LATCHES AND LOCKS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Self-Latching Gate Latch – Vertical Pull.
   2. Self-Latching Gate Latch Round Post Kit; Model.
   3. Self-Latching Gate Latch Spacer; Model.

B. Related Requirements:
   1. Section 32 31 13 “CHAIN LINK FENCES AND GATES” for chain link mesh fences at playgrounds or children play areas.
   2. Section 32 31 19.11 “ANTI-RAM METAL FENCES AND GATES” for anti-ram fencing at playgrounds or children play areas.

1.03 REFERENCES

A. The following Standards shall apply to the Work of this Section:
   1. ASTM: American Society for Testing and Materials:
      ASTM F2049-11 – Standard Safety Performance Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas.
   2. FCC: Federal Communications Commission:
      FCC 47 CFR Part 15 Subpart B – Unintentional Radiators. (Models: ML3ATPKAG2 and ML3AVPKAG 2only).

B. Definitions:
   1. Ideal Gate Gap: Optimal horizontal distance between gate frame and fence post at which the products in this specification are mounted thereto. On products with a fixed gate gap, do not deviate from manufacturer’s recommendation.
   2. Gate Gap Variance: Horizontal distance range between gate frame and fence post at which the products in this specification are mounted thereto. Do not deviate from manufacturer’s horizontal distance range.

1.04 ACTION SUBMITTALS

A. Submit under provisions of Section 01 30 00 “ADMINISTRATIVE REQUIREMENTS”.

B. Product Data: Submit product data sheets for each type of product used on project with full model code.

C. Hardware Schedule:
   1. Submit hardware schedule detailing hardware to be provided at each opening for coordination with gate frames, fence posts and related work.
   2. For load bearing hardware, provide product information showing quantity and type of hardware recommended by manufacturer to safely carry weight of gate and other applied loads.
   3. Coordinate requirements with Site Operator and/or Site Owner and indicate desired position of gate within fence line. This will determine the spacing of the mounting brackets.

D. Installation Instructions: Submit manufacturer's installation instruction for each hardware device. Mark installation instructions to indicate mounting heights for all operable hardware showing compliance with applicable codes requirements, including, but not limited to:
   1. ASTM F2049-11 (Standard Safety Performance Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas).
E. Warranty: Submit copy of manufacturer's warranty for each product.
F. Extra Materials: At project closeout provide installation and adjustment instructions, warranties and advisories, extra parts, accessories, and tools normally provided by manufacturer with installed hardware for maintenance and adjustment of installed hardware.

1.05 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Continuously engaged in manufacturing of gate and fencing hardware of similar type to that specified, with a minimum of 30 years successful experience.
   2. D&D Technologies operates a fully accredited and internationally recognized ISO 9001-2015 Quality Assurance System, which governs the design and manufacture of all our products.
   3. Member: American Fence Association (AFA).

1.06 WARRANTY

A. Limited Lifetime Warranty – Mechanical latching devices listed.

1.07 COMMISSIONING

A. Conduct these tests prior to requesting a certificate of substantial completion:
   1. With Installer present, test gate hardware operation.
   2. With Installer present, ensure gate hardware meets requirements set out in Section 1.3 REFERENCES.
   3. With installer present, ensure documents and instructions are handed to Site Operator and/or Site Owner.
   4. With Installer present, ensure keys and adjustment key tag are handed to Site Operator and/or Site Owner.
   5. With Installer present, ensure training is provided to Site Operator and/or Site Owner, including operating, making adjustments and conducting regular inspection and maintenance as per manufacturer's requirements set out in Part 3 EXECUTION.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:
   1. D&D Technologies Inc., 7020 Reames Rd. Suite D, Charlotte, NC 28216; Telephone: 800.716.0888; Fax: 800-464-6400; E-mail: info@ddtechusa.com; Website: https://us.ddtech.com.
   2. Nationwide Industries, 3505 Cragmont Drive, Tampa, FL, 33619; Telephone: 813.988.2628; Email: info@nationwideindustries.com; Website: https://nationwideindustries.com.
   3. DAC Industries, Inc., 600 Eleventh Street, N.W., Grand Rapids, MI 49504; Telephone: 800.888.9768; Fax: 616.235.2901; Website: https://dacindustries.com.
B. Any manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required.

This is not a proprietary specification, and it should be noted that "or equivalent" applies to all products denoted herein. It is understood that all manufacturers shall have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equivalent. It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that can supply similar products.

C. Other manufacturer's products accepted by the Awarding Authority as equal to the specified products in terms of construction, quality, durability, performance, and or appearance. Submit as substitutions: see Section 012500 "SUBSTITUTION PROCEDURES".

2.02 SELF-LATCHING GATE LATCH – VERTICAL PULL

A. Basis-of-Design Project: Self-latching gate latch: Self-Latching latches shall be MagnaLatch Series 3 Vertical Pull variants as manufactured by D&D Technologies Inc. or approved equal.
   1. Magnetic self-latching gate latch:
      a. Automatic self-latching upon gate closure.
      b. No mechanical jamming during closure and stops the latch from disengaging due to shaking the gate.
   2. Vertical Pull Variants –
      a. Suitable for taller play area gates that are 60-inches (1,500-millimeters) or higher as per ASTM F2049-11 (Standard Safety Performance Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas), or where child safety is important. Always confirm local fence / barrier regulations before installation
      b. Suitable for mounting on garden or household gates to provide a reliable safety barrier. Always confirm local fence / barrier regulations before installation
   3. Mounting: To be mounted on corners of posts with front and side fixing points and suitable for Fencing Materials: Metal, Wood and Vinyl. Chain link requires round posts adapters (ML3RPK) – Refer to section on Self-Latching Gate Latch Accessories.
   4. Orientation: Suitable for left or right-handed gate – rotate striker to suit orientation.
   5. Recommended and Minimum post sections – refer to table below.
   6. Ideal Gate Gap and Gap Variance – refer to table below.

MagnaLatch Series 3 Vertical Pull Models

Model Code	Color	Recommended Post Section		Minimum Post Section		Ideal Gate Gap*	Gap Variance*	Vertical Adjustment
		Latch	Striker	Latch	Striker			
ML3VPKA	Black	1-3/16" by 1-3/16" (30mm by 30mm)	1-3/4" by 1-3/4" (40mm by 40mm)	1" by 1" (25.4mm by 25.4mm)	1" by 1" (25.4mm by 25.4mm)	3/4" (19mm)	1/2" to 1-1/2" (13-38mm)	1-1/2" (38mm)
ML3VPKAWT	White							
ML3AVPKAG2	Black							

* For larger gate gap and/or increased gap variance, use ML3SPACER.

B. Performance Requirements:
   1. General: Provide fence(s) and gate(s) that have been designed and fabricated to specified performance requirements, as demonstrated in Section 1.3 REFERENCES.
   2. Compliance:

a. Suitable for safety applications, such as child safety gates of 60-inches (1,500-millimeters) or higher – ASTM F2049-11 (Standard Safety Performance Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas), and required to be paired suitable with gate closers. Always confirm local fence / barrier regulations before installation.
b. When used on play area gates as per ASTM F2049-11 (Standard Safety Performance Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas), the MagnaLatch Series 3 Vertical Pull Models shall be paired with suitable self-closing devices for the gate or gate closers. Always confirm local fence / barrier regulations before installation.

3. Suitable for safety applications, such as child safety gates where gates are 60-inches (1,500-millimeters) or higher. Always confirm local fence / barrier regulations before installation.
4. Recommended and Minimum post sections – refer to table above.
5. Ideal Gate Gap and Gap Variance – refer to table above.
6. Operation Temperature range:
   a. -40 degrees Fahrenheit to 140 degrees Fahrenheit (-40 degrees Celsius to 60 degrees Celsius) – Mechanical latching devices.
7. Suitable applications – refer to table below.

MagnaLatch Series 3 Vertical Pull Models – Applications	
Suitable Applications	Suitable Gate and Fencing Materials
• Swimming Pool Safety Gates (ASTM F1908-08 [Standard Guide for Fences for Residential Outdoor Swimming Pools, Hot Tubs, and Spa])**. • Outdoor Play areas (ASTM F2049-11 [Standard Safety Performance Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas])**. • Child Safety Gates. • Pedestrian Gates. • Garden Gates. • Household Gates.	• Metal • Wood • Vinyl • Chain Link***
** Gates are 60-inches (1,500millimeters) or higher and MagnaLatch Series 3 Vertical Pull Models shall be paired with suitable self-closing devices for the gate or gate closers. Always confirm local fence / barrier regulations before installation. *** Requires round posts adapters ML3RPK. See Section 2.5 on ML3RPK below for details and dimensions for Chain Link applications.	

C. Components
   1. Magnetic Latching:
      a. Automatic self-latching upon gate closure.
   2. Lock:
      a. Six-pin re-keyable security lock – re-keyable to match door set. Use Kwikset KW5 blank.
      b. Visual Lock Indicator for knowing when latch is locked or unlocked.
   3. Mounting and Adjustment:
      a. Height setting screw with fine increments to ensure release mechanism knob out is positioned out of reach to meet ASTM F2049-11 (Standard Safety Performance

Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas). Always confirm local fence / barrier regulations before installation.

b. To be mounted on corners of posts with front and side fixing points.
c. Alignment Indicators on latch and striker to show recommended alignment.
d. Vertical & horizontal adjustment.

4. Materials:
   a. Engineered polymer and aluminum construction with stainless steel components.

2.03 SELF-LATCHING GATE LATCH ROUND POST KIT

A. Self-latching gate latch round post kit shall be MagnaLatch Series 3 Round Post Kit as manufactured by D&D Technologies Inc.
   1. Recommended for use on MagnaLatch Series 3.
   2. Round Post Adaptor Kit: Optional kit for mounting MagnaLatch Series 3 models to gates and fences with round posts. Kit includes adaptor brackets and shims for the following chain link fitments.

MagnaLatch Round Post Kit – Chain Link Shim Fitments	
Post Size	Shim type
Fence post diameter 2-3/8” (60mm)	No shim required. Fence Post adapter bracket is suited for 2-3/8” (60mm) diameter.
Fence post diameter 1-7/8" – 2” (48-51mm)	Use shim marked 2” (51mm) provided
Fence post diameter 2-7/8” (73mm)	Use shim marked 2-7/8” (73mm) provided
Gate frame diameter 1-5/8" (41mm)	No shim required. Gate frame adapter bracket is suited for 1-5/8" (41mm) diameter.
Gate frame diameter 1-3/8" (35mm)	Use shim marked 1-3/8" (35mm) provided

2.04 SELF-LATCHING GATE LATCH SPACER

A. Self-latching gate latch spacer shall be MagnaLatch Series 3 Spacer as manufactured by D&D Technologies Inc.
   1. Recommended for use on MagnaLatch Series 3.
   2. Two-inch Gate Gap Spacer: MagnaLatch Series 3 comes standard with a gate gap variance of 1/2-inch to 1-1/2-inch (13-38-millimeters). Use gap spacer for gaps of 1-1/2-inch to 2-inch (38-50-millimeters).

PART 3 EXECUTION

3.01 EXAMINATION

A. Site Operator and/or Site Owner to examine gate frames and fence posts, with Installer present, for compliance with requirements for gate hardware installation tolerances, assembly construction, and other conditions affecting performance.
B. Proceed with installation once part A above has been met.

3.02 PREPARATION

A. Prepare gate frames and fence posts in accordance with manufacturer's installation instructions. Existing gate hardware shall be removed before installation. Apply corrosion protection and finish to exposed screw hole or area left over from the removal of existing hardware before installation of D&D Technologies' hardware.

3.03 INSTALLATION

A. Install each hardware items to comply with manufacturer's installation instructions, building code requirements, and requirements of Authorities Having Jurisdiction.
B. Install hardware types and quantities indicated on submitted hardware schedule.
C. Do not install surface-mounted hardware until substrate finishes have been completed.
D. Set all gates, fence posts and gate hardware level, plumb and true to line and location. Adjust and reinforce attachments where necessary for proper installation and operation.
E. Make final installation inspection with Site Operator and/or Site Owner and make final adjustments prior to acceptance, in particular where ASTM F2049-11 (Standard Safety Performance Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas) and/or local fence / barrier regulations are essential. The key points are as follows:
    1. Check placement and position of the release mechanism knob with respect to the standards mentioned above. Always confirm with local fence / barrier regulations.
    2. Check alignment between the latching pin of the latch and the keeper of the striker to ensure the latching pin is engaged with the keeper when the gate is in the closed position. Note MagnaLatch Series 3 Vertical Pull Models have alignment indicators for optimal alignment. Where applicable, make necessary adjustment(s) as per manufacturer's recommendation. Always confirm with local fence / barrier regulations.
    3. Check paired self-closing devices for the gate or gate closers to enable the gate to be closed from any position and allow the latching pin to be engaged with the keeper. Where applicable, make necessary adjustment(s) as per manufacturer's recommendation. Always confirm with local fence / barrier regulations.
    4. Check for any obstruction(s) or potential obstruction(s) that prevents the latching pin being engaged with the keeper when the gate is in the closed position.
F. Ensure documents and instructions are handed to Site Operator and/or Site Owner.
G. Ensure keys and adjustment key tag are handed to Site Operator and/or Site Owner.
H. Ensure training is provided to Site Operator and/or Site Owner including operating, making adjustments and regular maintenance is carried out as per manufacturer's requirements.
I. Highlight to Site Operator and/or Site Owner the following warning notes:
    1. MagnaLatch Series 3 Vertical Pull Models:
        a. Safety warning label on the side of the tube.
        b. Adjustment key tag with key.
    2. MagnaLatch Side Pull Lockable: Adjustment key tag with key.

3.04 MAINTENANCE

NOTE: Gates and Fencing can move due to wind loading, ground movement, and/or other factors. This can cause alignment to shift. Therefore, Site Operator and/or Site Owner shall ensure the following inspection and maintenance is carried out on a regular basis or when the gate(s) is prevented from being self-closed and its self-latching device is prevented from self-latching, i.e. the latching pin engaging with the keeper.

A. Check alignment between the latching pin of the latch and the keeper of the striker to ensure the latching pin is engaged with the keeper when the gate is in the closed position during regular maintenance and make adjustments where required to maintain alignment. Note MagnaLatch Series 3 Vertical Pull Models have alignment indicators for optimal alignment.
B. When self-latching gate latch is paired with suitable self-closing devices for the gate or gate closers to comply with ASTM F2049-11 (Standard Safety Performance Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas) and/or local fence / barrier regulations, always carry out maintenance on both self-latching gate

latch and suitable closing devices for the gate or gate closers at the same time. The key points are as follows:

1. Check placement and position of the release mechanism knob with respect to the standards mentioned above.
2. Check alignment between the latching pin of the latch and the keeper of the striker to ensure the latching pin is engaged with the keeper when the gate is in the closed position. Note MagnaLatch Series 3 Vertical Pull Models have alignment indicators for optimal alignment. Where applicable, make necessary adjustment(s) as per manufacturer's recommendation.
3. Check paired self-closing devices for the gate or gate closers to enable the gate to be closed from any position and allow the latching pin to be engaged with the keeper. Where applicable, make necessary adjustment(s) as per manufacturer's recommendation.
4. Check for any obstruction(s) or potential obstruction(s) that prevents the latching pin being engaged with the keeper when the gate is in the closed position.

END OF SECTION

SECTION 32 31 13
CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Chain Link fences.
   2. Gates: swing.
   3. Gates: swing, self-closing latching.
   4. Gate lock: per Owner's specifications (to be coordinated with installation)

B. Related Sections:
   1. Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for cast-in-place post footings.
   2. Section 31 00 00 "EARTH MOVING" for excavation for installing concrete footings.
   3. Section 32 31 00 "SELF-LATCHING GATE LATCHES AND LOCKS" for gates at playgrounds or children's play areas.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design chain link fences and gates, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Chain link fence and gate framework shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions.

C. Lightning Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain link fences and gates.
   1. Fence and gate posts, rails, and fittings.
   2. Chain link fabric, reinforcements, and attachments.
   3. Gates and hardware.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.

C. Samples for Initial Selection: For components with factory-applied color finishes.

D. Delegated-Design Submittal: For chain link fences and gate framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer registered in Massachusetts responsible for their preparation.

E. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.

a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.

3. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Factory-authorized service representative.
B. Product Certificates: For each type of chain link fence and gate, from manufacturer.
C. Product Test Reports: For framing strength according to ASTM F 1043.
D. Field quality-control reports.
E. Warranty: Sample special warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
   1. Powder-coated Polymer finishes.
   2. Gate hardware.

1.07 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing fence grounding. Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
B. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for gates with automatic gate operators serving as a required means of access.

1.08 PROJECT CONDITIONS

A. Field Measurements: Verify layout information for chain link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.
B. The General Contractor and his Subcontractors shall inspect all subbases for unstable, unsuitable or improperly prepared areas. Do not begin work over unacceptable areas. Beginning work means the General Contractor and his Subcontractors accept the subbase, previous work and conditions and shall be held responsible for any corrections required to properly implement the Construction Documents.
C. The work of this Section shall be completely coordinated with the work of other Sections. Verify dimensions and work of other trades which adjoin materials of this Section before installing specified items.

1.09 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of chain link fences and gates that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Faulty operation of gate operators and controls.
      b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 CHAIN LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top, intermediate (as required per details), and bottom of outer edge of selvage knuckle or twist. Comply with CLFMI Product Manual and with the requirements indicated below:
   1. Fabric Height: As indicated on Drawings.
   2. Steel Wire Fabric: Six-gauge Wire with a diameter of 0.192 inch (4.8768 millimeteres).
      a. Mesh Size: Two inches (50 millimeters).

b. Zinc-Coated Fabric: ASTM A 392, Type II, Class 2, 2.0 ounces per square foot (610 grams per square meter) with zinc coating applied before weaving.
c. Polymer-Coated Fabric: ASTM F 668, Class 2b over Zinc-coated steel wire.
   1) Color: Black, complying with ASTM F 934.
d. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.

3. Selvage: Knuckled at both selvages.

2.02 FENCE FRAMING

A. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 or ASTM F 1083 based on the following:
   1. Fence Height: As indicated on Drawings.
   2. Light Industrial Strength: Material Group II-L, roll-formed steel C-section shapes.
      a. Line Post: 2 3/8-inch (60.3-millimeter) outside diameter.
      b. End, Corner and Pull Post: Three-inch (76.2-millimeter) outside diameter.
   3. Horizontal Framework Members: top, intermediate (as required per details), and bottom rails complying with ASTM F 1043.
      a. Top Rail: 1 5/8-inch (9.525-millimeter) outside diameter.
   4. Brace Rails: Comply with ASTM F 1043.
   5. Metallic Coating for Steel Framing:
      a. Type B, zinc with organic overcoat, consisting of a minimum 0.9 ounces per square foot (0.27 grams per square meter) of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.
   6. Polymer coating over metallic coating.
      1) Color: Black, complying with ASTM F 934.

2.03 TENSION WIRE

A. Metallic-Coated Steel Wire: 0.177-inch-(4.5-millimeter) diameter, marcelled tension wire complying with ASTM A 817 and ASTM A 824, with the following metallic coating:
   1. Type I, aluminum coated (aluminized).
   2. Type II, zinc coated (galvanized) by hot-dip process, with the following minimum coating weight:
      a. Class 4: Not less than 1.2 ounce per square foot (366 grams per square meter) of uncoated wire surface.

B. Polymer-Coated Steel Wire: 0.148-inch- (3.8-millimeter) diameter, tension wire complying with ASTM F 1664, Class 2b over zinc-coated steel wire.
   1) Color: Black, complying with ASTM F 934.

2.04 SWING GATES

A. General: Comply with ASTM F 900 for gate posts and single and double swing gate types.
   1. Gate Leaf Width: As indicated.
   2. Gate Fabric Height: As indicated.

B. Pipe and Tubing:
   1. Zinc-Coated Steel: Comply with ASTM F 1043 and ASTM F 1083; protective coating and finish to match fence framing.
   2. Gate Posts: Round tubular steel.
   3. Gate Frames and Bracing: Round tubular steel.

C. Frame Corner Construction: Welded or assembled with corner fittings.

D. Hardware:
   1. Hinges: 180-degree outward swing.

2. Latches: self-latching device placed four feet above finish grade or to comply with state and local playground regulations. Permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
3. Lock: Owner to specify type of electronic or key access required.
4. Closer: Manufacturer's standard.

2.05 FITTINGS

A. General: Comply with ASTM F 626.
B. Post Caps: Provide for each post.
   1. Provide line post caps with loop to receive tension wire or top rail.
C. Rail and Brace Ends: For each gate, corner, pull, and end post.
D. Rail Fittings: Provide the following:
   1. Top Rail Sleeves: Pressed-steel or round-steel tubing not less than six inches (152 millimeters) long.
   2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate (as required per details), and bottom rails in the fence line-to-line posts.
E. Tension and Brace Bands: Pressed steel.
F. Tension Bars: Steel, length not less than two inches (50 millimeters) shorter than full height of chain link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
G. Truss Rod Assemblies: Steel, hot dip galvanized after threading rod and turnbuckle or other means of adjustment.
H. Tie Wires, Clips, and Fasteners: According to ASTM F 626.
   1. Standard Round Wire Ties: For attaching chain link fabric to posts, rails, and frames, complying with the following:
      a. Hot-Dip Galvanized Steel: 0.148-inch- (3.76-millimeter-) diameter; galvanized coating thickness matching coating thickness of chain link fence fabric.
      b. Aluminum: Six-gauge wire; 0.192-inch- (4.88-millimeters) diameter wire; coating thickness match chain link fence fabric.
   2. Band-it Ties: For attaching chain link fabric to posts, rails, and frames, complying with the following:
      a. Hot-Dip Galvanized Steel or Stainless Steel: self-locking head with smooth edge, Nominal Size: 15 inches, Actual Length: 14.9 inch (378 millimeters); Width: 0.187 inch (4.76 millimeters); Max Bundle Diameter: Four inch; Minimum Loop Tensile: 200-pound Coating thickness and finish to match coating of chain link fence fabric.
I. Finish:
   1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 ounce per square foot (366 grams per square meter) zinc.
      a. Polymer coating over metallic coating.

2.06 GROUT AND ANCHORING CEMENT

A. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.
B. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer, for exterior applications.

2.07 FENCE GROUNDING

A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
   1. Material above Finished Grade: Copper.
   2. Material on or below Finished Grade: Copper.
   3. Bonding Jumpers: Braided copper tape, one inch (25 millimeters) wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Connectors and Grounding Rods: Comply with UL 467.
   1. Connectors for Below-Grade Use: Exothermic welded type.
   2. Grounding Rods: Copper-clad steel, 5/8 by 96 inches (16 by 2440 millimeters).

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
   1. Do not begin installation before final grading is completed unless otherwise permitted by Owner's Representative.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152.5 meters) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.03 INSTALLATION, GENERAL

A. Install chain link fencing to comply with ASTM F 567 and more stringent requirements indicated.
   1. Install fencing on established boundary lines inside property line.

3.04 CHAIN LINK FENCE INSTALLATION

A. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.
   1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
   2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
      a. Exposed Concrete: Extend two inches (50 millimeters) above grade; shape and smooth to shed water.
      b. Concealed Concrete: Top two inches (50 millimeters) below grade as indicated on Drawings to allow covering with surface material.
      c. Posts Set into Concrete in Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
      d. Posts Set into Voids in Concrete: Form or core drill holes not less than five inches (125 millimeters) deep and 3/4 inches (20 millimeters) larger than outside diameter of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.

3. Mechanically Driven Posts: Drive into soil to depths of 36 inches (914 millimeters). Protect post top to prevent distortion.

C. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 30 degrees or more.

D. Line Posts: Space line posts uniformly at 10 feet (three millimeters) on center.

E. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.

1. Locate horizontal braces at midheight of fabric 72 inches (1830 millimeters) or higher, on fences with top rail and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

F. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- (3.05-millimeter) diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches (610 millimeter) on center. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:

1. Extended along bottom of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within six inches (152 millimeters) of bottom of fabric and tie to each post with not less than same diameter and type of wire.

G. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.

H. Intermediate and Bottom Rails: Install and secure to posts with fittings.

I. Chain link Fabric: Apply fabric to outside of enclosing framework. Leave two inches (50 millimeters) between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

J. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches (380 millimeters) on center.

K. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.

1. Maximum Spacing: Tie fabric to line posts at 12 inches (300 millimeters) on center and to braces at 24 inches (610 millimeters) on center.

L. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

3.05 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.06 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals of 1500 feet (450 millimeters) except as follows:

1. Fences within 100 Feet (30 meters) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet (225 meters).

a. Gates and Other Fence Openings: Ground fence on each side of opening.

1) Bond metal gates to gate posts.
2) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches (460 millimeters) below finished grade.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet (45 meters) on each side of crossing.

C. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is six inches (150 millimeters) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location, including the following:
   1. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
   2. Make grounding connections to each barbed tape coil with connectors designed for this purpose.

D. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

E. Connections: Make connections to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   2. Make connections with clean, bare metal at points of contact.
   3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
   4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

F. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

3.07 FIELD QUALITY CONTROL

A. Grounding-Resistance Testing: Engage a qualified testing agency to perform tests and inspections.
   1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance no fewer than two full days after the last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
   2. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify Owner's Representative promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
   3. Report: Prepare test reports certified by a testing agency of grounding resistance at each test location. Include observations of the weather and other phenomena that may affect test results.

3.08 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout

entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

3.09 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain chain link fences and gates.

END OF SECTION

SECTION 32 31 19.11
ANTI-RAM METAL FENCES AND GATES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Anti-Ram Barrier and Gates– PU30/P2 Engineered Cable System; or Approved Equal.

B. Related Requirements:
   1. Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" for concrete bases for gate operators, drives, and controls and post concrete fill.
   2. Section 31 00 00 "EARTH MOVING" for excavation for installing concrete footings.
   3. General Contractor shall coordinate access control devices installed at gates and provided as part of a security system with the Owner.
   4. Section 32 31 00 "SELF-LATCHING GATE LATCHES AND LOCKS" for gates at playgrounds or children's play areas.

1.03 REFERENCES

A. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
B. ASTM B117 - Practice for Operating Salt-Spray (Fog) Apparatus.
C. ASTM D523 - Test Method for Specular Gloss.
D. ASTM D714 - Test Method for Evaluating Degree of Blistering in Paint.
E. ASTM D1654 - Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.
F. ASTM D2244 - Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.
G. ASTM D2794 - Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
H. ASTM D3359 - Test Method for Measuring Adhesion by Tape Test.
I. ASTM F2656 – Standard Test Method for Vehicle Crash Testing of Perimeter Barriers
J. Federal Specification RR-W-410E / Wire Rope and Strand.
K. ASTM F2408 – Ornamental Fences Employing Galvanized Steel Tubular Pickets.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Shop Drawings: For fences and gates. Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, and operational clearances.
C. Samples: For each fence material and for each color specified.
   1. Provide Samples: eight inches by 10 inches (203 by 254 millimeters) minimum size sample of fence panel illustrating design, fabrication workmanship, and selected color coating.
D. Delegated-Design Submittal: For anti-ram fence and gates framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer registered in Massachusetts responsible for their preparation.
E. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.

a. Include statement indicating costs for each product having recycled content.

2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
3. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.05 INFORMATION SUBMITTALS

A. Field quality-control reports.

B. Product Test Reports: For decorative metallic-coated-steel picket fences, including finish, indicating compliance with referenced standard and other specified requirements.

Product Test Reports: For decorative metallic-coated-steel picket fences, including finish, indicating compliance with referenced standard and other specified requirements.

1.06 CLOSEOUT SUBMITTALS

A. Maintenance Date.

1.07 QUALITY ASSURANCE

A. The Installation Contractor shall provide laborers and supervisors who are thoroughly familiar with the type of construction involved and materials and techniques specified. Installation Contractor used for this scope of work shall provide documentation from the manufacturer showing completion of core training on anti-ram barrier systems.

B. Installer Qualifications: Fabricator of products.

C. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.
   1. Include 10-foot (three-meter) length of fence complying with requirements.
   2. Subject to compliance with requirements, accepted mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.08 DELIVERY, STORAGE AND HANDLING

A. Upon receipt at the job site, all materials shall be checked to ensure that no damage occurred during shipping or handling. Materials shall be stored in such a manner to ensure proper ventilation and drainage, and to protect against damage, weather, vandalism and theft.

1.09 PRODUCT WARRANTY

A. All structural fence components (i.e., rails, pickets, and posts) shall be warranted within specified limitations, by the Manufacturer for a period of 20 years from date of original purchase. Warranty shall cover any defects in material finish, including cracking, peeling, chipping, blistering or corroding.

B. Reimbursement for labor necessary to restore or replace components that have been found to be defective under the terms of manufactures' warranty shall be guaranteed for five years from date of original purchase.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:
   1. Ameristar Fence Products, Inc., 1555 N. Mingo Road, Tulsa, OK 74116; Telephone: 888.333.3422; Website: www.ameristarfence.com.
   2. Ametco Manufacturing Corporation, 4326 Hamann Parkway, P.O. Box 1210, Willoughby, OH 44096; Telephone: 440.951.4300; Fax: 440.951.2542; E-mail: ametco@ametco.com; Website: www.ametco.com.

3. Ultra Aluminum Manufacturing Inc., 2124 Grand Commerce Drive, Howell, MI 48855; Telephone: 517.548.6755; Fax: 517.548.6756; Website: www.ultrafence.com.

B. Any manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is not a proprietary specification, and it should be noted that "or equivalent" applies to all products denoted herein. It is understood that all manufacturers will have minor variations in configuration, appearance, and product specifications and such minor variations will not eliminate such manufacturers as an equivalent. It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that can supply similar products.

C. Other manufacturer's products accepted by the Awarding Authority as equal to the specified products in terms of construction, quality, durability, performance, and or appearance. Submit as substitutions: see Section 012500 "SUBSTITUTION PROCEDURES".

2.02 ANTI-RAM METAL FENCES AND GATES

A. The anti-ram cable barrier system shall conform to the Stalwart II Majestic PU30/P2 Engineered design, manufactured by Ameristar Perimeter Security USA Inc., in Tulsa, Oklahoma. This system shall be PU30/P2 Engineered based on test results of similar design. Engineering analysis shall be based upon ASTM F2656, Impact Condition Designation PU30, Penetration Rating P2, with capability of stopping a 5,070 pound vehicle traveling at speeds up to 30 miles-per-hour.

B. Basis-of-Design Project: The integrated steel fence panel system shall conform to Montage Plus Ornamental Steel ornamental fencing, Majestic Design, 3-rail, manufactured by Ameristar Perimeter Security USA Inc. in Tulsa, Oklahoma, or approved equal.

C. Decorative Anti-Ram Steel Fences: "Montage Plus Ornamental Steel" manufactured by Ameristar Fence Products, Inc.
   1. Model: Majestic Design
   2. Style: Three-Rail; 1-1/4-inch by 1-7/16-inch rails (0.110-inch side wall/0.090-inch top wall/0.060-inch internal web); 3/4-inch square by 0.045-inch-thick pickets; 2-1/2-inch by 2-1/2-inch by 0.060-inch posts with reinforced web
   3. Height: Four feet high
   4. Color: Black

D. The entire anti-ram barrier system, and all associated panels, gates, accessories, fittings, and fasteners shall be obtained from a single source.

2.03 PERFORMANCE REQUIREMENTS

A. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.04 MATERIAL

A. Steel material for cable-supporting framework (i.e., rails and I-beam posts) shall be galvanized prior to forming and shall conform to the requirements of ASTM A653/A653M, with a minimum yield strength of 45,000 pounds per square inch (310 Megapascal). The steel shall be hot-dip galvanized to meet the requirements of ASTM A653/A653M with a minimum zinc coating weight of 0.90 ounces per square foot (276 grams per square meter), Coating Designation G-90. Steel material for fence panels shall conform to the requirements of ASTM A653/A653M, with a minimum yield strength of 45,000 pounds per square inch (310 Megapascal) and a minimum zinc (hot-dip galvanized) coating weight of 0.60 ounces per square foot (184 grams per square meter), Coating Designation G-60.

B. The fence panel rails shall be steel channel, 1.5 inch by 1.4375 inch by 14 Gauge. Picket holes in the rail shall be spaced 4.675 inch on-center Material for pickets shall be 3/4 inch square by 18 Guage tubing. The cross-sectional shape of the anti-ram rails shall conform to the

manufacturer's Stalwart II rail design a nominal two inch by two inch by 11 Gauge. Tamperproof fasteners shall be used to fasten each fence panel to post bracket and rail to post connections. Posts shall conform to the manufacturer's Stalwart II I-Beam design with a nominal three inch by 2.75 inch by 12 Gauge.

C. The cable material shall be Independent Wire-Rope Core (IWRC) wire rope conforming to Federal Specification RR-W-410E, six by 36 Warrington Seale, preformed, right regular lay, medium lubrication, Extra Improved Plow Steel (EIPS), with a breaking strength of 103,400 pounds (51.7 tons). Cable diameter shall be one inch.

2.05 FABRICATION

A. Stalwart II rails and posts shall be pre-cut to specified lengths. Post flange shall be pre-punched to accept rail to post and fence panel to post bracket attachment. Post web shall be punched providing a clear opening for interior of rails to align throughout the entire system for affixing conduit, video cabling, IDS wiring, and other components for a complete systems integration. Stalwart II rails shall be attached to I-beam post flange providing a bracket-less design at each intermediate post.

B. Fence panel pickets and rails shall be precut to specified lengths. Pickets shall be inserted into the pre-punched holes in the rails and shall be aligned to standard spacing using a specially calibrated alignment fixture. The aligned pickets and rails shall be joined at each picket-to-rail intersection by Ameristar's proprietary fusion welding process, thus completing the rigid panel assembly.

C. The manufactured galvanized anti-ram framework and fence panels shall be subjected to the PermaCoat® thermal stratification coating process (high-temperature, in-line, multi-stage, multi-layer) including, as a minimum, a six-stage pretreatment/wash, an electrostatic spray application of an epoxy base, and a separate electrostatic spray application of a polyester finish. The base coat shall be a thermosetting epoxy powder coating (gray in color) with a minimum thickness of two mils (0.0508 millimeters). The topcoat shall be a "no-mar" TGIC polyester powder coat finish with a minimum thickness of 2 mils (0.0508 millimeters). The color shall be black. The stratification-coated framework shall be capable of meeting the performance requirements for each quality characteristic shown in Table 1.

Table 1 – Coating Performance Requirements

Quality Character-istics	ASTM Test Method	Performance Requirements
Adhesion	D3359 – Method B	Adhesion (Retention of Coating) over 90 percent of test area (Tape and knife test).
Corrosion Re-sistance	B117, D714 & D1654	Corrosion Resistance over 3,500 hours (Scribed per D1654; failure mode is accumulation of 1/8-inch coating loss from scribe or medium #8 blisters).
Impact Resistance	D2794	Impact Resistance over 60 inches per pound. (For-ward impact using 0.625-inch ball).
Weathering Re-sistance	D2244, D523 (60˚ Method)	Weathering Resistance over 1,000 hours (Failure mode is 60 percent loss of gloss or color variance of more than three delta-E color units).

D. The manufactured fence panel shall be capable of meeting the vertical load, horizontal load, and infill performance requirements for commercial weight fences under ASTM F2408.

PART 3 EXECUTION

3.01 PREPARATION

A. The purchaser shall indicate the location of barrier line with suitable stakes. Stake intervals shall not exceed 500 feet or line of sight.

B. The purchaser shall indicate all underground utility locations, USC&G benchmarks, property monuments, and other underground structures.

C. Before installing the Stalwart II Daycare Anti-Ram Cable System, all necessary site clearing and grading shall be performed by the purchaser. An adequate clearance on both sides of the cable barrier line is required.

D. An Installation Contractor for this scope of work shall be capable of bonding projects up to three million and shall demonstrate such with a letter from a reputable bonding entity with the bid documents.

E. The Installation Contractor for this scope of work shall provide documentation from the product manufacturer indicating they have been trained on installation practices for Stalwart anti-ram systems by the product manufacturer, documentation shall be provided with bid documents.

F. The Installation Contractor for this scope of work shall provide documentation with bid indicating that the company currently has in place a minimum two million in general liability coverage as well as a minimum one million in commercial vehicle insurance, documentation shall be provided with bid documents.

3.02 INSTALLATION

A. The Stalwart II barrier shall be installed per Ameristar's System Drawings. Fence panels, brackets, cabling, and fasteners shall be installed according to installation instructions and drawings. Posts and bollards shall be installed per product drawings and installation instructions. The "Earthwork" and "Concrete" sections of this specification shall govern material requirements for the concrete footer unless otherwise specified by the product drawings or installation instructions.

B. The "Section 03 30 00.13 "CAST-IN-PLACE CONCRETE (SITE)" and 31 00 00 "EARTH MOVING" sections of this specification shall govern material requirements for the concrete footer.

C. Posts setting by other methods such as plated posts or grouted core-drilled footers are permissible only if shown by engineering analysis to be sufficient in strength for the intended application.

3.03 FENCE INSTALLATION MAINTENANCE

A. When cutting/drilling rails or posts adhere to the following steps to seal the exposed steel surfaces:

1. Remove all metal shavings from cut area.
2. Apply zinc-rich primer to thoroughly cover cut edge and/or drilled hole; let dry.
3. Apply two coats of custom finish paint matching fence color. Failure to seal exposed surfaces per steps one through three above shall negate warranty. Ameristar spray cans or paint pens shall be used to prime and finish exposed surfaces; it is recommended that paint pens be used to prevent overspray. Use of non-Ameristar parts or components shall negate the manufactures' warranty.

3.04 GATE INSTALLATION

A. Gate posts shall be spaced according to the manufacturers' gate drawings, dependent on standard out-to-out gate leaf dimensions and gate hardware selected. Type and quantity of gate hinges shall be based on the application; weight, height, and number of gate cycles. The manufacturers' gate drawings shall identify the necessary child-safe gate hardware required for the application. Gate hardware shall be provided by the manufacture of the gate and shall be installed per manufacturer's recommendations.

3.05 CLEANING

A. The Installation Contractor shall clean the jobsite thoroughly to ensure it is left neat and free of any debris caused by the installation of the cable system.

END OF SECTION

SECTION 32 31 21
ENCLOSURE FENCES AND GATES METAL LOUVER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ornamental fixed louver modular fencing panels fabricated with extruded aluminum louvers and flat aluminum bars, including extruded aluminum fence posts and aluminum louver gates.

B. Related sections:
   1. Section 03 30 00.13 “CAST-IN-PLACE CONCRETE (SITE)” for concrete footings for support of fence posts.
   2. Section 31 00 00 "EARTH MOVING” for excavation for installing concrete footings.
   3. General Contractor shall coordinate access control devices installed at gates and provided as part of a security system with the Owner.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. ASTM B117 - Operating Salt Spray (Fog) Apparatus.
   2. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
   3. ASTM B221 - Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
   4. ASTM D822 - Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings.
   5. ASTM D2794 - Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   6. ASTM D3363 - Test Method for Film Hardness by Pencil Test.

1.03 SUBMITTALS

A. Provide in accordance with Section 01 30 00 “ADMINISTRATIVE REQUIREMENTS”

B. Product Data: For each type of product.

C. Shop Drawings: For fences and gates. Include plans, elevations, sections, details, and attachments to other work.
   1. Include diagrams for power, signal, and control wiring.

D. Samples: For each fence material and for each color specified.
   1. Provide Samples: Eight inches by 10 inches (203 by 254 millimeters) minimum size sample of fence panel illustrating design, fabrication workmanship, and selected color coating.

E. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
   3. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.04 WARRANTY

A. Provide in accordance with Section 01 77 00 “CLOSEOUT PROCEDURES”

1. 10-year warranty for factory finish against cracking, peeling, and blistering under normal use.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:
   1. Ametco Manufacturing Corporation, 4326 Hamann Parkway, P.O. Box 1210, Willoughby, OH 44096; Telephone: 440.951.4300; Fax: 440.951.2542; E-mail: ametco@ametco.com; Website: www.ametco.com.
   2. Omega II Fence Systems, 1735 St-Elzear Blvd. West; Laval (Quebec) Canada H7L 3N6; Telephone:1.800.836.6342; Fax:450.681.7905; E-mail: customerservice@omegatwo.com; Website: www.omegatwo.com; Massachusetts Sales Representative John Rocco Sales NG; Telephone: 732.431.2089.
   3. Palm Shield, 12330 Cary Circle, La Vista, NE 68128; Telephone: 531.329.4406; E-mail: info@palmsheildlouvers.com.

B. Any manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is not a proprietary specification, and it should be noted that "or equivalent" applies to all products denoted herein. It is understood that all manufacturers will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equivalent. It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that can supply similar products.

C. Other manufacturer’s products accepted by the Awarding Authority as equal to the specified products in terms of construction, quality, durability, performance, and or appearance. Submit as substitutions: see Section 012500 “SUBSTITUTION PROCEDURES”.

2.02 MATERIALS

A. Extruded aluminum: ASTM B221, Alloy 6063, Temper T-6.

B. Sheet aluminum: ASTM B209, Alloy 6063, Temper T-6.

C. Grout: Non-shrink type, pre-mixed compound consisting of non-metallic aggregate, cement, and water-reducing and plasticizing additives.

2.03 FENCE SYSTEM

A. Basis-of-Design Project: Subject to compliance with requirements, provide product indicated on Drawings by Ameristar Fence Products, Inc. or approved equal.

B. Type: Ornamental fencing system consisting of horizontal**,** fixed louver, modular fence panels fabricated with extruded aluminum framing bars and supported by extruded aluminum fence posts; 80 Shadow Eclipse Aluminum Fixed Louver Fencing as manufactured by Ametco Manufacturing Corporation.

C. Fence panel:
   1. Fixed louver bars: Extruded aluminum louver bars, 1-31/32-inches (50-millimeters) wide, spaced at 2-1/16-inches (52-millimeters). Extend louver flange to allow 80-percent direct visual screening.
   2. Cross bars: 1/2 by 1/8-inch (13 by three-millimeters) flat bars welded perpendicular to back side of louver bars and spaced at 18-inches (457-millimeters).
   1. Panel height: 72 inches (1828.8 millimeters).
   1. Panel width: As indicated on Drawings.

D. Posts:
   1. Type: three by three-inch (76 by 76-millimeters) extruded tubular aluminum sections with solid aluminum caps.

2. Length: As indicated on Drawings.

2.04 GATES

A. Provide gates of type and size indicated on Drawings. Equip gates with manufacturer's standard hardware for complete functional operation.

B. Type: Hinged swinging double gate.

1. Construction: Welded frame fabricated from 5 inches by 5 inches (127 millimeters by 127 millimeters) extruded aluminum tubing with aluminum fixed louver panels to match fencing material.
2. Nominal size: five feet wide by six feet high.
3. Hardware:
   a. Hinges: Size and type as determined by manufacturer. Provide two hinges for each leaf up to six-foot (1829 millimeters) high and one additional hinge for each additional 24-inches (610 millimeters) in height or fraction thereof.
   b. Latch: 3/4-inch (19 millimeters) diameter slide bolt to accommodate padlock.
   c. For double gates provide padlock, 5/8-inch (16 millimeters) diameter center cane bolt assembly and strike.

2.05 ACCESSORIES

A. Fasteners: Stainless steel bolts of type, size, and spacing as recommended by fence manufacturer for specific condition.

B. For exposed locations, provide anti-intruder bolts consisting of cup-head bolt and nut with clamping hexagon such that tightening shears hexagon and render bolt impossible to release.

2.06 FACTORY FINISH

A. Aluminum fence panels and posts shall receive polyester powder coating.

B. Polyester powder coating: Electrostatically applied colored polyester powder coating heat cured to chemically bond finish to metal substrate.

1. Minimum hardness measured in accordance with ASTM D3363: 2H.
2. Direct impact resistance tested in accordance with ASTM D2794. Withstand 160 inch-pounds.
3. Salt spray resistance tested in accordance with ASTM B117: No undercutting, rusting, or blistering after 500 hours in five percent salt spray at 95 degrees Fahrenheit and 95 percent relative humidity and after 1000 hours less than 3/16 inch (five millimeters) undercutting.
4. Weatherability tested in accordance with ASTM D822: No film failure and 88 percent gloss retention after one year exposure in South Florida with test panels tilted at 45 degrees.

C. Color: Black Velvet as manufactured by Ametco Manufacturing Company. Selected by Architect from manufacturer's standard range.

PART 3 EXECUTION

3.01 PREPARATION

A. Prior to fabrication, field verify required dimensions.

B. Cast concrete footings in accordance with 03 30 00.13 “CAST-IN-PLACE CONCRETE (SITE)” as detailed on Drawings and accepted shop drawings.

1. Minimum footing diameter:
   a. Terminal and gate posts: 12 inches (305 millimeters).
   b. Intermediate line posts: 10 inches (254 millimeters).
2. Allow eight inches (203 millimeters) minimum embedment of posts.
3. Allow six inches (152 millimeters) minimum concrete beneath post bottom.

A. Provide setting holes for embedment of fence posts. The hole shall be two inches (51 millimeters) minimum greater than post width.

3.02 INSTALLATION

A. Install fencing in accordance with manufacturer's installation instructions and accepted shop drawings.

B. Install fence posts plumb and level by embedding post directly in concrete footing. Temporarily brace fence posts with two by four wood supports until concrete is set.

C. Do not install bent, bowed, or otherwise damaged panels. Remove damaged components from site and replace.

D. Secure fence panels with standard stainless-steel bolts to fence posts after posts have been set in footings.

E. Gates:

1. Install gates and adjust hardware for smooth operation.
2. Provide concrete center foundation depth and drop rod retainers at center of double swinging gate openings.
3. After installation, test gate. Open and close a minimum of five times. Correct deficiencies and adjust.

F. Touch-up damaged finish with paint supplied by manufacturer and matching original coating.

END OF SECTION

SECTION 32 31 29
WOOD PRIVACY FENCES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Wood Screen Fence.

B. Related Sections: The following items of related Work are specified and included in other Sections of the Specifications:
   1. Section 03 30 10.13 “CAST-IN-PLACE CONCRETE (SITE)“ for cast-in-place footings and pads.
   2. Section 31 00 00 "EARTH MOVING” for excavation for installing concrete footings.

1.03 ACTION SUBMITTALS

A. Product Data: Material descriptions, construction details, dimensions of individual components and profiles, and finishes for the following
   1. Fence posts, rails, and fittings

B. Shop Drawings: Show locations of fence, posts, rails, and details of extended posts, extension arms, or other operation, hardware, and accessories. Indicate materials, dimensions, sizes, weights, and finishes of components. Include plans, elevations, sections, and other required installation and operational clearances, and details of post anchorage and attachment and bracing.

C. Samples for Initial Selection: Manufacturer’s color charts or six-inch (150-millimeters) lengths of actual units showing the full range of colors available for components with factory-applied color finishes

D. Samples for Verification: For the following products, in sizes indicated, showing the full range of color, texture, and pattern variations expected. Prepare Samples from the same material to be used for the Work
   1. Wood sample in six-inch lengths.
   2. Paint and stain coatings in six-inch lengths on shapes for posts, and rails.

E. Product Certificates: Signed by manufacturers of wood fences certifying that products furnished comply with requirements.

F. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of Owners, and other information specified.

G. Maintenance Data: For the following to include in maintenance manuals specified in Division 1:
   1. Polymer finishes.
   2. Paints and stains.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed wood screen fences similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the International Electrical Testing Association and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.

C. Source Limitations for Wood Fences: Obtain each color, grade, finish, type, and variety of component for wood fences from one source with resources to provide wood fences of consistent quality in appearance and physical properties.

1.05 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others.

B. Field Measurements: Verify layout information for wood fences shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of wood fences that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Deterioration of wood, metals, metal finishes, and other materials beyond normal weathering.
2. Warranty Period: Five years from date of Substantial Completion.

1.07 DELIVERY, STORAGE AND HANDLING

A. Fence panels, posts and accessories shall be delivered to the construction site in packaged cartons.

B. Each package shall be identified and shall bear the name of the manufacturer.

C. All fence materials shall be adequately protected from damage during transit and shall not be dropped.

D. All fence and other appurtenances shall be inspected before placement in the work and any found to be rusted, damaged or defective from any cause, including damage caused by handling, and determined by the Engineer to be unrepairable, shall be replaced at no cost to the Owner.

E. Storage and handling of fence and other system appurtenances shall be in accordance with the manufacturer's recommendations and in a manner to prevent wracking or stress of components, and to prevent mechanical damage or damage by the elements. All stored materials and items shall be protected from weather, careless handling and vandalism.

1.08 REFERENCE STANDARDS

A. References herein are made in accordance with the following abbreviations and all work shall conform to the latest editions, as applicable.

1. Screen Fence:

American Society for Testing and Materials (ASTM)	
ASTM A36	Structural Steel
ASTM A153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM F537	Standard Specification for Design, Fabrication, and Installation of Fences Constructed of Wood and Related Materials

PART 2 PRODUCTS

2.01 WOOD SCREEN FENCE ENCLOSURE

A. All wood for fence shall be 100 percent top grade Northern White Cedar, dimensioned as noted on the accepted Shop Drawings.

B. All wood materials to be stained with two coats of transparent oil-based stain prior to installation. Touch-up stain shall be applied in the field. Stain shall be suitable for exterior application.

1. Manufacturers, or approved equal:
   a. Penofin Ultra-Premium Transparent Clear Oil-Based Penetrating Wood Stain.
   b. Benjamin Moore Woodluxe C591 Translucent Oil-Based Stain.

c. ProLuxe Cetol SRD RE Transparent Matte Cedar Oil-Based All-in-One Stain and Finish

C. Nails, latch and other hardware shall be hot-dipped galvanized (ASTM A153) steel or stainless steel to the dimensions and type noted on the accepted Shop Drawings.

2.02 CAST-IN-PLACE CONCRETE

A. General: Comply with ACI 301 for Section – 03 30 00.13 “CAST-IN-PLACE CONCRETE (SITE)” of these specifications.

2.03 GROUT AND ANCHORING CEMENT

A. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.

B. Erosion-Resistant Anchoring Cement: Factory-packaged, non-shrink, non-staining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer for exterior applications.

PART 3 PRODUCTS

3.01 EXAMINATION

A. General Contractor shall inspect the job site conditions prior to commencing Work of this Section. Examine conditions for compliance with requirements for installation tolerances and other specific conditions, and other conditions affecting performance of unit masonry.

B. Examine existing conditions for coordination with other trades and other sections of this Specification.

C. Do not proceed until any unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Stake locations of fence lines, and terminal posts. Do not exceed intervals of 500 feet (152.5 meters) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, property monuments, and other features which may affect the Work.

B. Discard timbers that are warped, twisted, bowed, crooked or otherwise defective.

3.03 INSTALLATION

A. General:

1. Install fencing to comply with ASTM537 or ASTM F567, as applicable, and more stringent requirements specified.
2. Installation shall be performed in accordance with manufacturer’s recommendations, Contract Documents, accepted Shop Drawings.
3. Fencing shall be erected as indicated on the Drawings, plum, level, snug, and free from rocking. Make final adjustments.
4. Fencing installed prior to paving operations shall be covered with plastic and all care shall be provided to ensure paving materials do not collect on or stain the steel. Plastic shall be removed after paving operation is completed.

B. Post Excavation:

1. Drill or hand-excavate holes for posts to diameters and spacing indicated, in firm, undisturbed or compacted soil.

C. Post Setting:

1. Hand-excavate holes for post foundations in firm, undisturbed or compacted soil. Set posts in concrete footing. Protect portion of posts aboveground from concrete splatter. Place concrete around posts and vibrate or tamp for consolidation. Verify that posts are set

plumb, aligned, and at correct height and spacing, and hold in position during placement and finishing operations until concrete is sufficiently cured.

a. Dimensions and Profile: As indicated on Drawings.
b. Exposed Concrete Footings: Extend concrete two inches (50 millimeters) above grade, smooth, and shape to shed water.
c. Concealed Concrete Footings: Stop footings below grade as indicated on Drawings to allow covering with surface material.
d. Posts Set into Concrete in Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with non-shrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
e. Posts Set into Concrete in Voids: Form or core drill holes not less than five inches (125 millimeters) deep and 3/4 inch (20 millimeters) larger than outside diameter of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with non-shrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.

3.04 SCREEN FENCE, ENCLOSURES

A. Install fence as shown on the Contract Documents and accepted Shop Drawings. Caps and top rails shall be installed in place.
B. All posts shall be set plumb.
    1. Rails of the wood fence shall be held level. Nails shall be aligned.

END OF SECTION

SECTION 32 33 00
SITE FURNISHINGS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section consists of providing all labor, equipment, materials, incidental work and construction methods necessary to furnish and install designated Site Improvements and related items as indicated on the Drawings, as specified in this Section, and includes, but is not limited to, the following:

1. Benches; backed; surface mount.
2. Benches; backless; surface mount.
3. Free-Form Bench; free-standing.
4. Sculptural Bench; surface mount.
5. Curved Bench; backless; surface mount.
6. Movable Cube Seats; free-standing.
7. Circular Bench; surface mount.
8. Table with integral seats.
9. Table with integral seats; ADA-compliant model.
10. Litter and recycling receptacle.
11. Bicycle rack.
12. Drinking fountain and bottle-filler.
13. Shed; prefabricated; 10’-0” x 20’-0” set on cast-in-place concrete pad.
14. Raised garden bed; ADA-compliant model.
15. Shade sail.
16. Tree Stump Seat.
17. Vehicular barrier swing gate; 22 feet wide and 24 feet wide.

B. Related Sections:

1. Section 03 30 00.13 "SITE CAST-IN-PLACE CONCRETE (SITE)" for concrete slabs, footings, and installing pipe sleeves cast in concrete footings.
2. Section 31 00 00 "EARTH MOVING” for excavation for installing concrete footings.
3. Section 26 00 10 “ELECTRICAL” for connections to stainless steel bollards with LED lighting and shed.
4. General Contractor shall verify model numbers, drawings and manufacturer’s specifications are accurate before proceeding with the installation of site furnishings. Any discrepancies shall be reported to the Owner’s Representative for review and final acceptance.
5. General Contractor shall verify the location of all site furnishings with the Landscape Architect prior to installation or attachment to surfaces.

1.03 REFERENCES

A. The following Standards shall apply to the work of this Section:

1. Commonwealth of Massachusetts Department of Transportation (MassDOT) Highway Division Specifications: Standard Specifications for Highways and Bridges.
2. ASTM: American Society for Testing and Materials:
   Alloy-Steel and Stainless-Steel Bolting Materials for High Temperature Service: A193/A193M-99a.
   Stainless Steel Bars and Shapes: A276-98b.

Seamless and Welded Austenitic Stainless-Steel Pipes: A312.
Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes: ASTM A 500.
Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing: ASTM A 513.
Standard Practice for Operating Salt Spray (Fog) Apparatus: ASTM B 117.
Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings: ASTM D 522.
Standard Test Method for Specular Gloss: ASTM D 523.
Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity: ASTM D 2247.
Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact): ASTM D 2794.
Standard Test Methods for Measuring Adhesion by Tape Test: ASTM D 3359.
Standard Test Method for Film Hardness by Pencil Test: ASTM D 3363.
Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials: ASTM G 155.

3. AISI: American Iron and Steel Institute:
   Stainless Steel Alloy Designation: AISI 304.
   Stainless Steel Alloy Designation: AISI 316.
4. AWS: American Welding Society:
   Structural Welding Code – Stainless Steel: D1.6-99.
5. ISO Testing Standards:
   Paints and Varnishes – Cupping Test: ISO 1520.
   Paints and Varnishes – Buchholz Indentation Test: ISO 2815.

1.04 ACTION SUBMITTALS

A. Shop Drawings: Prior to ordering the below listed materials, submit Shop Drawings to the Owner's Representative for acceptance as follows:
   1. Provide shop drawings for the concrete footings of each site item specified herein.
   2. Provide shop drawings for each Bench installation and plan locations.
   3. Provide shop drawings for each Table with Integral Seats installation and plan locations.
   4. Provide shop drawings for each Litter Receptacle installation and plan locations.
   5. Provide shop drawings for Bicycle Rack installation and plan locations.
   6. Provide shop drawings for each Drinking Fountain with Bottle Filler and Hose Bib installation and plan locations.
   7. Provide shop drawings for each Prefabricated Shed, for full details, installation and plan location; reviewed and stamped by Massachusetts Licensed Structural Engineer.
   8. Provide shop drawings for Raised Garden Bed for installation and plan locations.
   9. Provide shop drawings for Planter and Self-watering Irrigation Bladder system for installation and plan locations.
   10. Provide shop drawings for each Shade Sail, for full details, installation and plan location; reviewed and stamped by Massachusetts Licensed Structural Engineer.
   11. Provide shop drawings for Stainless steel bollard; with LED lighting; crash-test rated.
   12. Provide shop drawings for Stainless steel bollard; without LED lighting; crash-test rated.
   13. Provide shop drawings for Vehicular Barrier Swing Gate installation and plan locations.

B. Manufacturer's Literature: Submit copies of each of the manufacturer's material descriptions and installation instructions for the following. Do not order materials until Owner Representative's acceptance has been obtained. Delivered materials shall closely match the accepted samples:
   1. Benches; backed; surface mount.
   2. Benches; backless; surface mount.

3. Free-Form Benches; free standing.
4. Sculptural Bench; surface mount.
5. Curved Bench; backless; surface mount.
6. Moveable Cube Seats; free-standing.
7. Circular Bench; surface mount.
8. Table with Integral Seats.
9. Table with Integral Seats; ADA-compliant model.
10. Litter and recycling receptacle.
11. Bicycle rack.
12. Drinking fountain and bottle-filler with hose bib.
13. Shed; prefabricated; 10'-0" x 20'-0" set on cast-in-place concrete pad.
14. Raised garden bed; ADA-compliant model.
15. Shade sail.
16. Tree Stump Seat.
17. Vehicular barrier swing gate; 22 feet wide.
18. Vehicular barrier swing gate; 24 feet wide.
19. Non-shrink grout.
20. Sealant.

C. Samples: For each exposed product and for each color and texture specified.
D. Samples for Initial Selection: For units with factory-applied finishes.
E. Samples for Verification: For each type of exposed finish, not less than six-inch-long linear components and four-inch square sheet components.
   1. Include full-size Samples of bench, litter receptacle and bicycle rack.
F. Product Schedule: For site furnishings. Use same designations indicated on Drawings.
G. LEED
   1. LEED Materials and Resources Credit 4, Recycled Materials: Submit letter from manufacturer certifying the products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Materials and Resources Credit 5, Regional Materials: Submit letter from manufacturer certifying products having been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the project site.
   3. Source Limitations: Obtain materials mined or manufactured in Massachusetts first and the United State of America second whenever possible.

1.05 INFORMATIONAL SUBMITTALS

A. Material Certificates: For site furnishings.
   1. Wood Preservative Treatment: Include certification by treating plant stating type of preservative solution and pressure process used, net amount of preservative retained, and compliance with applicable standards and with manufacturer's recommendations.

1.06 CLOSEOUT SUBMITTALS

A. Maintenance Data: For site furnishings to include in maintenance manuals.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful site furnishing installations.
   1. Experience: Three years' experience in site furnishing installation of similar quality, schedule requirement and construction detailing.

2. Installer's Field Supervision: Require Installer to maintain an experienced full-time foreman or crew leader on Project site when work is in progress.

1.08 GUARANTEE

A. All site improvements' parts shall be guaranteed against workmanship and material defects for one-year from time of delivery, or as noted herein.

1.09 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Bench Replacement Slats: No fewer than two full-size units for each size indicated.
   2. Table Replacement Slats: No fewer than two full-size units for each size indicated.
   3. Litter Receptacle Inner Containers: five full-size units for each size indicated, but no fewer than two units.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal.

B. Any manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is not a proprietary specification, and it should be noted that "or equivalent" applies to all products denoted herein. It is understood that all manufacturers will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equivalent. It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that can supply similar products.

C. Other manufacturer's products accepted by the Awarding Authority as equal to the specified products in terms of construction, quality, durability, performance, and or appearance. Submit as substitutions: see Section 01 25 00 "SUBSTITUTION PROCEDURES".

2.02 SITE FURNITURE

A. Manufacturers:
   1. Forms+Surfaces, 30 Pine Street, Pittsburgh, PA 15223; Telephone: 800.451-0410; Fax: 412.781.7840; E-mail: sales@forms-surfaces.com; Erik Walsh Massachusetts Sales Representative; Telephone: 800.451-0410; Email: erik.walsh@forms-surfaces.com.
   2. Vestre Inc., 1740 Broadway, 15th Floor, New York, NY 10019; Dan Delongchamp Massachusetts Sales Representative; Telephone: 617.780.4134; E-mail: dan@vestre.com; Website: www.vestre.com
   3. Landscape Forms, 7800 E. Michigan Avenue, Kalamazoo, MI 49048; Telephone: 800.430.6209; Fax: 269.381.0396; E-mail: comments@landscapeforms.com; Website: www.landscapeforms.com; Nadene Worth Massachusetts Sales Representative; Cell: 978.460.5306; E-mail: nadenew@landscapeforms.com.
   4. Nature's Instruments; Telephone: 877.733.7456; E-mail: sales@naturesinstruments.com; Website: www.naturesinstruments.com.
   5. Elkay, Regional Distributor Halsey Taylor, 2222 Camden Court, Oak Brook, IL 60523, Telephone: 630.572.3192; Website: www.elkay.com; E-mail: www.halseytaylor.com.
   6. GameTime, 150 PlayCore Drive SE, Fort Payne, AL 35967; Telephone 800.235.2440; Email: info@gametime.com; Website: https://www.gametime.com; MRC Local Representative; Erik Walsh, Cell: 978.569.3797; Email: ewalsh@mrcrec.com
   7. UltraPlay, 1675 Locust Street, Red Bud, IL 62278; Telephone: 888.403.7684Email: customerservice@ultraplay.com; Website: www.ultraplay.com;

8. The 4 Kids, 4400 Oneal Street, Suite 200, Greenville, TX 75401-7018; Telephone: 903.454.9237; Email: info@the4kids.com; Website: www.the4kids.com

B. Products: Basis-of-Design: Subject to compliance with requirements, provide the following, or approved equal. See graphic example at end of Specification for use in determining an approved equal.
   1. Backed Bench: Model Number SBKNI-072B (Knight Bench) manufactured by Forms+Surfaces.
      a. Design: Backed with Armrests.
      b. Dimension: Six-feet overall length, 21.9-inches overall depth, 15.2-inch seat depth, 31.1-inch overall height, 17.9-inch seat height, 20.8-inch armrest height.
      c. Frame: Solid Aluminum.
      d. Frame Finish: Outer frame edges are polished.
      e. Frame Finish: Inner surfaces have a powder coated finish.
      f. Finish: All surfaces are clear coated.
      g. Slat Materials: FSC 100-percent Cumaru hardwood slats to resist moisture, insects, fire, vandalism and decay.
      h. Color: Standard”; final color selection by Owner as confirmed in Shop Drawings.
      i. Mount: Surface Mount; Stainless-steel anchors and mounting bolts.
      j. Number and field location of benches as shown on plans.
   2. Backless Bench: Model Number SF-SBKNI-072N-BEN-OARM-SFM (Knight Bench) manufactured by Forms+Surfaces.
      a. Design: Backless.
      b. Dimension: Six-feet overall length, 20-inches overall depth.
      c. Frame: Solid Aluminum; Powdercoat, Color: Aluminum Texture with polished edges and clear top coat.
      d. Frame Finish: Outer frame edges are polished.
      e. Frame Finish: Inner surfaces have a powder coated finish.
      f. Finish: All surfaces are clear coated.
      g. Slat Materials: FSC 100-percent Cumaru hardwood slats to resist moisture, insects, fire, vandalism and decay with natural oiled finish.
      h. Color: Standard; final color selection by Owner as confirmed in Shop Drawings.
      i. Mount: Surface Mount; Stainless-steel anchors and mounting bolts.
      j. Number and field location of benches as shown on plans.
   3. Free-Form Bench: Twig Bench manufactured by Landscape Forms.
      a. Design: Backless.
      b. Dimension: 93-inches overall length, 76-inches seat depth.
      c. Material: Reinforced concrete.
      d. Mount: Freestanding.
      e. Number and field location of benches as shown on plans.
   4. Sculptural Bench: Models Curved End VROOM 630D4 + 2X650 + 622Ds, Straight Bench VROOM 600, and Curved End VROOM 630D3 + 2X650 +622D3 (VROOM bench modules) manufactured by Vestre.
      a. Design: Backless and backed.
      b. Dimension: 14’-6” long; 1’-9” wide, 2’-7” high.
      c. Material: Hot-Dip Galvanized Steel with Powder Coat; Kebony Clear Wood Slats.
      d. Colors: Standard; final color selection by Owner as confirmed in Shop Drawings.
      e. Mount: Surface Mount; Stainless-steel anchors and mounting bolts.
      f. Number and field locations of benches as shown on plans.

5. Curved Bench: Model 1308-930 (VIA Curved Bench) manufactured by Vestre.
   a. Design: Backless
   b. Dimension: 82.7-inches overall length, 20.1-inches overall depth, 17.7-inches overall height. Inner and outer radii vary, as indicated per plan.
   c. Material: Hot-Dip Galvanized Steel with Powder Coat; Kebony Clear Wood Slats.
   d. Colors: Standard; final color selection by Owner as confirmed in Shop Drawings.
   e. Mount: Surface Mount; Stainless-steel anchors and mounting bolts.
   f. Number and field location of curved benches as shown on plans.
6. Movable Cube Seats: Model Number 4010 (KONG cube) by Vestre.
   a. Dimension: 16.5 inches wide, 15.5 inches long, and 15.4 inches heigh.
   b. Material: Hot-Dip Galvanized Steel with Powder Coat; Kebony Clear Wood Slats.
   c. Color: Standard; final color selection by Owner as confirmed in Shop Drawings.
   d. Mount: Free-Standing.
   e. Number and field locations of benches as shown on plans.
7. Circular Bench: Model Number 3610 (STRIPES bench) by Vestre.
   a. Design: Circle Bench.
   b. Dimension: 70.1 inch diameter.
   c. Material: Hot-Dip Galvanized Steel with Powder Coat; Kebony Clear Wood Slats.
   d. Color: Standard; final color selection by Owner as confirmed in Shop Drawings.
   e. Mount: Surface Mount; Stainless-steel anchors and mounting bolts.
   f. Number and field locations of benches as shown on plans.
8. Table with Integral Seats: Model# STKNI-72NA (Knight Table Ensemble) manufactured by Forms+Surfaces.
   a. Design: Backless.
   b. Dimension: Six-foot-length.
   c. Slat Materials: Aluminum.
   d. Color: Standard; final color selection by Owner as confirmed in Shop Drawings.
   e. Mount: Surface Mount; Stainless-steel anchors and mounting bolts.
   f. Number and field location of benches as shown on plans.
9. ADA-Compliant Table with Integral Seats: Model# STKNI-72NA-ADA (Knight Table Ensemble with ADA option) manufactured by Forms+Surfaces.
   a. Design: Backless.
   b. Dimension: Six-foot and Three-foot-length ADA benches.
   c. Slats: Aluminum.
   d. Color: Standard; final color selection by Owner as confirmed in Shop Drawings.
   e. Mount: Surface Mount; Stainless-steel anchors and mounting bolts.
   f. Number and field location of table and bench ensembles as shown on plans.
10. Litter and Recycling Receptacle: Model# SLUNN-36SSR (Universal Litter & Recycling Receptacle) manufactured by Forms+Surfaces.
    a. Size: 36-Gallon.
    b. Lid type: Side openings with one standard opening, one round opening.
    c. Lid tether: Yes.
    d. Lid material: stainless steel; Finish satin.
    e. Body type: Split-Stream; Stainless Steel; final body selection by Owner as confirmed in Shop Drawings.
    f. Finish: Diamond Finish; final finish selection by Owner as confirmed in Shop Drawings.
    g. Base material: Polyethylene Slate.
    h. Mount: Surface mount with levelers.

i. Liners (side opening receptacles only): Two half liners (including the internal baffle) bag straps and drain holes.
j. Graphic message and background color: “Litter” and “Recycling” graphics; Black.
k. Number and field location of litter and recycling receptacles as shown on plans.

11. Bicycle Rack: Model# SKTRO (Trio Bike Rack) manufactured by Forms+Surfaces.
    a. Finish: Standard powder coat.
    b. Color: “Silver Texture”; final color selection by Owner as confirmed in Shop Drawings.
    c. Mount: Surface Mount; Stainless-steel anchors and mounting bolts.
    d. Number and field location of bicycle racks as shown on plans.
12. Tree Stump Seat: Model# 38239 (Tree Stump) manufactured by GameTime.
    a. Design: Backless.
    b. Dimension Use Zone: 13’-6” by 13’-4”.
    c. Fall Height : Two-feet.
    d. Materials: Pre-cast Concrete.
    e. Color: Standard; final color selection by Owner as confirmed in Shop Drawings.
    f. Mount: Surface Mount; Stainless-steel anchors and mounting bolts.
    g. Number and field location of tree stump seats as shown on plans.
13. Drinking Fountain and Bottle Filler: Model# LK4420BF1U (Outdoor ezH2O Upper Bottle Filling Station Bi-Level Pedestal) manufactured by Elkay.
    a. Finish: Standard Color: “Hunter green”; final color selection by Owner as confirmed in Shop Drawings.
    b. Mount: General Contractor shall also need the Direct Bury Adapter accessory: 97864C.

2.03 PREFABRICATED SHED

A. The General Contractor shall submit Prefabricated Shed Shop Drawings based on Contract Document details. General Contractor’s shop drawings shall be reviewed and stamped by Massachusetts Licensed Professional Structural Engineer (PE) verifying compliance with Massachusetts Building Code prior to submission and review by Owner’s Representative.

B. Manufacturers:
    1. Package Steel Systems, Inc., 15 Harback Road, Sutton, MA 01590; Telephone: 508.466.4598; Website: packagesteelsystem.com.
    2. Shelters of New England, 251 West Hollis Street, Nashua, NH 03060; Telephone: 603.886.2701; Website: sheltersofnewengland.com.
    3. Viking Steel Structures, 113 W Main Street, Boonville, NC 27011; Telephone: 877.959.9683; Website: https://www.vikingsteelstructures.com.

C. Products: Basis-of-Design: Subject to compliance with requirements, provide the following by Package Steel Systems, Inc., or approved equal.
    1. Design Load items:
        a. IBC Code 2012 Ground Snow Load 42.5 PSF
        b. Snow Load Factor of .7
        c. Wind Load 105 MPH.
    2. Design load certification including seismic zone, wind loads, and snow loads shall be confirmed in writing with local code authorization by Buyer prior to manufacture of the building by Seller. If the above loads change it could affect the price of the building.
    3. Size:
        a. Building Size: 10 feet wide by 20 feet long by 12 feet high
        b. Eave Height: Left Eave nine feet high; Right Eave 9’-6” high
        c. Roof Pitch 0.5:12; 1/2 inch by 12-inch slope.

d. Exterior roll-up doors are seven-foot-high by eight-foot and eight-inches wide on one-foot-wide units.
e. Roof is insulated with ply-foil insulation to help prevent condensation.

4. Materials:
   a. 24-gauge galvalume plus standing seam roof with 20-year manufacturer's warranty (galvalume color).
   b. 26-gauge rake and eave trim, with 40-year manufacturer's warranty.
   c. 26-gauge "R" panel siding with siliconized polyester finish for walls and blank wall areas (there are 15).
   d. 29-gauge galvalume plus interior partitions designed to provide resistance to smudging, staining and corrosion. Interior structural steel is galvanized.
   e. 26-gauge exterior roll-up doors with corrugated door headers.
   f. Tension control and ball-bearings included for all roll up doors.
   g. Floor: Open floor system that sits on top of cast-in-place concrete pad.
   h. Floor system: consists of two-inch by four-inch and two-inch by six-inch pressure treated joists covered with three-quarter-inch exterior grade plywood with the exterior edges wrapped in a 16-gauge galvanized steel sill.
   i. Standard industry latches.
5. Color:
   a. Shed Building Exterior Wall: “Saddle Tan” from Signature® 200 Standard colors available with a 40-year manufacturer's warranty”; final color selection by Owner as confirmed in Shop Drawings. General Contractor to submit a minimum sized three-inch by three-inch sample for final acceptance.
   b. Trim between exterior doors, walls and roof: 16-gauge galvanized structural steel covered with pre-painted 26-gauge jamb covers with a 40-year manufacturer's warranty. Color: “Harbor Blue”; final color selection by Owner as confirmed in Shop Drawings.
   c. Roll-up Doors: Shed door color to be “White” from Standard Siliconized Polyester Colors”; final color selection by Owner as confirmed in Shop Drawings. The General Contractor shall submit a minimum sized three-inch by three-inch sample for final acceptance.
6. Prefabricated Shed to sit on top of cast-in-place concrete pad, engineered to support the weight of the structure.

2.04 GARDEN FURNITURE

A. Manufacturers:
   1. ShelterWorks Ltd., 427 North 15th Street, PO Box 1311, Philomath, OR 97370; Telephone: 541.368.7935; Website: www.durablegreenbed.com.
   2. Eartheasy, 22 E. 5th Avenue #433, Vancouver, BC V5T 1G8 Canada; Telephone: 888.451.6752; E-mail: service@eartheasy.com; Website: www.eartheasy.com.
   3. Polymade Planters, 450 South 55th Street, Kansas City, KS, 66106; Telephone: 913.349.7276, E-mail: sales@polymade.com.
   4. ADA-Compliant Raised Garden Square Bed; Durable. manufactured by ShelterWorks.
      a. Dimension: four-feet by four-feet by 24-inch height.
      b. Material: Faswall; Nontoxic woodchip/concrete composite; four Aluminum corner brackets.
      c. Finish: Stock; 3.5-inch-wide PVC top trim, Cast Aluminum Trim Cap.
      d. Color: Sample to be provided to Owner prior to purchase and for final acceptance.
      e. Mount: Open Bottom on Grade; install filter fabric between planting soil and finished grade; 10-inch minimum extension up planter wall.

f. Number and field location of planters as shown on plans.
g. Approved Equal items can be constructed in Western Red Cedar or Eastern White Cedar at the same Durable Bed dimensions.

2.05 SHADE SAIL

A. General Contractor shall submit Shade Sail Drawings based on Contract Document details. General Contractor's shop drawings shall be reviewed and stamped by Massachusetts Licensed Professional Structural Engineer (PE) verifying compliance with Massachusetts Building Code prior to submission and review by Owner's Representative.

B. Products: Basis-of-Design: Subject to compliance with requirements, provide the following, or approved equal.
   1. SkyWay Hip shade structures: Triangular Color: "Orange"; final color selection by Owner as confirmed in Shop Drawings. Fabric sample(s) to be provided to Owner's Representative prior to purchase, as manufactured by Landscape Structures, 601 7th Street South, Delano, MN 55328; Telephone: 888.438.6574; Email: info@playlsi.com; Website: www.playlsi.com; John McConkey Massachusetts Sales Representative; Telephone: 508.533.6342; Email: JohnMcConkey@obrienandsons.com.
   2. Shade Sail "Sails" Product. Shape: Triangular, Color: "Fire Orange"; final color selection by Owner as confirmed in Shop Drawings. Fabric sample(s) to be provided to Owner's Representative prior to purchase, as manufactured by Shade Systems, Inc., 4150 SW 19th Street, Ocala, FL 34474; Telephone: 1.800.609.6066; Fax: 352.237.2256; Website: shadesystemsinc.com; Email: JohnMcConkey@obrienandsons.com.
   3. Shade Sail "Skyclipse 370" product. Shape: Triangular, Color: "Orange"; final color selection by Owner as confirmed in Shop Drawings. Fabric sample(s) to be provided to Owner's Representative prior to purchase, as manufactured by Shade Sails, LLC., 2216 Padre Boulevard, Suite B #77, South Padre Island, TX 78597; Telephone: 956.772.4711.

2.06 VEHICULAR BARRIER SWING GATE

A. Manufacturers:
   1. Hoover Fence Co., 4521 Warren Ravenna Rd., Newton Falls, Ohio 44444; Telephone: 330.358.2335, Web: www.hooverfence.com.
   2. Barrier Gate Brands, provided by the Tiger Teeth Store,10050 Wellman Road, Streetsboro, OH 44241, Representative Brian Livaich; Telephone: 800.878-7829; E-mail: brian@dfsupplyinc.co; Website: www.tigerteethstore.com.
   3. Secure Lane, LLC, 3220 S. Dodge Blvd. #8, Tucson, AZ 85713; Christine Richards, Owner-Operator; Telephone: 520.780.9751; E-mail: christine@secure-lane.com; Website: www.secure-lane.com.

B. Products: Basis-of-Design: Subject to compliance with requirements, provide the following, or approved equal.
   1. Vehicular Barrier Swing Gate: Model# HCG-Z-4X22DB-KIT-A (Z-Series Tubular Barrier Double Gate Kit – Aluminum) manufactured by Hoover Fence.
      a. Size: 22-feet-width; four feet tall; Two Gate Leaves; See plans for gate width locations.
      b. Material: Rigid construction of premium two inch O.D. (1-7/8 inch) actual Schedule 40 Aluminum.
      c. Joints: Notched and/or Hammered.
      d. Gate Posts Caps: Four two-inch Aluminum Caps for Gate Uprights.
      e. Posts: Two four-inch by eight-inch Schedule 40 Aluminum Gate Posts.
      f. Post Caps: Two four-inch Aluminum Caps for Posts.
      g. Hinges: Four four-inch by two-inch Malleable Butt Hinges.
      h. Latch: One Industrial Fulcrum Double Gate Latch.
      i. Mount: In-ground installation; Bell-shaped Hole.

j. Number and field location of aluminum vehicular gates as shown on plans.
k. Aluminum posts shall be embedded in 4,500 pounds-per-square-inch concrete cement.
l. General Contractor to provide cutsheet and installation drawings per manufacturer for acceptance.

2. Vehicular Barrier Swing Gate: Model# HCG-Z-4X24DB-KIT-A (Z-Series Tubular Barrier Double Gate Kit – Aluminum) manufactured by Hoover Fence.
   a. Size: 24-feet width; four feet tall; Two Gate Leaves; See plans for gate width locations.
   b. Material: Rigid construction of premium two inch O.D. (1-7/8 inch) actual Schedule 40 Aluminum.
   c. Joints: Notched and/or Hammered.
   d. Gate Posts Caps: Four two-inch Aluminum Caps for Gate Uprights.
   e. Posts: Two four-inch by eight-inch Schedule 40 Aluminum Gate Posts.
   f. Post Caps: Two four-inch Aluminum Caps for Posts.
   g. Hinges: Four four-inch by two-inch Malleable Butt Hinges.
   h. Latch: One Industrial Fulcrum Double Gate Latch.
   i. Mount: In-ground installation; Bell-shaped Hole.
   j. Number and field location of aluminum vehicular gates as shown on plans.
   k. Aluminum posts shall be embedded in 4,500 pounds-per-square-inch concrete cement.
   l. General Contractor to provide cutsheet and installation drawings per manufacturer for acceptance.

2.07 MATERIALS

A. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:
   1. Rolled or Cold-Finished Bars, Rods, and Wire: ASTM B 211.
   2. Extruded Bars, Rods, Wire, Profiles, and Tubes: ASTM B 221.
   3. Structural Pipe and Tube: ASTM B 429/B 429M.
   4. Sheet and Plate: ASTM B 209.
   5. Castings: ASTM B 26/B 26M.

B. Steel and Iron: Free of surface blemishes and complying with the following:
   1. Plates, Shapes, and Bars: ASTM A 36/A 36M.
   2. Steel Pipe: Standard-weight steel pipe complying with ASTM A 53/A 53M, or electric-resistance-welded pipe complying with ASTM A 135/A 135M.
   3. Tubing: Cold-formed steel tubing complying with ASTM A 500/A 500M.
   4. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A 513, or steel tubing fabricated from steel complying with ASTM A 1011/A 1011M and complying with dimensional tolerances in ASTM A 500/A 500M; zinc coated internally and externally.
   5. Sheet: Commercial steel sheet complying with ASTM A 1011/A 1011M.
   6. Perforated Metal: From steel sheet not less than 0.075-inch nominal thickness; manufacturer's standard perforation pattern.
   7. Expanded Metal: Carbon-steel sheets deburred after expansion, and complying with ASTM F 1267.
   8. Malleable-Iron Castings: ASTM A 47/A 47M, grade as recommended by fabricator for type of use intended.
   9. Gray-Iron Castings: ASTM A 48/A 48M, Class 200.

C. Stainless Steel: Free of surface blemishes and complying with the following:
   1. Sheet, Strip, Plate, and Flat Bars: ASTM A 666.

2. Pipe: Schedule 40 steel pipe complying with ASTM A 312/A 312M.
3. Tubing: ASTM A 554.

D. Wood: Surfaced smooth on four sides with eased edges; kiln dried, free of knots, solid stock of species indicated.
   1. Wood Species:

      a. Douglas Fir: Clear Grade, vertical grain.
      b. Pine: Southern pine, No. 2 or better.
      c. Nordic Pine: Linseed oil proofed.
      d. Cedar: Select Grade or better.
      e. Redwood: free-of-heart center.
      f. Teak (Tectona Grandis): Clear Grade.
      g. Ipe: Recycled.

   2. Certified Wood: Fabricate site furnishings with components produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
   3. Finish: Manufacturer's standard.

E. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.
   1. Polyethylene: Fabricated from virgin plastic HDPE resin.
   2. Recycled Content of Polyethylene.

F. Anchors, Fasteners, Fittings, and Hardware: commercial quality, tamperproof, vandal and theft resistant
   1. Angle Anchors: For inconspicuously bolting legs of site furnishings to grade substrate.
   2. Antitheft Hold-Down Brackets: For securing site furnishings to substrate.

G. Concrete Footing: Concrete footing shall be 4,500-pounds per square inch (31 megapascals), 28-day strength air entrained, 3/4-inch aggregate cast-in-place concrete as specified in Section 03 30 10.13 "CAST-IN-PLACE CONCRETE (SITE)". Concrete footings shall be placed as shown on the Drawings.

H. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M; recommended in writing by manufacturer, for exterior applications.

I. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.

J. Self-leveling Polyurethane Sealant: Provide two or more part, self-leveling, polyurethane based elastomeric sealant, complying with ASTM C 920, Type 1 Class A, having Shore A hardness of not less than 30 when tested according to ASTM C 920, cured modulus of elasticity at 50 percent elongation of not more than 150 pounds per square inch, when tested according to ASTM D 412, and tear resistance of not less than 50 pounds per inch when tested according to ASTM D 624. Where joint surfaces contain bituminous materials, provide modified sealants which are compatible with bituminous materials encountered.

K. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
   1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 ounces/square foot of zinc after welding, a chromate conversion coating, and a clear,

polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil thick.

2. Hot-Dip Galvanizing: According to ASTM A 123/A 123M, ASTM A 153/A 153M, or ASTM A 924/A 924M.

2.08 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment: Pressure-treat wood according to AWPA U1 and the following:

1. Use preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
2. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.

2.09 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

D. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWPA M4 to cut surfaces.

E. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

F. Factory Assembly: Assemble components in the factory to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.10 GENERAL FINISH REQUIREMENTS

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of accepted Samples and are assembled or installed to minimize contrast.

2.11 ALUMINUM FINISHES

A. Baked-Enamel, Powder-Coat Finish: Manufacturer’s standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.12 STEEL AND GALVANIZED-STEEL FINISHES

A. Baked-Enamel, Powder-Coat Finish: Manufacturer’s standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

B. PVC Finish: Manufacturer’s standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

2.13 IRON FINISHES

A. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.14 STAINLESS-STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.

1. Run directional finishes with long dimension of each piece.
2. Directional Satin Finish: No 4.
3. Dull Satin Finish: No. 6.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION, GENERAL

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Install site furnishings level, plumb, true, and positioned at locations indicated on Drawings.

D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 inch larger than outside diameter of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

F. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

3.03 GENERAL ACCEPTANCE STANDARDS

A. Site Furnishings items specified within this Section 32 33 00, "SITE FURNISHINGS", will be rejected by the Owner's Representative for the following reasons and as determined by the Owner's Representative:

1. Upon installation, horizontal or vertical curves do not meet the shapes and profiles shown on the Drawings. Curves that have broken backs, sags, saddles, tangents or kinks will be rejected.
2. Posts are not plumb. Rails do not follow grade as noted on the Drawings.
3. Indications of field welding or cutting.
4. Threaded connections are not drawn up tightly. Threads have not been deformed to prevent loosening.
5. Anchorage into concrete or masonry is not solid but is perceptibly loose. Anchorage does not meet the requirements in the Drawings.

6. Finishes that do not meet the Specifications or Drawings, due to damage that occurred onsite, manufacturing error or other causes.

3.04 MISCELLANEOUS METALS ACCEPTANCE STANDARDS

A. Miscellaneous metal items, including handrails, bollards and specialty fencing will be rejected by the Owner's Representative for the following reasons:

1. Welders were not qualified under or did not perform work in accordance with AWS "Standard Qualification Procedure."
2. Fabricated items show metal pieces that were not accurately saw cut and were not fitted together. Gaps, spaces, voids, breaks and crooks in arriss lines, humps, bumps, sags and saddles are present.
3. Sections are not well formed and do not meet the shapes and profiles shown in the Drawings.
4. Horizontal or vertical curves do not meet the shapes and profiles shown in the Drawings. Curves that have broken backs, sags, saddles, tangents or kinks shall be rejected.
5. Connections are not full seam welded or not ground flush and smooth.
6. Threaded connections are not drawn up tightly. Threads have not been deformed to prevent loosening.
7. Exposed surfaces do not have a smooth finish and show surface differentiation and variation. Edges show nicks, grind marks or machine marks.
8. Castings do not have sharp corners and edges and are not clean, smooth and true to pattern.
9. Welds are not continuous extending for the entire length of the joints.
10. Welds are not ground smooth.
11. The presence of flux deposits.
12. Welds are not watertight.

END OF SECTION

SECTION 32 84 00
IRRIGATION

PART 1 - GENERAL

1.01 SUMMARY

A. Provide materials, labor, equipment, technical service, and testing to complete construction of automatic irrigation system, with two-wire, soil moisture sensing, and internet-based irrigation controller as defined in Construction Documents.

B. Work items include:
   1. Submitting qualifications and product cut sheets as specified below.
   2. Procurement of applicable licenses, permits, and fees.
   3. Coordination of utilities and verification of existing and proposed site conditions.
   4. Connection of electrical power supply to irrigation control system and the irrigation control system to earth ground; coordinating with Electrical Contractor.
   5. Connection of domestic water supply to irrigation system.
   6. Adherence to safety protocols in place during construction, including:
      a. Occupational Safety and Health Administration (OSHA)
      b. Local and State Plumbing Boards
      c. Local and State Health Departments
   7. Demonstration of completed irrigation installation and irrigation components operating within specified Sequence of Operation as determined by specified Commissioning Procedure prior to request for final payment (see Part 3 – Execution).

C. After date of acceptance of completion by Owner's Representative, guarantee entire system with parts and labor for one year, including first-year winterization and spring startup.

1.02 QUALIFICATIONS

A. Qualified irrigation system installers shall have experience of five years with work and products specified herein, including:
   1. Two-Wire Controller and Valve Installation
   2. Soil Moisture and Weather-Based Smart Controllers
   3. Solvent Weld and/or Gasket Joint PVC Pipe two inches and Greater
   4. Commercial/Municipal/Institutional Irrigation Systems

B. Attest qualifications below for three recent projects of similar scope and size in previous five years.
   1. Contact Name
   2. Company Name
   3. Contact Phone Number
   4. Project Name and Location
   5. Brief Project Description

1.03 UTILITIES

A. Water Service Point of Connection
   1. One new two inch domestic water service provided by Plumbing/Mechanical. Approximate Irrigation System point of connection location is noted on Drawings.
   2. Equipment requirements:
      a. Deduct Water Meter, Backflow Preventer, and Domestic Water Supply shall be provided
      a. by Plumbing to meet applicable codes.
      b. Requirements at Irrigation System point of connection:
         1) Type: Domestic Water

2) Flow: Maximum 50 gallons per minute (gpm)
3) Pressure (dynamic): 60 pounds per square inch (psi) at point of connection in landscape

c. Floor Drain

B. Electrical Power Source to Irrigation Controller (Outdoor Irrigation Mechanical Space)
1. Power Source to be provided by Electrical Contractor (Refer to Division 26 Electrical).
a. Power Requirements
1) 120-Volt, One-Phase, 60-Hz, 20-Amp (Irrigation Controller)
2. Conduits from building to point of connection as shown on Drawings to be provided by Electrical Contractor for power and communications as outlined above and below.
3. Irrigation Contractor to coordinate underground power and data connections from Electrical Contractor and use project licensed electricians provided by Electrical Contractor to connect Irrigation Controller.
4. Irrigation Contractor to feed valve wire from Irrigation Controller through pad conduits to field, transitioning to direct burial installation outside of pad limits.
5. Irrigation Contractor to ground Irrigation Controller to specified earth ground (see below).

C. Communications to Outdoor Irrigation Mechanical Space
1. Communications to be provided by Electrical Contractor (Refer to Division 26 Electrical) and Communications (Refer to Division 27 – Communications). Also cross-reference Division 23 – Building Management Systems.

D. Pipe Sleeves
1. Coordinate pipe sleeves provided by General Contractor beneath hardscape, as indicated on Drawings.
a. Pipe sleeve requirements:
1) SDR 40 PVC (size noted on plan)
2) Extend 18 inches beyond edge of hardscape
3) Minimum cover: 24 inch

1.04 RELATED REQUIREMENTS

A. Plans and general provisions of the Drawings, including but not limited to the Agreement and General Conditions and other Division 01 Specification Sections, apply to this Section.

B. Coordinate with other project trades and refer to overall project Construction Documents, including, but not limited to:
1. Division 01 – General Requirements
2. Division 02 – Existing Conditions
3. Division 03 – Concrete
4. Division 22 - Plumbing
5. Division 23 – Building Communication Systems
6. Division 26 – Electrical
7. Division 27 – Communications
8. Division 31 – Earthwork
9. Division 32 – Exterior Improvements
10. Division 33 – Utilities
11. Drawings
a. Drawings IR-100 - IR-400
b. Review other Project Construction Documents for coordination.

1.05 APPLICABLE STANDARDS AND CODES

A. Comply with following standards and codes:
   1. American Society for Testing and Materials (ASTM)
   2. National Standard Plumbing Code (NSPC)
   3. National Electric Code (NEC)
   4. National Sanitary Foundation (NSF)
   5. Underwriters Laboratories, Inc. (UL)
   6. Occupational Safety and Health Administration (OSHA)
   7. Hydraulic Institute (HI)
   8. American Wire Gauge (AWG)

B. Comply with applicable laws, standards, and regulations of local governing authority. Local laws more stringent than those referenced above shall take precedent.

1.06 SUBMITTALS

A. Submit following under provisions of Division 01 – General Conditions:
   1. Literature: Manufacturer's product data sheets, specifications and installation instructions for materials listed in this Specification (Part 2 – Products).
      a. Product submittals shall be concise (no extraneous pages or sections) and clearly marked to show submitted product model, type, and size.
      b. Substitute Product Submittal
         1) Provide specified product submittals for “Or Equal” to Owner’s Representative for acceptance.
         2) Substitute products are acceptable when products of equal or better quality and performance are submitted and accepted by Owner’s Representative.
         3) Substitute Product Submittals constitute representation that:
            a) Substitute products have been thoroughly investigated and have been determined to be equal or superior in respects to that specified.
            b) Substitute products shall provide identical or better warranties as specified products.
            c) Substitute products are compatible with interfacing items.
            d) Assume responsibility and guarantee of system performance as result of product substitution, including making subsequent changes to meet design specifications.
      c. Install new products without defects and of quality and performance as specified.
      d. Work shall not commence until all products specified are submitted and accepted by written notification by Owner’s Representative.
      e. Products to be submitted for acceptance include, but not be limited to:
         1) Automatic Irrigation Controller
         2) Moisture Sensors (Soil and Rain)
         3) Communications Connection for Irrigation Controller
         4) Wire and Connectors
         5) Conduit and Fittings
         6) Manual, Self-Regulating, and Electric Valves
         7) Valve Boxes
         8) Grounding Equipment
         9) Valves (Isolation, Winterization)
         10) Flow Sensors and Master Valves
         11) Outdoor Enclosures

2. Schedule: Submit Schedule of all products to be furnished hereunder, indicating manufacturer, size, and model.
    a. Ensure that all types/styles of products and installation equipment specified herein can be furnished by manufacturer submitted.
    b. Provide all spare parts as noted here within
    c. Prior to submitting schedule, confirm current site conditions are as provided in Drawings.

1.07 DELIVERY, STORAGE AND HANDLING

A. Do not deliver materials to Site until specified submittals have been accepted by Owner's Representative.
B. Coordinate with Owner's Representative for temporary storage and staging areas.
C. Protect materials from damage from construction traffic, weather, corrosion, and other causes while stored on-site. Minimize on-site storage as possible.
D. Store and handle all products and materials in compliance with manufacturer's instructions and recommendations.

1.08 GUARANTEE AND REPLACEMENT

A. Guarantee entire irrigation system, parts, and labor, for one year from official written date of substantial completion by Owner's Representative.
B. System malfunctions occurring during guarantee period due to defective materials, poor workmanship, or improper adjustment shall be corrected to satisfaction of Owner's Representative at no additional cost to Owner.
    1. Repair all defects within ten days of notification from Owner's Representative.
    2. Repair defects with accepted products.
C. First-year spring system start-up and winterization shall be included in system guarantee.
D. Manufacturer warranties shall be provided for all products and materials where such warranties are offered in published product data. Copies of manufacturer warranties are to be included in Operations and Maintenance Manual (See Operation and Maintenance).
    1. Provide written warranty showing date of completion and period of warranty prior to request for final payment.

PART 2 - PRODUCTS

2.01 AUTOMATIC IRRIGATION CONTROLLER

A. Controller
    1. Quantity: One
    2. Size: Approximately 16 inches tall by 12 inches wide by six inches deep
    3. Construction: Electronic with 120-Volt Input and 24-28 Volt Output, Stainless Steel Pedestal-Mounted Enclosure
        a. Irrigation Controller Enclosure Manufacturer:
            1) VIT Strongbox SB-16SS
            2) Or Equal
    4. Standards: UL-Listed
    5. Features: Manual and Automatic Control, Water Budgeting, Cycle-Soak, Sensor Input Terminals, Internal Transformer, Flow Monitoring Capability, Lightning Protection, Remote Control, Two-Wire System with Conventional Wire Retrofit Capability.
    6. Manufacturer/Model:
        a. Baseline BL-3200
        b. Rain-Bird ESP-LXD
        c. Hunter ACC2 Decoder
        d. Or Equal

B. External Devices
   1. Decoders
      a. Manufacturer/Model:
         1) Baseline BL-5201
         2) Rain-Bird FD-101
         3) Hunter ICD-100
         4) Or Equal
   2. Soil Moisture Sensor
      a. Manufacturer/Model:
         1) Baseline Biosensor BL-5315
         2) Rain-Bird SMRT-Y
         3) Hunter Soil-Clik
         4) Or Equal
   3. Rain Sensor
      a. Manufacturer/Model:
         1) Baseline BLTRB400
         2) Rain-Bird RSDBEX
         3) Hunter Rain-Clik
         4) Or Equal
      b. Coordinate attachment location in the field with Landscape Architect. Rain Sensor to be unobstructed from elements overhead.
   4. Flow Sensor
      a. Quantity: One
      b. Size: One and a half inch
      c. Flow Range one to 90 gallons per minute
      d. Manufacturer/Model:
         1) Baseline BFS150
         2) Rain-Bird FS150B
         3) Hunter Flow-Clik 150
         4) Or Equal
   5. Normally Open (NO) Master Valve
      a. Quantity: One
      b. Size: Two inch
      c. Construction: Brass Globe Valve
      d. Ratings: 220 psi
      e. Features: Manual Bleed Screw, Flow Control, Pressure Regulation
      f. Manufacturer/Model:
         1) Griswold Controls, 2160 Normally Open
         2) Superior Controls, 3100PRS Normally Open
         3) Cla-Val, 136-01 Normally Open
         4) Or Equal
      g. Note: Demonstrate master valve closing within three minutes by simulating broken pipe through unexpected flows through drain valves or multiple zones operating manually and simultaneously.
   6. Web-Based Management

a. Enroll and configure Irrigation Controller web application for remote management of irrigation system with web-enabled devices.
b. Manufacturer/Model:
    1) Baseline BaseManager Plus
    2) Rain-Bird IQ
    3) Hunter Centralus
    4) Or Equal

2.02 WIRE

A. Two-Wire
    1. Size: 14/2 AWG
    2. Construction: Dual Strand Solid Copper Conductors with PE Insulation and Polyethylene Jacket.
    3. Ratings: UL-Listed, NEC (Class II Circuit), Direct Burial UF/TWU, up to 600-Volt Potential
    4. Standards: ASTM B-3, ASTM B-8
    5. Markings: Manufacturer, Rating, Size, and Type
    6. Manufacturer/Model:
        a. Paige Wire, P7389D
        b. Regency Wire, R7534D
        c. Service Wire, DEC 14/2
        d. Or Equal
B. Conventional Wire
    1. Size: 14AWG
    2. Construction: Single Strand Solid Copper Conductor with Polyethylene Insulation
    3. Ratings: UL-Listed, NEC (Class II Circuit), Direct Burial UF/TWU, up to 600-Volt Potential
    4. Standards: ASTM B-3, ASTM B-8
    5. Markings: Manufacturer, Rating, Size, and Type
    6. Manufacturer/Model:
        a. Paige Wire, P7313D
        b. Regency Wire, R7079D
        c. Service Wire, GOLF14
        d. Or Equal
C. Wire Splices
    1. Type: Direct Burial Wire Splice Kit (All Components Intact)
    2. Construction: Lockable Plastic Tube, Pre-Filled with Insulation Gel
    3. Ratings: UL-Listed, NEC, Direct Burial and Submersion, up to 600-Volt Potential
    4. Manufacturer/Model:
        a. 3M, Direct Bury Splice Kit (DBR/Y-6)
        b. Rain Bird, WC100 Wire Connectors (DBR/Y-6)
        c. Underhill, Direct Bury Splice Kit (DBR/Y-6)
        d. Or Equal
D. Decoder Cable Fuse Device
    1. Type: Direct Burial Quick Disconnect Signal Splitter with Five-Amp Fuses
    2. Construction: Waterproof PVC with O-Ring Seal and ACME Threads
    3. Provide in-line, two-way split, and three-way split configurations following mainline branch splits.
E. Electrical Conduit (through Concrete Pads)

1. Size: One inch Minimum
2. Construction: PVC, Solvent Weld
3. Ratings: Schedule 40
4. Fittings: Long Sweep Elbows
5. Manufacturer:
    a. Cresline
    b. Certainteed
    c. JM Eagle
    d. Or Equal

2.03 ELECTRIC ZONE VALVES

A. Sprinkler Zone Valve
1. Size: two inch
2. Construction: Plastic Globe Valve with Reinforced Nylon or Fiberglass Body
3. Ratings: 200 psi
4. Features: Manual Bleed Screw, Flow Control, Pressure Regulation, and Filter/Scrubber
5. Manufacturer/Model:
    a. Hunter, ICV-G-FS
    b. Rain Bird, PESB
    c. Toro, P-220S
    d. Or Equal

2.04 ISOLATION VALVES

A. Mainline Isolation Valves
1. Sizes: Two inch
2. Construction: Bronze, Gate Valve
3. Ratings: 200 psi
4. Features: Steel Cross Handle, Non-Rising Stem
5. Manufacturer/Model:
    a. Nibco, T-113K
    b. Apollo, 102T-K
    c. Matco-Norca, MN-514XLF
    d. Or Equal

2.05 QUICK COUPLING VALVES

A. Mainline Quick Coupling Valve
1. Size: One inch
2. Construction: Brass, Spring-Loaded Valve Seat, Key Engaged, Brass Swing Joint Assembly
3. Ratings: 125 psi
4. Features: ACME Key with one inch Male ACME and 3/4-inch Female AMCE Top, Vinyl Cover
5. Manufacturer/Model:
    a. Hunter, HQ44 - LRC - AW
    b. Rain Bird, 44-RC
    c. Toro, 100-2SLVC
    d. Or Equal

B. Swing Joint Assembly
1. Size: one inch
2. Construction: PVC, with O-Ring Seals and Brass Threaded Outlet

3. Manufacturer/Model:
    a. Hunter, HSJ-1 with Snap-Lok
    b. Rain-Bird, TSJ-12
    c. Lasco, Male Thread x Snap-Lok
    d. Or Equal

2.06 VALVE BOXES

A. Valve Boxes ten feet off out of bounds lines along field perimeter. Coordinate final field locations with Landscape Architect.

B. General
    1. Size
        a. Six inch Round
            1) Wire Splice
            2) Decoder Cable Fuse Device
        b. Ten inch Round
            1) Isolation Valve
            2) Quick Coupling Valve
        c. 12 inch Standard Valve Box
            1) Single two inch Electric Zone Valve
    2. Construction: Resin
    3. Ratings: Tensile Strength 3,000 to 5,000 psi
    4. Lid Color: Green
    5. Features: Lockable, Bolt-Down Covers (Provide Bolts and Install), Brick Supported
    6. Manufacturer/Model:
        a. Carson, Specification Grade NDS Pro
        b. Rain Bird, VB Series
        c. Dura, Valve Boxes
        d. Or Equal

2.07 FIELD EARTH GROUND SYSTEM

A. Bond field decoders and provide Earth Ground System per manufacturer requirements.
    1. Grounding Plate
        a. Wire: 6AWG Bare Copper
        b. Plate: Four inches by 96 inches by 1/16-inches Thick (25 feet roll)
        c. Construction:
            1) Plate: Copper with Loresco PowerSet Ground Enhancement Material Above and Below
        d. Ratings: UL-Listed
        e. Features: Cadweld Connectors from Wire to Plate, Manufacturer provided Plate Connections, PVC or ADS Drain Pipe and Grate Cover over Plate with Metal Detection.
        f. Standards: NEC 250.52 (7)
            1) Manufacturer/Model:
                a) Paige Wire, Model 182199
                b) nVent, Model UGP4966F25
                c) Regency Wire, Model GRPL4X96
                d) Or Equal
    2. Separate Field Earth Ground System from Irrigation Controller Earth Ground System

2.08 PIPE AND FITTINGS

A. Irrigation Mainline and Laterals (PVC)
   1. Size: Two inch Maximum
   2. Construction: Polyvinyl Chloride (PVC), Solvent Weld
   3. Ratings: Class 200 Pressure Pipe
   4. Standards: ASTM D-1785
   5. Markings: Manufacturer, Nominal Size, Class or Schedule, Pressure, Extrusion Date, Pipe Insertion Mark.
      a. Manufacturer/Model:
         1) Cresline
         2) Certainteed
         3) JM Eagle
         4) Or Equal

B. Irrigation Mainline and Lateral Fittings (PVC)
   1. Size: Two inch Maximum
      a. For Valves TOE Nipples: Schedule 80 PVC
      b. Other Fittings: Schedule 40 PVC
   2. Markings: NSF Designation, Size, Class or Schedule
      a. Manufacturer/Model:
         1) Lasco
         2) Spears
         3) Dura
         4) Or Equal

C. PVC Solvent
   1. Type: NSF Type I or Type II PVC
   2. Standards: ASTM D-2564
      a. Manufacturer/Model:
         1) IPS Weld-On 711
         2) Oatey HD Cement
         3) Rectorseal Gold
         4) Or Equal

D. PVC Primer
   1. Type: NSF for PVC
   2. Standards: ASTM F-656
      a. Manufacturer/Model:
         1) IPS Weld-On P-68
         2) Oatey Clear Primer
         3) Rectorseal Jim PR-2
         4) Or Equal

E. Pipe Sleeves
   1. Sizes: Four inch Minimum, Refer to Drawings for Sizes
   2. Construction: Polyvinyl Chloride (PVC), Solvent Weld
   3. Ratings: Schedule 40
   4. Standards: ASTM D-1785

5. Pipe Markings: Manufacturer, Nominal Size, Schedule, Pressure, Extrusion Date, NSF 14, Pipe Insertion Mark.
    a. Manufacturer/Model:
        1) Cresline
        2) Certainteed
        3) JM Eagle
        4) Or Equal

2.09 METALLIC UTILITY TRACER TAPE

A. All drain pipe, irrigation pipe, direct burial wire installations shall also include the installation of metallic underground warning tape

B. Colors:

Color	Utility
Purple	Irrigation Pipe
Red	Direct Burial Wire
Green	Drain Pipe

C. Size: Four inch to six inch wide

D. Markings: Tape marking shall indicate that a water pipe is buried below by reading " CAUTION DRAIN/IRRIGATION/ELECTRICAL BELOW" or a similar marking

2.10 GEAR-DRIVEN ROTOR SPRINKLERS

A. 3/4-inch Inlet Rotor
    1. Body
        a. Size: six inch Pop-Up
        b. Construction: Gear-Drive, Removable Nozzle, Internal Check Valve, Stainless Steel Retraction Spring, Rubber Cover, Stainless Steel Riser
        c. Features: Adjustable Part and Full Circle
        d. Manufacturer:
            1) Hunter, I-20-SS-06 (Basis of Design on Drawings)
            2) Rain-Bird, Falcon 6504-SS
            3) Toro, T7PSS-02
            4) Or Equal

B. Swing Joints
    1. Size: 3/4-inch
    2. Construction: PVC, with O-Ring Seals and Brass Threaded Outlet
    3. Manufacturer/Model:
        a. Hunter HSJ
        b. Rain Bird TSJ
        c. Lasco Swing Joint Assemblies
        d. Or Equal

2.11 EARTH MATERIALS

A. Stone (in Valve Boxes at Grade)
    1. Type: 3/4-inch Washed Crushed Stone

B. Clean Sand (Pipe Bedding Material)
    1. Gradation: (passing by weight)
        a. No. 4 Sieve: 80 percent
        b. No. 200 Sieve: Five percent

C. Concrete (Irrigation Controller Pedestal Enclosure Pad)
   1. Ratings: 4,000 pounds per square inch 28-day Compressive Strength
   2. Standards: ASTM C-33, ASTM C-94, ASTM-C150

2.12 SPARE PARTS

A. Wrenches, Keys, and Tools for Servicing and Adjusting Sprinkler Heads, quantity, two.
B. Quick Coupler Valve Keys, quantity, one.
C. Gate Valve, quantity, one.
D. Assorted Valves and Fittings
E. Sprinkler Heads and Nozzle Racks, quantity, three of each.

PART 3 - EXECUTION

3.01 GENERAL

A. Competent superintendents and assistants shall be on-site at all times during product delivery, installation, testing, and system adjustments.
B. System features shall be laid out as indicated on Drawings, making minor adjustments for variations in planting arrangements or field conditions. Major changes shall be reviewed with Owner's Representative before acceptance.
   1. Irrigation lines shown on Drawings are diagrammatic only. Location of irrigation equipment is contingent upon and subject to integration with all other underground utilities, tree roots, and hardscape design elements.

3.02 EXAMINATION

A. Review and verify project conditions are as indicated on Drawings prior to starting work, including but not limited to:
   1. Utilities
   2. Site grades and dimensions
   3. Landscaping features and hardscaping
   4. Structures
B. Report any irregularities of site conditions to Owner's Representative prior to beginning work.
C. Beginning of installation connotes acceptance of existing project conditions.

3.03 PROJECT COORDINATION

A. Coordinate with Owner's Representative to expeditiously install system.
B. Provide written notifications (electronic is acceptable) to Owner's Representative prior to work commencement, weekly for progress report, for any proposed changes to system design, and upon installation completion.
C. All questions of design intent, proposed design changes, field notifications, and product substitution after installation commences shall be in writing to Owner's Representative as Request for Information (RFI).
D. Utility Coordination
   1. Maintain six inch clearance between irrigation lines and any utility line. Do not install irrigation mainlines nor lateral lines directly above another utility of any kind.
   2. Exercise care when working near existing utilities.

3.04 SITE PROTECTION

A. Protect landscaping, paving, structures, walls, and footings from damage caused during work. Damage to work of another trade shall be reported at once.
B. Replace or repair any damage with same product or material, to satisfaction of Owner's Representative at no additional cost per Guarantee.

3.05 AUTOMATIC IRRIGATION CONTROLLER INSTALLATION

A. Controller

1. Install controller at location shown on Drawings.
2. Wire valves and external sensors into controller through conduits and set proper programming.
    a. Program “Cycle-Soak” feature for all zones with sloped or poorly draining soils.
    b. Install and calibrate soil moisture sensors as per manufacturer instructions.
    c. Soil moisture sensors are not required for each irrigation zone. Assign representative soil moisture sensors for similar zones, such as:
        1) Sun vs. Shade
        2) Crown of Field vs. Edge of Field
        3) Use Irrigation Plans provided for Recommended Quantity and Assignment
3. Using licensed electrical, wire controller to 120-Volt, 20-Amp electrical supply provided by Electrical Contractor.
4. Provide keys after final walkthrough.

B. Flow Sensor
1. Install Flow Sensor as shown on Drawings.
2. Provide straight pipe for Flow Sensor to reduce turbulence.
    a. Upstream: ten times pipe diameter
    b. Downstream: five times pipe diameter
3. Wire Flow Sensor to Automatic Irrigation Controller as specified with waterproof connectors. Do not use splices between Controller and Flow Sensor.

C. Grounding
1. Coordinate with Electrical Contractor for acceptable earth ground locations.

D. Soil Moisture Sensors
1. Install Soil Moisture Sensors below grade as per manufacturer recommendations and connect to two-wire path. Use controller to identify connection to soil moisture sensors.
2. Once installed in field and recognized by controller, set controller to calibrate soil moisture, typically saturating surrounding soil and allow to drain (as per manufacturer instructions).
3. Once calibrated, set representative irrigation zones (see above) to operate only when soil moisture meets watering criteria.
4. Coordinate with Owner’s Representative on how to set irrigation watering criteria; generally:
    a. High-Limit (keep soil moist constantly, generally required for establishment)
    b. Low-Limit (allow soil to dry out)
    c. Combination of High and Low-Limit: (keep at moderate soil moisture level)

3.06 WIRE INSTALLATION

A. Install low-voltage valve two-wire per NEC, state, and local electrical codes for less 30-Volt service.

B. Install valve two-wire in trench alongside mainline at invert elevation. Backfill carefully to avoid any damage to wire insulation on conductors.
1. In areas of unsuitable material, use clean sand in bottom of trench before placing wire (see Excavation, Trenching, and Backfilling)
2. Cover over wire: 12 inch

C. Maintain sufficient slack for expansion, contraction and servicing. Do not install wiring tightly.
1. Provide and install additional eight inches to 12 inches slack for conventional wire from decoder to valve.
2. Provide 30 inches slack between decoders for two-wire.
3. Provide sufficient length of wire in valve boxes to allow valve solenoid, splice, decoder wire, and all connections to be brought above grade for servicing.
4. Coil slack for neatness in valve box.

D. Install Decoder Cable Fuse Device as shown on Drawings; generally, prior to junction points on two-wire path.
E. Provide waterproof splices at in-ground wire connections using accepted splice kits. Splices shall be made in valve boxes and recorded on Record Drawings.
F. Provide complete wiring diagram showing wire routing for connections between controller and valves as specified in Record Documents.
G. Securely store wire when not scheduled for installation.

3.07 GROUND INSTALLATION

A. Decoder Grounding
   1. Provide lightning surge arrestors as shown on Drawings.
   2. Provide grounding per manufacturer's instructions. Where no grounding requirements are specified, provide grounding every six decoders or 500 feet maximum.
B. Lightning/Surge Arrestor
   1. With waterproof splices, connect lightning arrestor red wire to site red wire and lightning arrestor black wire to site black wire. Decoder, lightning arrestor, and site two-wire may be connected in same waterproof splice as per manufacturer.
   2. With waterproof splice, connect lightning arrestor ground green wire to 8AWG solid bare copper wire. Bury bare copper wire grounding wire 12 inches (or per local code) and run to accepted building ground location.
   3. Place wired lightning arrestor neatly inside valve box.
C. Controller Grounding
   1. Connect bare copper 8WG wire to controller ground lug and connect to earth ground.
   2. Do not create grounding loop with field decoders (different ground locations outside of influence spheres).

3.08 DECODER INSTALLATION

A. Wiring
   1. With waterproof splices, connect decoder red wire to site red wire and decoder black wire to site black wire.
   2. With waterproof splices, connect decoder valve leads to electric zone valve solenoid leads.
   3. Place wired decoder neatly inside valve box.
   4. Connect with irrigation controller and run diagnostic decoder search to link.
B. Provide grounding for decoders per manufacturer's instructions. Refer to Ground Installation section.
   1. With waterproof splice, connect lightning arrestor ground green wire to 8AWG solid bare copper wire. Bury bare copper wire grounding wire 12 inches (or per local code) and run to grounding plate.
   2. Place wired lightning arrestor neatly inside valve box.
   3. Splice all lightning arrestor green wires in series (with 8AWG green jacketed copper wire) and coordinate acceptable earth grounding with Electrical Contractor.

3.09 PIPE INSTALLATION

A. PVC Pipe Installation
   1. Cut plastic pipe with handsaw or pipe cutter, removing all burrs at cut ends. All pipe cuts shall be square and true. Bevel cut end to conform to manufacturer instructions.
   2. Make all solvent-weld joints as per manufacturer's instructions and avoid applying excess primer or solvent. Do not wipe off excess solvent from each connection.
      a. Allow welded joints Five minutes set-up/curing time before moving or handling.
         1) Above 80 degrees Fahrenheit: Allow connections to set 24 hours.

2) Below 80 degrees Fahrenheit: Follow manufacturer instructions.
3) Below 40 degrees Fahrenheit: Prohibited.

b. Maximum deflection per joint shall not exceed manufacturer limits.
c. Maintain one inch between lines which cross at angels of 45 to 90 degrees.

B. Pipe Cover (unpaved surfaces at grade)
1. PVC Mainline: 24 inches unless otherwise specified
2. PVC Lateral: 14 inches

C. Pipe Protection
1. Prevent foreign material from entering pipe during installation.
2. Open ends of pipe shall be closed by watertight plug or seal when not in use.
3. Securely store pipe when not scheduled for installation.
4. Pipe shall not be installed when water is in trench, during rainstorms, or when temperature is below 40 degrees Fahrenheit.
a. No additional pipe may be installed or backfilled if water enters trench during pipe installation. Remove all water from trench before resuming installation.
b. Pipe installed at temperatures below 40 degrees Fahrenheit shall be removed and replaced at no cost to Owner.
5. Trenched PVC pipe shall be snaked to accommodate for expansion and contraction due to changes in temperature.

3.10 METALLIC UTILITY TRACER TAPE

A. Metallic underground warning tape shall be installed six inches above the crown of the pipe and above direct burial wire.
B. Tape shall be installed in accordance with the manufacturer's recommendations.
C. Any tape damaged during shipment or installation shall be immediately replaced prior to backfilling the trench.

3.11 ELECTRIC ZONE VALVE INSTALLATION

A. Install electric zone valves on level crushed stone base generally where shown on Drawings. Do not pour stone around valves that are already installed.
B. Install all Schedule 80 PVC threaded nipples with Teflon tape, isolation valves, and/or union couplings in and out of electric zone valves as shown on details on Drawings.
C. Set valves plumb with adjusting handle and bolts, screws, and wiring accessible through valve box opening.
D. Install at sufficient depth to provide between four inches and six inches of cover from top of valve to finish grade.
E. Install specified valve box over all electric zone valves. Set lid is flush with final proposed grade. Coordinate with Landscape and Civil Drawings.
F. Adjust zone valve operation after installation using flow control device on valve.

3.12 QUICK COUPLING VALVE INSTALLATION

A. Install quick coupling valves where indicated on Drawings; generally, at ends of mainline branches for winterization.
B. Mount mainline quick coupling valves on one inch diameter, 12 inch long brass swing joint assemblies and stabilizers.

3.13 VALVE BOX INSTALLATION

A. Furnish and install valve boxes as per valve schedule above for each valve, splice, or sensor.
B. Install plastic valve boxes on minimum four inches crushed stone base. Pouring stone into valve box after installation is not acceptable.

C. Finish elevation of all boxes shall be at grade, unless otherwise noted in Drawings.
D. Provide level brick supports beneath valve boxes.
    1. For square/rectangular boxes, provide four supports - one at each corner.
    2. For round boxes, provide three supports equally spaced.

3.14 SPRINKLER INSTALLATION

A. Sprinklers shall not exceed maximum spacing as indicated on Construction Drawings.
B. Install sprinklers flush with grade on PVC swing joints as specified.
C. Flush system before installing internals, flush caps, and nozzles (see Testing and Adjustments)
D. Adjust sprinklers after installation using flow control device on valve. Do not exceed radius reduction recommendations from manufacturer.

3.15 PUNCHLIST SITE VISIT

A. Punchlist Site Visit requirements to be submitted to Owner's Representative for acceptance:
    1. Pressure and Leak Test Results of Pipe Network
    2. Solenoid Valve Resistance Readings
    3. Receipt of Cellular Card, Antenna, and/or Data Service Plan).
B. Verification of Web-Enabled Application with:
    1. Account Information (Login and Password)
    2. Owner's Representative shall Login to verify system setup and programming
    3. Push Notification and Short Messaging Service (SMS) setup to designated landscape managers and irrigation installer to notify of alerts during guarantee period.
    4. Screenshots of Learned Flow, Master Valve Enabling, and Programs.
    5. Connection and operation of pressure sensor, flow sensor, and weather sensing devices.
    6. Demonstrate to Owner's Representative during Commissioning Site Visit
    7. All components of irrigation system including:
        a. Clean and neat layout of all components
        b. Pressure Gauges showing adequate pressure
        c. Secured pipe, wire conduit, and controller
        d. Valve Boxes flush with finish grade
        e. Interiors of all Valve Boxes that have neat, clean valves and wiring
    8. Normal operation of irrigation watering sequence for two minutes per zone sequentially.
    9. Ability to hand water through quick coupling valve with key.
    10. Ability of Normally Open (NO) Master Valve to close within three minutes of abnormal flow using multiple quick coupling valves and multiple solenoid valves manually open.

3.16 TESTING AND ADJUSTMENTS

A. Include all testing and adjustments in submitted bid price.
B. System Flushing:
    1. Flush irrigation system after complete installation.
C. Testing
    1. Test pipe and valves for leaks at operating pressure. Repair leaks and retest until leaks are remedied.
    2. Perform coverage test with Owner's Representative present. Operate electric zone valves for five minutes during coverage test. Readjust sprinkler nozzles and head locations to attain proper coverage. Replace any equipment that does not meet specified standards.
    3. After testing, clean equipment of debris during installation.
D. Adjust sprinkler heads and valve boxes for mowing and landscaping.

E. Throughout the guarantee period, adjust sprinklers and ensure coverage due to settlement and landscaping operations.

3.17 RECORD DOCUMENTS

A. As-Built Drawings
   1. Maintain and update Record Drawings with red-line markings as project progresses, including locations of:
      a. Sprinklers and descriptions (nozzles, pop-up height, and type)
      b. Valve Boxes and descriptions (valve type, zone numbers, and splice)
      c. All equipment installed with distinct symbols.
      d. Pipe routing and tees.
      e. Wire routing and splices.
   f. Controller Location
   2. Locations of installed equipment (valve, controller, sensors) shall be referenced by two permanent locations (swing ties) or GPS.
   3. Make all notes legible as work progresses, any new equipment added shall use distinct symbols denoting location.
   4. Document any changes from original Drawings.
   5. Prints of original Drawings may be obtained from Owner's Representative at cost.
   6. Record Drawings shall be used as basis of payment for work completed. Provide copies of red-lined set to Owner's Representative along with payment request.

B. Record Documents
   1. Maintain Record Documents at site. Maintain record of following as project progresses:
      a. Materials accepted and acceptance date.
      b. Materials delivered, Accepted, and Installed by whom and date.
      c. Field Communications and Requests for Information (RFI).
   2. Prior to final punchlist, provide complete electronic and hard copy files of Record Drawings and Documents to Owner's Representative as part of project completion. All information shall be complete and shall be added to submitted documents prior to acceptance.

3.18 OPERATION AND MAINTENANCE

A. General
   1. Bid price shall include up to four hours of irrigation system overview and instruction with Owner's Representative.
   2. Refer to Division 01 – General Requirements for Additional Requirements.
   3. Operation and Maintenance Manual shall include, but not be limited to:
      a. Title Page and Table of Contents
      b. One-Paragraph Written Description of Irrigation System
      c. Manufacturers' Data and Cut Sheets of Equipment, including:
         1) Copies of all accepted submittals
         2) Wire resistance readings to each electric valve at completion (for future troubleshooting)
         3) Recommended operating settings
         4) Recommended maintenance schedule
         5) Name, address, and telephone number of installer (for repairs, spring startup, and winterization during one-year guarantee period)
         6) Irrigation program for periods without rain and recommended settings including, zone run time, days per week, cycle-soak, and rain sensor suspension.

d. Winterization and Spring Startup Instructions (after one-year guarantee period)
e. Guarantee Data
f. Pockets with Folded Plans of:
    1) Original Design Drawing
    2) Final Record Drawing
    3) Controller Valve and Wiring System Diagram Drawing

3.19 SITE CLEANUP

A. Remove unused materials and equipment from project site safely and efficiently. Dispose of unused materials legally, including construction debris and trash.
B. Adjust ground, compact, and re-plant around irrigation sprinkler heads and trenches for proper angle and elevation.
C. Fill depressions and erosion rills with specified planting soil mix to ensure site drainage.

3.20 FINAL ACCEPTANCE

A. Final Acceptance of Irrigation System is predicated on:
    1. Complete system installation, adjustment, testing, and instructional overview.
    2. Submission of Operation and Maintenance Manuals to Owner's Representative.
    3. Proper Programming of Automatic Irrigation Controller.
    4. Completed and accepted punchlist items.
B. Owner's Representative shall provide written notice (hard copy and/or electronic) for Final Acceptance. Date of Final Acceptance notice shall serve as start of one-year Guarantee period as described above.

END OF SECTION

SECTION 32 90 00
UNDERDRAIN SYSTEM

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 DESCRIPTION OF WORK

A. Work Includes:
   1. Provide labor, materials, tools, and equipment required to complete work as indicated on Drawings and as specified within this Section.
   2. Work includes installation of athletic field underdrains and conveyance infrastructure as shown on Drawings.
   3. Work includes excavation, aggregate drainage media, backfill, compaction, outlet structures, and stabilization.
   4. Coordinate and complete work with connecting storm drainage improvements as indicated in other specification sections (see Division 33).

1.03 RELATED WORK

A. Related Work: The following items are noted and included in this Section and shall be performed under the designated sections:
   1. Division 01 – General Requirements
   2. Division 02 – Existing Conditions
   3. Division 03 – Concrete
   4. Division 22 – Plumbing
   5. Division 26 – Electrical
   6. Division 27 – Communications
   7. Division 31 – Earthwork
   8. Division 32 – Exterior Improvements
   9. Division 33 – Utilities

1.04 SUBMITTALS

A. Refer to Division 01 – General Conditions, for submitted provisions and procedures.
   1. Qualifications: Provide three projects demonstrating successful athletic field underdrain system installation in previous five years. Qualifications are subject to acceptance of Owner's Representative.
      a. Contact Name
      b. Company Name
      c. Contact Phone Number
      d. Project Name and Location
      e. Project Completion Date
      f. Brief Project Description
   2. Shop Drawings: Shop drawings showing dimensions, joint and other details of materials proposed for the work. Submit Shop Drawings for acceptance prior to ordering material.
   3. Sieve Analysis: Provide sieve analysis for aggregate drainage materials for acceptance prior to ordering material.
   4. Products: Provide product cut sheets for pipe, fittings, and geotextiles as specified below.
   5. As-Built Plan: Provide as-built showing pipe locations and invert elevations of Athletic Field Underdrain System.

6. Maintenance Instructions: Provide recommended procedures to be established for maintenance of underdrain system during calendar year. Submit after substantial completion and punchlist site visit prior to start of one year guarantee period.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Qualified landscape installer whose work has resulted in successful athletic field underdrain installation meeting acceptance of qualifications submittal above by Owner's Representatives. Require Installer to maintain experienced full-time supervisor on Project site when construction is in progress.

B. Mandatory construction milestone reports and observations as specified in the Drawings.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Aggregate materials

1. Coordinate and deliver aggregates to a pre-accepted location in separate piles.
2. Stockpiles left for over 72 hours to be surrounded by containment straw bales and completely covered with an accepted blanket material to prevent invasive seed contamination from mixing with the stockpiled materials.

B. Store pipe and geotextile safely and securely from vandalism, theft, and weather.

1.07 PROJECT CONDITIONS

A. Weather Limitations

1. Do not install Athletic Field Underdrain System during any form of precipitation.
2. Do not install Athletic Field Underdrain System below 40 degrees Fahrenheit as per manufacturer recommendations for solvent-weld drainage pipe.

B. Coordinate with athletic field soils installation and irrigation system installation.

1.08 QUALITY ASSURANCE

A. The Owner's Representative's duties do not include the supervision or direction of the actual work by the Contractor, their employees, or agents. Neither the presence of the Owner's Representative nor any observation and testing by the Owner's Representative shall excuse the Contractor from defects discovered in their Work.

PART 2 – PRODUCTS

2.01 DOUBLE WASHED CRUSHED STONE

A. Crushed stone shall consist of durable crushed rock or durable crushed gravel stone, free from ice and snow, sand, clay, loam, collapsible material, and organic material.

B. Double wash crushed stone used within Underdrain pipe bedding prior to installation/placement.

C. Crushed stone to be uniformly blended conforming to the gradation for 3/4 inch crushed stone as specified in Division 31 - Earthwork.

2.02 COARSE SAND FOR UNDERDRAIN SYSTEM

A. Sand for underdrain system to consist of clean inert, hard, durable grains of quartz or other hard durable rock, free from clay, organics, surface coatings or other deleterious material.

B. Sand to meet ASTM C-33 (Fine Aggregate) with Fines Modulus Index of 2.75 or greater conforming to following gradation:

Sieve Size	Percent Passing by Weight
3/8 in.	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

2.03 DRAIN MANHOLE

A. Drain Manhole:
   1. Size:
      a. Inner Diameter: 24 inches
      b. Wall thickness minimum: Six inches
   2. Construction:
      a. Precast Concrete
      b. Ratings: 4,000 psi 28-day
      c. Designed for AASHTO HS-20 Loading
   3. Cover:
      a. Size: 24 inch Round Lid
      b. Construction: Cast Iron

B. Manufacturer:
   1. Two foot Area Drains by Phoenix Precast Products
      a. With Optional Cast Iron Frame and Cover
   2. Two foot Area Drains by Shea Concrete
      a. With Optional Cast Iron Frame and Cover
   3. Or Equal

2.04 PEA GRAVEL (SOIL PROFILE COORDINATION NEEDED)

A. Pea gravel to be placed over underdrain crushed stone.

B. Pea gravel consists of durable crushed rock or durable crushed gravel stone free from ice, snow, sand, clay, loam, collapsable material, or organic material.

C. Pea gravel to be double washed with 1/4-inch to 3/8-inch in size or equivalent to Number nine double washed crushed stone.

2.05 PLASTIC PIPE

A. Perforated Underdrain Pipe under Athletic Field
   1. Size: Four inch and eight inch Diameter
   2. Construction: Corrugated Single Wall HDPE Plastic Pipe with perforations.
   3. Features: AASHTO M252 or AASHTO M294

B. Solid Drain Pipe under Athletic Field
   1. Size: Eight inch and 12 inch Diameter
   2. Construction: Corrugated HDPE Plastic Pipe
   3. Manufacturer/Model:
      a. ADS N-12 Dual Wall Pipe
      b. Eagle Corr PE (Dual Wall) by JM Eagle
      c. Menards
      d. Or Equal

C. Pipe Fittings
   1. Construction: High Density Polyethylene (HDPE)
   2. Cell Classification: 424420C
   3. Standards: AASHTO M252, Type S or SP
   4. Joints and Fittings:
      a. Bell and Spigot Gasketed Joints
         1) Standards: AASHTO M252, AASHTO M294, or AASHTO F477
      b. Bell and Spigot Fittings
         1) Standards: AASHTO M252, AASHTO M294, or AASHTO F2306
   5. Manufacturer – Matches supplied Solid Drain Pipe

2.06 PORTLAND CEMENT MORTAR

A. Mortar shall be a Portland cement mortar conforming to ASTM C 270, Type M.

B. Mortar shall contain a waterproofing admixture.

C. Waterproofing admixture Manufacturers:

1. Hydratite Plus by W.R. Grace and Company
2. Medusa Waterproofing by Medusa Portland Cement Company
3. Omicron Mortarproofing by Master Builders Company
4. Or Equal

2.07 NON-SHRINK GROUT

A. Grout shall be non-shrink type.

B. Manufacturer:

1. Embeco by Master Builders
2. 5 Star Grout by U.S. Grout Corp.
3. Upcon 262 by Upco Co.
4. Or Equal

2.08 GEOSYNTHETICS

A. Filter Fabric is to be placed as shown on Underdrain Drawings.

B. Filter fabric to conform to Division 31 - Earthwork.

PART 3 – EXECUTION

3.01 COORDINATION

A. Pre-Installation Examination Required

1. Examine previous work, related work, and conditions under which this work is to be performed and notify Owner's Representative in writing of deficiencies and conditions detrimental to completion of this work.
2. Beginning work means acceptance of substrates, previous work, and conditions.

B. Do not place underdrain materials until work in adjacent areas is complete and accepted according to overall construction sequence.

C. Coordinate activities with other trades to prevent soil disturbance from traffic or other construction activities after placement.

D. Excavate and install underdrainage system after downstream storm drainage system has been installed to facilitate ease of subsurface connections.

E. Protect crushed stone and underdrainage perforated piping from construction sediment by temporarily covering crushed stone/piping with filter fabric.

F. Flush underdrain pipe and drainage connection with freshwater supply (coordinate in field).

G. Schedule and coordinate underdrain installation with athletic field installation.

H. Restrict traffic over field prior, during, and after installation.

3.02 EXCAVATION AND COMPACTION

A. Avoid compaction of athletic field areas prior to construction. Place barricades to restrict access.

B. Do not excavate underdrain trenches when soil is moist or frozen. Smearing soil is not acceptable to continue work.

C. Provide subgrade with gradient less than 1/2-percent slope.

D. Subsoil compaction at underdrain trench bases to prepare using primary tilling equipment such as chisel plow, ripper, or subsoiler. Tilling operations to refracture subgrade to depth of 12 inches

E. Do not use heavy equipment within athletic field underdrain system and trenches. Heavy equipment may be used around athletic field to supply materials. Use light equipment such as compact loader or loader with marsh tracks.

F. Minimize over-compaction of both base and backfill lifts of underdrain system. When possible, use excavation hoes to remove original soil. Compaction significantly contribute to degradation of infiltration capacity of underdrain compaction.

3.03 UNDERDRAIN CONSTRUCTION

A. Do not use heavy equipment within athletic field underdrain system limit of work.

B. Use filter fabric to temporarily protect layers and lifts of installation of athletic field underdrain system work. Remove filter fabric before installing next lifts.

C. Perforated Pipe Installation

1. Collector pipe for underdrain systems shall be constructed with slope as indicated on Drawings. Install pipe with uniform gradient and provide unrestricted flow to outlet.
2. Install perforated pipe with perforations down at four and eight o'clock positions.
3. Cap ends of underdrain pipes without cleanouts.
4. Place crushed stone to depth of 12 inches
5. Temporarily cover crushed stone surface with filter fabric to prevent sedimentation of gravel layer prior to placement of pea gravel layer.
6. Remove filter fabric prior to pea gravel layer placement.

D. Pea Gravel Installation

1. Place pea gravel to depth of one inch, install underdrain pipe, and then fill trench around pipe to two inches above pipe crown (five inches overall depth).

E. Sand Installation

1. Do not install or work sand when moist or frozen.
2. Place sand in six inch lifts. Traffic from installation equipment is permitted to spread and seat sand. Additional compaction is forbidden.
3. Scarify surface of each lift to prevent compaction interfaces that reduce functionality of drainage system.
4. Do not back-blade sand with buckets or dozer blades.
5. No other materials or substances to be mixed or dumped within underdrain trenches that may be harmful to plant growth or prove hindrance to planting or maintenance operations.

3.04 HDPE pipe installation

A. Sections of HDPE pipe should be connected using bell and spigot joints into continuous lengths on-site, above ground, before installation.

B. HDPE Pipe Joints

1. Bell and Spigot
2. HDPE pipe shall be joined using a bell and spigot joint. The joint shall utilize a spun-on or welded bell and valley or saddle gasket meeting the requirements of the manufacturer; including, but not limited to:
    a. Soil-tight
    b. Meet AASHTO M252, AASHTO M294, AASHTO F2306, or AASHTO F477

3.05 PRECAST CONCRETE STRUCTURES

A. The Precast Concrete Structures shall be installed in accordance with the Manufacturer's installation instructions and recommendations, and in accordance with the Drawings.

B. Precast structures shall be set to the required elevation and shall be plumb and vertical, with each section in true alignment.

1. Lifting holes in precast sections shall be thoroughly plugged with mortar and finished smooth and flush with adjoining surfaces.
2. Pipe shall extend, around its entire circumference, to inside surface of wall of structure into which it is inserted. Pipe shall be joined to manhole wall using either a flexible manhole sleeve or non-shrink grout. For grouted joints, surface between pipe and wall shall be filled with non-shrink grout.

C. Portland cement-based mixtures used on this work shall receive a minimum of three days of moist curing, which shall start immediately after the material has been placed. Suitable means shall be

employed to protect cement-based mixtures from too rapid drying and damage from cold weather and frost.

D. The work shall be conducted in such manner that no loose excavation or other foreign material can enter the precast structure and/or pipe(s).

E. Precast structure installations shall be bedded and enveloped in Crushed Stone in accordance with this Specification and the Drawings.

F. Provide concrete manhole risers as shown on plan. Seal all joints with watertight tape, sealant, or hydraulic cement.

G. Core pipe entering and leaving through concrete manhole and seal with non-shrink grout.

3.06 MANHOLE SOLID COVERS

A. Install per manufacturer's directions and as shown on the Drawings.

B. Brick or Pre-Cast Concrete Top Slabs shall be employed to bring cast iron frame, cover, and grate to required elevation. Completed brick installation shall be coated with at least a 3/4 inch thickness of mortar on outside to provide a fully sealed and watertight collar between the top of the precast structure section and the cover or grate frame.

1. Improperly set grates that cause disturbances in the paving pattern shall be re-set if not acceptable to the Owner’s Representative.
2. Before installation of castings, chipped and scraped areas shall be touched up with one coat of bituminous paint.
3. Cast iron frame shall be set centered over opening in a full bed of mortar. A thick ring of mortar extending to the outer edge of brick or concrete shall be placed all around the bottom flange of the cast iron frame. Mortar surface shall be smooth and shall be sloped to shed water away from the frame.
4. Waterproofing shall be added to the mortar for underground masonry in accordance with the water proofing manufacturer’s directions. Other additives shall not be permitted in the mortar.

C. Portland cement-based mixtures used on this work shall receive a minimum of three days of moist curing, which shall start immediately after the material has been placed. Suitable means shall be employed to protect cement-based mixtures from too rapid drying and damage from cold weather and frost.

3.07 CLEAN UP

A. At completion of work, remove debris, materials, rubbish, and excess dirt from site and legally dispose.

B. Leave premises in clean, safe, and condition.

C. Vacuum sediment and construction debris from structure prior to and during guarantee.

END OF SECTION

SECTION 32 91 31
ATHLETIC FIELDS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Non-irrigated Multiuse Athletic Field turfgrass seeding.
   2. Irrigated Multiuse Athletic Field turfgrass seeding.
   3. Maintenance.

B. Related Sections:
   1. Section 31 10 00 "SITE CLEARING" for topsoil stripping and stockpiling.
   2. Section 31 00 00 "EARTH MOVING" for excavation, filling and backfilling, and rough grading.
   3. Section 31 25 00 “EROSION AND SEDIMENTATION CONTROLS” for earthwork stockpiles, cut and fill slopes, constructed and existing swales and ditches, and unestablished lawn and seeded embankments.
   4. Section 32 92 00 “TURF AND GRASSES” for border turf.
   5. Section 32 93 00 "PLANTS" for border edgings.
   6. Section 33 41 00 “STORM UTILITY DRAINAGE PIPING” for subsurface drainage.
   7. Section 33 49 23 “STORM DRAINAGE RETENTION STRUCTURES” for structures under multiuse athletic field.
   8. Section 32 84 00 “IRRIGATION” for irrigation at the multiuse athletic field.
   9. Section 32 90 00 “UNDERDRAIN SYSTEM” for underdrains at the multiuse athletic field and playgrounds.

1.03 DEFINITIONS

A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

F. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

G. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

H. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.

I. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.

B. Shop Drawings:
   1. Stripping plan; layouts showing any field lines, markings and boundaries, and field logos per project drawings.

1.05 INFORMATIONAL SUBMITTALS

A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

B. Qualification Data: Submit proof of qualified landscape Installer to the Owner's Representative in accordance with QUALITY ASSURANCE paragraph of this Section.

C. Product Certificates: At least 30 days prior to ordering materials, submit to the Owner's Representative samples, certifications, manufacture's product data and certified test results for materials as specified below. No materials shall be ordered or delivered until the required submittals have been reviewed and approved by the Owner's Representative. Delivered materials shall closely match the approved samples. Approval shall not constitute final acceptance. The Owner's Representative reserves the right to reject, on or after delivery, any materials which does not meet these Specifications:
   1. Fertilizer: Submit product literature of seeding fertilizer and certificates showing composition and analysis.
   2. Soil Additives: Submit product literature on all soil additives to be used on site.
   3. Limestone: Submit supplier's certificate that the limestone being supplied conforms to these Specifications.
   4. Hydroseeding: Submit a certified statement for approval as to the number of pounds of materials to be used per 100 gallons of water.
   5. Wood Cellulose Fiber Mulch: Submit one copy of manufacturer's literature and one material sample.

D. Material Test Reports: For sampling and testing of Loam Borrow from Off-Site Sources and from On-Site Sources shall be as specified in QUALITY ASSURANCE paragraph of this Section.

E. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turfgrass during a calendar year including the painting and striping of the fields. Submit before expiration of required initial maintenance periods.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful athletic field establishment.
   1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
   2. Experience: Three years' experience in turfgrass installation of similar quality, schedule requirement and construction detailing.
   3. Installer's Field Supervision: Require Installer to maintain an experienced full-time foreman or crew leader on Project site when work is in progress.
   4. Personnel Certifications: Installer's foreman or crew leader shall be either a certified landscape professional or a certified horticulturalist:

B. Landscape professional shall be a Massachusetts Certified Landscape Professional currently certified by the Associated Landscape Contractors of Massachusetts.
    a. Horticulturalist shall be a Massachusetts Certified Horticulturalist as currently certified by the Massachusetts Nursery and Landscape Association.
    b. Certified Turfgrass Professional, designated CTP.
2. Pesticide Applicator: State of Massachusetts licensed, commercial.

C. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

D. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; buffer pH, Soluble Salts, and mineral and plant-nutrient content of the soil.
1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Owner's Representative. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
3. Report suitability of tested soil for turfgrass growth.
    a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 square feet or volume per cubic yard for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
    b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.
4. The General Contractor shall notify the Owner's Representative in writing at least 10 days in advance of the time he intends furnishing Screened Loam Borrow stating the location and amount of such deposit, the name and address of the supplier and also shall furnish such facilities, transportation and assistance as the Owner may require for collecting and forwarding samples.

E. Pre-Construction Walk: Conduct pre-construction site walk at the Project site at a day and time specified by the Owner's Representative.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Seed, Fertilizer and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable at time of first use. Any packaged materials that become caked or otherwise damaged will not be acceptable.

B. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turfgrass areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers, limestone and soil amendments with appropriate certificates.

1.08 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.
   1. Seed Spring Planting: April 1 to May 30.
   2. Seed Fall Planting: August 15 to October 15.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions. When special conditions warrant a variance to the turfgrass operations, proposed times shall be submitted to the Owner's Representative for approval prior to implementation.

1.09 WARRANTY

A. Warranty: Provide written warranty agreeing to remove and replace work that exhibits defects in materials or workmanship for the specified periods. "Defects" is defined to include, but is not limited to; death, unsatisfactory growth, disease, abnormal foliage density, abnormal size, abnormal color, failure to thrive and other unsatisfactory characteristics.

B. Replacement: Replace each defective plant or work with same species, size, character, and quality of originally accepted work. With each replacement plant or material, provide a new one-year warranty for the replacement work. If a replacement is unacceptable during its one-year warranty, the General Contractor shall provide another replacement or, when approved by Owner, equivalent cash payment.

C. Replacement Planting Season: Planting and reseeding for replacement and warranty work shall comply with the planting season contained herein.

D. Owner's Responsibilities and Warranty Exclusions: After completion of the Installation Contractor's maintenance responsibilities, the Owner is responsible for maintaining the work in reasonable compliance with the Installation Contractor's maintenance instructions. The Installation Contractor's warranty shall exclude problems due to improper or inadequate maintenance after the maintenance period or vandalism.

E. General Contractor Responsibilities: During the warranty period the General Contractor shall visit the site at one-month intervals to review the conditions of the accepted work. The General Contractor shall submit in writing his/her concerns regarding the Owner's maintenance practices and/or any vandalism. The Owner shall make reasonable efforts to correct the problems cited by the General Contractor, but the Owner shall not be held responsible for the Installation Contractor's defects in materials or workmanship that result in decline or death to plants and lawns.

F. Failure of the General Contractor to make the required monthly review of the site during the warranty period and submit written notice to the Owner of maintenance defects shall negate the General Contractor's ability to make claim against the Owner for negligence of maintenance.

G. Warranty Period for Multi-Use Fields: One Year from date of final acceptance.

H. Warranty Period for Soccer Fields: One Year from date of final acceptance.

1.10 MAINTENANCE SERVICE

A. Initial Turfgrass Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain according to Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turfgrass is established but for not less than the following periods:

PART 2 PRODUCTS

2.01 TURFGRASS SEED

A. Turfgrass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances. Turfgrass seed shall be of the previous year's crop and in no case shall weed seed content exceed one percent by

weight. The seed shall be furnished and delivered in the proportion specified below in new, clean and properly labeled containers. All seed shall comply with State and Federal seed laws. Submit manufacturer's Certificate of Compliance. Seed that becomes wet, moldy or otherwise shall not be acceptable. Chewings fescue, hard fescue, tall fescue and ryegrass shall contain *Acromonium* endophytes. Seed containing endophyte shall be kept cool and dry at all times; do not stockpile in the sun.

B. All seed mixes and blends must consist of seed varieties which are highly rated in the most recent NTEP (National Turfgrass Evaluation Program) trial report. Highly rated is defined as being in the top 70-percent of the "Turfgrass Quality Rating".
C. Non-irrigated turf area seed mixes or blends must include 50-70-percent, by weight, A-LIST (Alliance for Low Input Sustainable Turf) or TWCA (Turfgrass Water Conservation Alliance) approved turfgrass cultivars.
D. A-LIST or TWCA approved turfgrass cultivars are also preferred for irrigated turf areas in all accepted seed mixes or blends.
E. Turfgrass Seed Mixes:
    1. General Seed for Temporary Cover are as follows:
        a. Annual Ryegrass; 40 pounds per acre (one pound per 1000 square feet); Recommended seeding date – April 1st to June 1st.
        b. Foxtail Millet; 30 pounds per acre (0.7 pounds per 1000 square feet); Recommended seeding dates – May 1st to June 30th.
        c. Oats; 80 pounds per acre (two pounds per 1000 square feet); Recommended seeding dates – April 1st to July 1st and August 15th to September 15th.
        d. Winter Rye; 120 pounds per acre (three pounds per 1000 square feet); Recommended seeding dates – August 15th to October 15th.
        e. Seeding rate for winter application shall be three tons per acre (150 pounds per 1000 square feet). Mulch shall not be spread on top of snow. Snow shall be removed down to one inch depth or less prior to application.
        f. Mulching rate shall be 1.5 to two tons per acre (two bales (70-90 pounds) per 1000 square feet). Hay or straw mulch shall be air-dried, free of undesirable seeds and coarse materials. There should be no bare spots showing.
    2. Non-Irrigated Multiuse Athletic Fields including, but not limited to Soccer. Seed Mixture Composition shall be the following seed mixes as supplied by Northeast Nursery, 8 Dearborn Road, Peabody, MA 01960; Northeast Golf & Turf Supply; Turf and Soil Specialist Paul Carey; Telephone: 978.239.6449; Email: pcarey@northeast nursery.com; or approved equal. Proportioned by weight as follows:
        a. 70-80-percent Turf Type Tall Fescue containing three or four drought and heat tolerant cultivars.
        b. 10-20-percent Perennial Ryegrass containing one or two drought and heat tolerant cultivars.
        c. 5-10-percent Kentucky Bluegrass containing one drought and heat tolerant cultivar.
        d. Seeding rate for the Non-irrigated Multiuse Athletic Fields shall be six to 10 pounds per 1000 square feet, or seeding rate recommended by the supplier. For field specifications which are greater than 75-percent Turf Type Tall Fescue, the preferred seeding rate is 10-pounds per 1,000 square feet.
        e. Seed may be mixed by an approved method on the site or may be mixed by a dealer. If the seed is mixed on site, each variety shall be delivered in the original containers that bear the dealer's guaranteed analysis. If the seed is mixed by a dealer, then the Contractor shall furnish to the Owner's Representative the dealer's guaranteed statement of the composition of the mixture.

3. Irrigated Multiuse Athletic Fields including, but not limited to Soccer. Seed Mixture Composition shall be the following seed mixes as supplied by Northeast Nursery, 8 Dearborn Road, Peabody, MA 01960; Northeast Golf & Turf Supply; Turf and Soil Specialist Paul Carey; Telephone: 978.239.6449; Email: pcarey@northeast nursery.com; or approved equal. Proportioned by weight as follows:
    a. 50-100-percent Premium, Low-cut Kentucky Bluegrass containing four or five genetically diverse cultivars.
    b. 25-50-percent Premium, Low-cut Perennial Ryegrass containing two or three cultivars.
    c. Seeding rate for the Irrigated Multiuse Athletic Fields shall be three to five pounds per 1000 square feet, or seeding rate recommended by the supplier. For field specifications which are greater than 75-percent Kentucky Bluegrass, the seeding rate shall be no greater than four-pounds per 1,000 square feet.
    d. Seed may be mixed by an approved method on the site or may be mixed by a dealer. If the seed is mixed on site, each variety shall be delivered in the original containers that bear the dealer's guaranteed analysis. If the seed is mixed by a dealer, furnish to the Owner's Representative the dealer's guaranteed statement of the composition of the mixture.

2.02 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
    1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.

2.03 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 6.5 to 8.0; moisture content 35 to 55 percent by weight; 100 percent passing through 3/8 inch or smaller sieve; soluble salt content of five to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
    1. Organic Matter Content: 40 percent dry weight.
    2. Nutrient Content: The material shall contain some nitrogen, phosphorous, potassium, calcium, magnesium, sodium and micronutrients including iron, copper, boron, manganese and molybdenum so that heavy application of fertilizers is not required to sustain plant growth. Also, the nutrients shall be present in appropriate agricultural and horticultural proportions to prevent ion antagonism.
    3. Heavy Metals: Concentrations of zinc, mercury, cadmium, lead, nickel, chromium, and copper shall be below EPA and State of Massachusetts standards for applications to soils with human activity.
    4. Pesticide Residue: Composted organic materials shall not contain any pesticide residues of any kind.
B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.04 FERTILIZERS

A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of one percent nitrogen and 23 percent phosphoric acid.
B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium. Fertilizer shall be a commercial product complying

with the State and United States fertilizer laws. Deliver to the site in the original unopened containers that bear the manufacturer's certificate of compliance covering analysis. Fertilizer shall contain not less than the percentages of weight of ingredients recommended and shall be adjusted per the soil analysis.

1. Composition: one pound per 1000 square feet of actual nitrogen, four percent phosphorous, and two percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

D. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium. Fertilizer shall be a commercial product complying with the State and United States fertilizer laws. Deliver to the site in the original unopened containers that bear the manufacturer's certificate of compliance covering analysis. Fertilizer shall contain not less than the percentages of weight of ingredients recommended and shall be adjusted per the soil analysis.

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.05 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt marsh hay or threshed straw of winter wheat, rye, oats, or barley.

B. Fiber Mulch for hydro-seeding: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5. Size Range: 1/4 inch minimum to 3/4 inch maximum. Color: Uniform tan-beige range or green range to allow for easy visual metering during application but shall be non-injurious to plant growth.

C. Nonasphaltic Tackifier for hydro-seeding: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; non-toxic and free of plant-growth or germination inhibitors.

D. Asphalt Emulsion for straw mulching: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

E. Water: Suitable for irrigation and free of substance harmful to plant growth. Hoses, pumps, sprinklers or other methods of transportation shall be furnished by Installation Contractor.

2.06 PESTICIDES AND HERBICIDES

A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.

3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination and replace with new planting soil.

3.02 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
2. Protect grade stakes set until required to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.03 TURFGRASS AREA PREPARATION

A. Limit turfgrass subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of six inches. Remove stones larger than two inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
1. Apply soil amendments and/or fertilizer directly to subgrade before loosening.
2. Thoroughly blend planting soil off-site before spreading.
3. Spread planting soil in two equal lifts to a depth of six inches for new lawn and two inches for overseed, but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top four inches of subgrade. Spread remainder of planting soil.

C. Unchanged Subgrades: If turfgrass is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
1. Remove existing grass, vegetation, and turfgrass. Do not mix into surface soil.
2. Loosen surface soil to a depth of at least six inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top four inches of soil. Till soil to a homogeneous mixture of fine texture.
a. Apply soil amendments and/or fertilizer directly to surface soil before loosening.
3. Remove stones larger than two inches in any dimension and sticks, roots, trash, and other extraneous matter.
4. Legally dispose of waste material, including grass, vegetation, and turfgrass, off Owner's property.

D. Remediation of Compacted or Poorly Drained Subsoil in Planted Areas: If the soils are deemed to be compacted or poorly draining, the General Contractor shall remedy the condition prior to proceeding with further work. Remove any vegetative growth on the surface of the work area. Remove any extraneous materials. Loosen subgrade with a backhoe bucket to a depth of 18 inches. After gathering subsoil in the bucket, drop soil onto the ground from a height of six feet to break up the soil clumps. Position backhoe during work to prevent re-compaction of soils beginning the work in corners or against walls, or the center of isolated beds, and progressing outward towards the border’s edge. After subgrade has been broken up, rototill entire area to a depth of six inches. Heavy clay soils shall be amended with organic material.

E. Finish Grading: Set sufficient grade stakes for checking finished grades. Stakes shall be set at the top and bottom of slopes. The material should be rough graded with a dual laser-guided blade each time after rolling to ensure consistent depth of installation. Final grading shall be performed with a dual laser-guided blade and roll. Grades shall be established which are accurate to 1/10th

of a foot either way. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/4 inch of finish elevation. Limit finish grading to areas that can be planted in the immediate future.

F. Scarifying: After loam has been spread, it shall be carefully prepared by scarifying or harrowing and hand raking. All large stiff clods, lumps, brush, roots, stumps, litter and other foreign matter, and stones over one inch in diameter shall be removed from the loam. Loam shall also be free of smaller stones in excessive quantities as determined by the Owner's Representative.

G. Rolling: Roll the entire surface with a hand roller weighing not more than 100 pounds per foot of width. During the rolling, remove all ridges and all depressions caused by settlements or rolling shall be filled with additional loam and the surface shall be regarded and rolled until it presents a smooth and even finish to the required grade or to the shapes and configurations shown on the details.

H. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

I. Before planting, obtain Owner's Representative's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.04 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds five mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
   1. Do not use wet seed or seed that is moldy or otherwise damaged.
   2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
   3. Apply fertilizer to the topsoil at a rate of 25 pounds per 1000 square feet. Work the soil into the top four inches of the topsoil.

B. Spread the seed mixture in two passes at 90 degrees to each other.

C. Sow seed at a total rate of three pounds per 1000 square feet on each pass for a total application of six pounds per 1000 square feet.

D. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

E. Protect seeded areas with slopes exceeding 3:1 with erosion control blankets or erosion control fiber mesh, installed and stapled / anchored according to manufacturer's written instructions.

F. Protect seeded areas with slopes not exceeding 6:1 by spreading straw mulch. It is the Installation Contractor's responsibility to place the mulch at its optimum thickness and to add or remove mulch to encourage seed germination, plant growth and to prevent erosion. Spread by hand, blower, or other suitable equipment.
   1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
   2. Or if required by Owner's Representative, bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gallons per 1000 square feet. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

G. Water with a fine spray. Watering shall be started seven days after completing the seeded area. Water shall be applied at a rate sufficient to ensure moist soil conditions to a minimum depth of one inch. Run-off and puddling shall be prevented.

3.05 HYDROSEEDING

A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed applications. Continue mixing until it is uniformly blended into homogeneous slurry suitable for hydraulic application.
   1. Mix slurry with non-asphaltic tackifier per manufacturer's recommendation.
   2. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500 pounds per acre

dry weight, and seed component is deposited at the rate of six pounds per 1000 square feet for lawn areas. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 pounds per acre. Apply fertilizer at the rate of three pounds per1000 square feet.

3. Remove all overspray and repair all surfaces that are rutted or otherwise damaged by the hydroseeding materials or vehicle to a condition satisfactory to the Owner's Representative.
4. Take all necessary precautions to prevent overspray on structures, pavements and plantings adjacent to the seed areas.

3.06 PROTECTION

A. Erect warning signs and barricades (consisting of stakes with plastic tape) by the Owner's Representative to protect newly seeded areas from pedestrian, bicycle and vehicular traffic. Maintain barricades throughout the maintenance period until turfgrass is accepted by the Owner's Representative. If requested by the Owner's Representative, Contractor shall remove the barricades prior to acceptance of the newly planted areas.

3.07 TURFGRASS MAINTENANCE

A. The maintenance period for turfgrass shall begin immediately after the seeding has occurred and shall continue until final acceptance by the Owner's Representative.

B. Maintain and establish turfgrass by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations to establish healthy, viable turfgrass. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turfgrass. Provide materials and installation the same as those used in the original installation.
   1. Fill in soil subsidence that may occur because of settling or other processes. Replace materials and turfgrass damaged or lost in areas of subsidence.
   2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor to prevent displacement.
   3. Apply treatments to keep turfgrass and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

C. Watering: Install and maintain temporary piping, hoses, and turfgrass-watering equipment to convey water from sources and to keep turfgrass uniformly moist to a depth of four inches.
   1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
   2. Water turfgrass with fine spray at a minimum rate of one inch per week unless rainfall precipitation is adequate.

D. Mowing and edging:
   1. Mow turfgrass as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowing. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Mow turfgrass areas a minimum of three times before acceptance by the Owner's Representative.
   2. At each mowing, all edges of walks, drives, plant beds and other border conditions shall be edge trimmed by hand or machine to produce a straight and uniform edge condition.
   3. Remove and discard from paved areas only clippings and debris generated by each mowing and edging operation legally off-site. Owner's Representative, if practical and aesthetic, may allow sweeping (not blowing) clippings back into grass. Mowers shall be equipped with mulching blades. Do not remove from grass areas any clippings that have been generated by mowing operations.
   4. Schedule initial and subsequent mowing to maintain the following grass height:

a. Mow Multi-Use Turfgrass Seed Mixture to a height of two inches.

E. Turfgrass Post-fertilization: Apply fertilizer after initial mowing and when turfgrass is dry.
   1. The first application of fertilizer as specified herein occurs during the initial installation of turfgrass seed.
   2. A second application of fertilizer as specified herein shall be applied to seeded areas at the time of the first mowing. This second application shall be applied at a rate that ensures a nitrogen application of at least 1/2 pound per 1000 square feet. Phosphorous and potassium shall be applied proportionally in accordance with the recommendations of the soil tests and the quantities previously integrated into the soil during the first application.
   3. A third application of nitrogen fertilizer shall be applied to seeded areas approximately two months after the second. This third application shall correspond to the following application rates depending upon the month of application.
      a. May 1 through May 15: Use fertilizer that will provide actual nitrogen of at least one pound per 1000 square feet to turfgrass area.
      b. June 15 through June 30: Use fertilizer that will provide actual nitrogen of at least one pound per 1000 square feet to turfgrass area.
      c. August 15 through September 15: Use fertilizer that will provide actual nitrogen of at least one pound per 1000 square feet to turfgrass area.
      d. November 1 through November 15: Use fertilizer that will provide actual nitrogen of at least 1-1/2 pounds per 1000 square feet to turfgrass area.

F. Applying limestone
   1. The Installation Contractor shall return to the site at the beginning of the next seeding season and spread limestone across all lawn areas installed under this Contract. Limestone shall be spread at rates determined by the soil tests specified.

G. Maintenance Record: Full and complete written records for the maintenance of the athletic fields are to be furnished to the Owner by the General Contractor at least 10 days prior to the end of the contractual maintenance period, to familiarize the Owner with the maintenance requirements for proper care and development of the turfgrass.

3.08 SATISFACTORY TURFGRASS

A. Request for Acceptance: In writing, request Owner’s Representative inspection for acceptance at least 10 days in advance of preferred acceptance date. Do not request inspection for acceptance until work is 100 percent complete (not including maintenance) and in compliance with Contract requirements.

B. Partial Acceptance: Acceptance of partial areas or portions of the total work may be granted, at the Owner’s option, if the area to be inspected is large, well-defined, and easily described. The Owner and Owner’s Representative are not obliged to provide partial acceptance of the work.

C. Turfgrass installations shall meet the following criteria as determined by Owner’s Representative:
   1. Satisfactory Seeded Turfgrass: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds, undesirable grass species, disease, insects and surface irregularities. For the purpose of establishing an acceptable standard for seeded areas, scattered bare spots not larger than one square foot will be permitted up to a maximum of three percent of any lawn area. At least 90 percent of the grass established shall be permanent grass species.

D. Use specified materials to reestablish turfgrass that does not comply with requirements and continue maintenance until turfgrass is satisfactory.

3.09 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations.

Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.10 FIELD MARKINGS AND DECORATIONS

A. Markings are to be per the plan and must comply with all Client preferred sport league guidelines.

3.11 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turfgrass work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs to protect newly planted areas from traffic. Maintain fencing and barricades throughout the initial maintenance period and remove after plantings are established.

C. Remove nondegradable erosion-control measures after grass establishment period.

D. Perform cleaning during the installation and upon completion of the work. Remove from site all debris and equipment. Repair all damage resulting from installation.

END OF SECTION

SECTION 32 92 00
TURF AND GRASSES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes providing all labor, equipment, materials, incidental work and construction methods required to perform all turf and grass installation and fine grading work and related items as indicated on the Contract Documents and/or as specified herein, and includes, but is not limited to, the following:
   1. Fine grading and loaming.
   2. Seeding.
   3. Hydroseeding.
   4. Grasses and wildflowers.
   5. Turf renovation for damaged areas.
   6. Erosion-control material(s).
   7. Maintenance and protection.

B. Related Sections:
   1. Section 31 10 00 "SITE CLEARING" for topsoil stripping and stockpiling.
   2. Section 31 00 00 "EARTH MOVING" for excavation, filling and backfilling, and rough grading.
   3. Section 31 25 00 “EROSION AND SEDIMENTATION CONTROLS” for earthwork stockpiles, cut and fill slopes, constructed and existing swales and ditches, and unestablished lawn and seeded embankments.
   4. Section 32 84 00 “IRRIGATION” for irrigation at the multiuse athletic field.
   5. Section 32 90 00 “UNDERDRAIN SYSTEM” for underdrains at the multiuse athletic field and play areas.
   6. Section 32 93 00 "PLANTS" for trees, shrubs, perennials, turf, stabilization, and border edgings.
   7. Section 33 41 00 – “STORM UTILITY DRAINAGE PIPING” for subsurface drainage.

1.03 DEFINITIONS

A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

F. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

G. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

H. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.

I. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.

1.05 INFORMATIONAL SUBMITTALS

A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

B. Qualification Data: Submit proof of qualified landscape Installer to the Owner’s Representative in accordance with QUALITY ASSURANCE paragraph of this Section.

C. Product Certificates: At least 30 days prior to ordering materials, the General Contractor shall submit to the Owner’s Representative samples, certifications, manufacture’s product data and certified test results for materials as specified below. No materials shall be ordered or delivered until the required submittals have been reviewed and accepted by the Owner’s Representative. Delivered materials shall closely match the accepted samples. Acceptance shall not constitute final acceptance. The Owner’s Representative reserves the right to reject, on or after delivery, any materials which does not meet these Specifications:

1. Fertilizer: Submit product literature of seeding fertilizer and certificates showing composition and analysis.
2. Erosion Control Matting: Submit one copy of manufacturer’s literature and one material sample.
3. Soil Additives: Submit product literature on all soil additives to be used on site.
4. Limestone: Submit supplier’s certificate that the limestone being supplied conforms to these Specifications.
5. Hydroseeding: Submit a certified statement for acceptance as to the number of pounds of materials to be used per 100 gallons of water.
6. Wood Cellulose Fiber Mulch: Submit one copy of manufacturer’s literature and one material sample.

D. Material Test Reports: For sampling and testing of Loam Borrow from Off-Site Sources and from On-Site Sources shall be as specified in QUALITY ASSURANCE paragraph of this Section.

E. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf, and Grasses and Wildflowers during a calendar year. Submit before expiration of required initial maintenance periods.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf, and Grasses and Wildflowers establishment.

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: Three years’ experience in turf installation of similar quality, schedule requirement and construction detailing.

3. Installer's Field Supervision: Require Installer to maintain an experienced full-time foreman or crew leader on Project site when work is in progress.
4. Personnel Certifications: Installer's foreman or crew leader shall be either a certified landscape professional or a certified horticulturalist:
   a. Landscape professional shall be a Massachusetts Certified Landscape Professional currently certified by the Massachusetts Association of Landscape Professionals (MLP).
   b. Horticulturalist shall be a Massachusetts Certified Horticulturalist as currently certified by the Massachusetts Nursery and Landscape Association.
   c. Certified Turfgrass Professional, designated CTP.
5. Pesticide Applicator: State of Massachusetts licensed, commercial.

B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; buffer pH, Soluble Salts, and mineral and plant-nutrient content of the soil.
1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Owner’s Representative. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
3. Report suitability of tested soil for turf growth.
   a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 square feet or volume per cubic yard for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
   b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

D. Pre-Construction Walk: Conduct pre-construction site walk at the Project site at a day and time specified by the Owner’s Representative.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Seed, Fertilizer and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable at time of first use. Any packaged materials that become caked or otherwise damaged will not be acceptable.

B. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers, limestone and soil amendments with appropriate certificates.

1.08 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from the date of Substantial Completion.
   1. Seed Spring Planting: April 1 to May 30.
   2. Seed Fall Planting: August 15 to October 15.
   3. Seed Grasses and Wildflowers Spring Planting: May 1 to June 30.
   4. Plug Grasses and Wildflowers Fall Planting: August 15 to September 15

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions. When special conditions warrant a variance to the turf operations, proposed times shall be submitted to the Owner's Representative for acceptance prior to implementation.

1.09 WARRANTY

A. Warranty: Provide a written warranty agreeing to remove and replace work that exhibits defects in materials or workmanship for the specified periods. "Defects" is defined to include, but is not limited to; death, unsatisfactory growth, disease, abnormal foliage density, abnormal size, abnormal color, failure to thrive and other unsatisfactory characteristics.

B. Replacement: Replace each defective plant or work with same species, size, character, and quality of originally accepted work. With each replacement plant or material, provide a new one-year warranty for the replacement work. If a replacement is unacceptable during its one-year warranty, the General Contractor shall provide another replacement or, when accepted by Owner, equivalent cash payment.

C. Replacement Planting Season: Planting and reseeding for replacement and warranty work shall comply with the planting season contained herein.

D. Owner's Responsibilities and Warranty Exclusions: After completion of the Installation Contractor's maintenance responsibilities, the Owner is responsible for maintaining the work in reasonable compliance with the Installation Contractor's maintenance instructions. The Installation Contractor's warranty shall exclude problems due to improper or inadequate maintenance after the maintenance period or vandalism.

E. General Contractor Responsibilities: During the warranty period the General Contractor shall visit the site at one-month intervals to review the conditions of the accepted work. The General Contractor shall submit in writing his/her concerns regarding the Owner's maintenance practices and/or any vandalism. The Owner will make reasonable efforts to correct the problems cited by the General Contractor, but the Owner will not be held responsible for the General Contractor's defects in materials or workmanship that result in decline or death to plants and lawns.

F. Failure of the General Contractor to make the required monthly review of the site during the warranty period and submit written notice to the Owner of maintenance defects shall negate the General Contractor's ability to make claim against the Owner for negligence of maintenance.

G. Warranty Period for Lawns: One Year from the date of final acceptance.

H. Warranty Period for Grasses and Wildflowers: One Year from the date of final acceptance.

1.10 MAINTENANCE SERVICE

A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as indicated in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:

1. Seeded Turf: 60 days from date of final acceptance of lawn areas.
    a. When the initial maintenance period has not elapsed before the end of planting season, or if turf is not fully established, continue maintenance during next planting season.

B. Initial Grasses and Wildflowers Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as indicated in Part 3. Begin maintenance immediately after each area is planted and continue for Two Years until acceptable grasses and wildflowers is established, but for not less than the following periods:
    1. Seeded Grasses and Wildflowers: 120-days from the date of final acceptance of grasses and wildflowers areas.
        a. When the initial maintenance period has not elapsed before the end of planting season, or if turf is not fully established, continue maintenance during next planting season.
    2. Plugged Grasses and Wildflowers: 120-days from date of final acceptance of grasses and wildflowers areas.

PART 2 PRODUCTS

2.01 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances. Grass seed shall be of the previous year's crop and in no case shall weed seed content exceed one percent by weight. The seed shall be furnished and delivered in the proportion specified below in new, clean and properly labeled containers. All seed shall comply with State and Federal seed laws. Submit manufacturer's Certificate of Compliance. Seed that becomes wet, moldy or otherwise shall not be acceptable. Chewings fescue, hard fescue, tall fescue and ryegrass shall contain *Acromonium* endophytes. Seed containing endophytes shall be kept cool and dry at all times; do not stockpile in the sun

B. All seed mixes and blends shall consist of seed varieties which are highly rated in the most recent NTEP (National Turfgrass Evaluation Program) trial report. Highly rated is defined as being in the top 70-percent of the "Turfgrass Quality Rating".

C. Non-irrigated turf area seed mixes or blends shall include 50-70-percent, by weight, A-LIST (Alliance for Low Input Sustainable Turf) or TWCA (Turfgrass Water Conservation Alliance) approved turfgrass cultivars.

D. A-LIST or TWCA approved turfgrass cultivars are also preferred for irrigated turf areas in all accepted seed mixes or blends.

E. Grass Seed Mixes:
    1. General Seed for Temporary Cover are as follows:
        a. Annual Ryegrass; 40 pounds per acre (one pound per 1000 square feet); Recommended seeding date – April 1st to June 1st.
        b. Foxtail Millet; 30 pounds per acre (0.7 pounds per 1000 square feet); Recommended seeding dates – May 1st to June 30th.
        c. Oats; 80 pounds per acre (two pounds per 1000 square feet); Recommended seeding dates – April 1st to July 1st and August 15th to September 15th.
        d. Winter Rye; 120 pounds per acre (three pounds per 1000 square feet); Recommended seeding dates – August 15th to October 15th.
        e. Seeding rate for winter application shall be three tons per acre (150 pounds per 1000 square feet). Mulch shall not be spread on top of snow. Snow shall be removed down to one inch depth or less prior to application.
        f. Mulching rate shall be 1.5 to two tons per acre (two bales (70-90 pounds) per 1000 square feet). Hay or straw mulch shall be air-dried, free of undesirable seeds and coarse materials. There should be no bare spots showing.

2. Non-irrigated General Lawn Seed Mixture Composition shall be the following seed mixes as supplied by Northeast Nursery, 8 Dearborn Road, Peabody, MA 01960; Northeast Golf & Turf Supply; Turf and Soil Specialist Paul Carey; Telephone: 978.239.6449; E: pcarey@northeast nursery.com; or approved equal. Proportioned by weight as follows:
   a. 70-80-percent Turf Type Tall Fescue containing three or four drought and heat tolerant cultivars.
   b. 10-20-percent Perennial Ryegrass containing one or two drought and heat tolerant cultivars.
   c. 5-10-percent Kentucky Bluegrass containing one drought and heat tolerant cultivar.
   d. Seeding rate for the Non-irrigated General Lawn Seed Mix shall be six pounds per 1000 square feet, or per supplier's recommendation.
   e. Seed may be mixed by an approved method on the site or may be mixed by a dealer. If the seed is mixed on site, each variety shall be delivered in the original containers that bear the dealer's guaranteed analysis. If the seed is mixed by a dealer, then the General Contractor shall furnish to the Owner's Representative the dealer's guaranteed statement of the composition of the mixture.
3. Non-Shade Lawn Seed Mixture Composition shall be the following seed mixes as supplied by Northeast Nursery, 8 Dearborn Road, Peabody, MA 01960; Northeast Golf & Turf Supply; Turf and Soil Specialist Paul Carey; Telephone: 978.239.6449; E: pcarey@northeast nursery.com; or approved equal. Proportioned by weight as follows:
   a. 25-35-percent Creeping Red or Slender Fescue containing one or two shade tolerant cultivars.
   b. 25-35-percent Chewing's Fescue containing one or two shade tolerant cultivars.
   c. 10-15-percent Hard or Sheep Fescue containing one shade tolerant cultivar.
   d. 10-30-percent Perennial Ryegrass containing one shade tolerant cultivar.
      1) For heavy dense shade, Perennial Ryegrass can be substituted with Rough Stock Bluegrass (Poa trivialis).
   e. Seeding rate for the Non-Irrigated Shade Lawn Seed Mix shall be five pounds per 1000 square feet, or per supplier's recommendation.
   f. Seed may be mixed by an approved method on the site or may be mixed by a dealer. If the seed is mixed on site, each variety shall be delivered in the original containers that bear the dealer's guaranteed analysis. If the seed is mixed by a dealer, then the General Contractor shall furnish to the Owner's Representative the dealer's guaranteed statement of the composition of the mixture.
4. Non-Irrigated Slope | Sustainable Lawn Seed Mixture Composition shall be the following seed mixes as supplied by Northeast Nursery, 8 Dearborn Road, Peabody, MA 01960; Northeast Golf & Turf Supply; Turf and Soil Specialist Paul Carey; Telephone: 978.239.6449; E: pcarey@northeast nursery.com; or approved equal. Proportioned by weight as follows:
   a. 35-50-percent Hard Fescue.
   b. 20-40-percent Blue Sheep Fescue.
   c. 35-50-percent Chewing's Fescue.
   d. 10-20-percent Intermediate Ryegrass as cover crop
   e. Seeding rate for the Non-Irrigated Slope | Sustainable Lawn Seed Mix shall be five pounds per 1000 square feet, or per supplier's recommendation.
   f. Seed may be mixed by an approved method on the site or may be mixed by a dealer. If the seed is mixed on site, each variety shall be delivered in the original containers that bear the dealer's guaranteed analysis. If the seed is mixed by a dealer, then the

General Contractor shall furnish to the Owner's Representative the dealer's guaranteed statement of the composition of the mixture.

5. Non-Irrigated Multiuse Athletic Fields including, but not limited to Football, Soccer, Lacrosse, and Field Hockey. Seed Mixture Composition shall be the following seed mixes as supplied by Northeast Nursery, 8 Dearborn Road, Peabody, MA 01960; Northeast Golf & Turf Supply; Turf and Soil Specialist Paul Carey; Telephone: 978.239.6449; E: pcarey@northeast nursery.com; or approved equal. Proportioned by weight as follows:
   a. 70-80-percent Turf Type Tall Fescue containing three or four drought and heat tolerant cultivars.
   b. 10-20-percent Perennial Ryegrass containing one or two drought and heat tolerant cultivars.
   c. 5-10-percent Kentucky Bluegrass containing one drought and heat tolerant cultivar.
   d. Seeding rate for the Non-irrigated Multiuse Athletic Fields shall be six to 10 pounds per 1000 square feet, or per supplier's recommendation. For field specifications which are greater than 75-percent Turf Type Tall Fescue, the preferred seeding rate is 10-pounds per 1,000 square feet.
   e. Seed may be mixed by an approved method on the site or may be mixed by a dealer. If the seed is mixed on site, each variety shall be delivered in the original containers that bear the dealer's guaranteed analysis. If the seed is mixed by a dealer, then the General Contractor shall furnish to the Owner's Representative the dealer's guaranteed statement of the composition of the mixture.
6. Irrigated Multiuse Athletic Fields including, but not limited to Football, Soccer, Lacrosse, and Field Hockey. Seed Mixture Composition shall be the following seed mixes as supplied by Northeast Nursery, 8 Dearborn Road, Peabody, MA 01960; Northeast Golf & Turf Supply; Turf and Soil Specialist Paul Carey; Telephone: 978.239.6449; E: pcarey@northeast nursery.com; or approved equal. Proportioned by weight as follows:
   a. 50-100-percent Premium, Low-cut Kentucky Bluegrass containing four or five genetically diverse cultivars.
   b. 25-50-percent Premium, Low-cut Perennial Ryegrass containing two or three cultivars.
   c. Seeding rate for the Irrigated Multiuse Athletic Fields shall be three to five-pounds per 1000 square feet, or per supplier's recommendation. For field specifications which are greater than 75-percent Kentucky Bluegrass, the seeding rate shall be no greater than four-pounds per 1,000 square feet.
   d. Seed may be mixed by an approved method on the site or may be mixed by a dealer. If the seed is mixed on site, each variety shall be delivered in the original containers that bear the dealer's guaranteed analysis. If the seed is mixed by a dealer, then the General Contractor shall furnish to the Owner's Representative the dealer's guaranteed statement of the composition of the mixture.

2.02 GRASSES AND WILDFLOWERS

A. "Low-Growing Wildflower and Grass Mix; ERNMX-156" supplied by: Ernst Seeds, 8884 Mercer Pike, Meadville, PA 16335; Telephone: 800.873.3321; or approved equal. Fresh, clean and dry new seed, of mixed species as follows:
   1. Sheep Fescue (Festuca ovina), Annual Ryegrass (Lolium multiflorum), Sideoats Grama (Bouteloua curtipendula), Perennial Blue Flax (Linum perenne), Blue Bachelor's Button (Centaurea cyanus), Lanceleaf Coreopsis (Coreopsis lanceolata), Perennial Gaillardia (Gaillardia aristata), Blackeyed Susan (Rudbeckia hirta), Annual Gaillardia (Gaillardia pulchella), Shasta Daisy (Chrysanthemum maximum), Golden Alexanders (Ziziaa urea), Aromatic Aster (Aster oblongifolius), Narrowleaf Mountainmint (Pycnathemum tenuifolium), Butterfly Milkweed (Asclepias tuberosa), Red Corn Poppy (Papaver rhoeas), Corn

Poppy/Shirley Mix (Papaver rhoeas), Anise Lavender Hyssop (Agastache foeniculum), Hairy Beardtongue (Penstemon hirsutus), Common Yarrow (Achillea millefolium).

a. Seeding rate for the Low-Growing Wildflower and Grass Mix; ERNMX-156 mix shall be 25 to 40 pounds per acre, or per supplier's recommendation.
b. Seed may be mixed by an approved method on the site or may be mixed by a dealer. If the seed is mixed on site, each variety shall be delivered in the original containers that bear the dealer's guaranteed analysis. If the seed is mixed by a dealer, then the General Contractor shall furnish to the Owner's Representative the dealer's guaranteed statement of the composition of the mixture.

B. "Right-of-Way Native Woods Mix with Annual Ryegrass; ERNMX-132-1" supplied by: Ernst Seeds, 8884 Mercer Pike, Meadville, PA 16335; Telephone: 800.873.3321; or approved equal. Fresh, clean and dry new seed, of mixed species as follows:
1. Annual Ryegrass (Lolium multiflorum), Tioga Deertongue (Panicum clandestinum), Switchgrass "Habitat" (Panicum virgatum 'Habitat'), Madison Virginia Wildrye (Elymus virginicus), Creeping Red Fescue (Festuca rubra), Albany Pine Buch Autumn Bentgrass (Agrostis perennans), Fox Sedge (Carex vulpinoidea), Heath Aster (Aster pilosus).
   a. Seeding rate for the Right-of-Way Native Woods Mix with Annual Ryegrass; ERNMX-132-1 mix shall be 30 pounds per acre, or per supplier's recommendation.
   b. Seed may be mixed by an approved method on the site or may be mixed by a dealer. If the seed is mixed on site, each variety shall be delivered in the original containers that bear the dealer's guaranteed analysis. If the seed is mixed by a dealer, then the General Contractor shall furnish to the Owner's Representative the dealer's guaranteed statement of the composition of the mixture.

C. Seed Carrier: Inert material, sharp clean sand or perlite, mixed with seed at a ratio of not less than 2:1; two parts seed carrier to one part seed.

2.03 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.

2.04 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 6.5 to 8.0; moisture content 35 to 55 percent by weight; 100 percent passing through 3/8 inch or smaller sieve; soluble salt content of five to 10 decisiemens/m; not exceeding one half percent inert contaminants and free of substances toxic to plantings; and as follows:
1. Organic Matter Content: 40 percent of dry weight.
2. Nutrient Content: The material shall contain some nitrogen, phosphorous, potassium, calcium, magnesium, sodium and micronutrients including iron, copper, boron, manganese and molybdenum so that heavy application of fertilizers is not required to sustain plant growth. Also, the nutrients shall be present in appropriate agricultural and horticultural proportions to prevent ion antagonism.
3. Heavy Metals: Concentrations of zinc, mercury, cadmium, lead, nickel, chromium, and copper shall be below EPA and State of Massachusetts standards for applications to soils with human activity.
4. Pesticide Residue: Composted organic materials shall not contain any pesticide residues of any kind.

B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.05 FERTILIZERS

A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of one percent nitrogen and 23 percent phosphoric acid.

B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium. Fertilizer shall be a commercial product complying with the State and United States fertilizer laws. Deliver to the site in the original unopened containers that bear the manufacturer's certificate of compliance covering analysis. Fertilizer shall contain not less than the percentages of weight of ingredients recommended and shall be adjusted per the soil analysis.
   1. Composition: one pound per 1000 square feet of actual nitrogen, four percent phosphorous, and two percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

D. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium. Fertilizer shall be a commercial product complying with the State and United States fertilizer laws. Deliver to the site in the original unopened containers that bear the manufacturer's certificate of compliance covering analysis. Fertilizer shall contain not less than the percentages of weight of ingredients recommended and shall be adjusted per the soil analysis.
   1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.06 PLANTING SOILS

A. Planting Soil for Seeded Lawn: ASTM D 5268 topsoil, screened, sandy loam that is fertile, friable natural loam free from subsoil, clay, brush, litter, roots, stones 3/4 inch or larger and any other foreign materials harmful to plant growth. Loam shall have an acidity range of pH 5.8 to 7.0 and shall contain not less than four percent or more than six percent organic material content as determined by the loss of ignition (LOI) of samples which have been oven-dried to a constant weight at a temperature of 221 degrees Fahrenheit (105 degrees Celsius).
   1. Mix ASTM D 5268 topsoil with the following soil amendments in the following quantities to produce planting soil:
      a. Ratio of soil mixture compositions shall be one part topsoil as specified above, one-part organic matter, and one-part native soil mixed prior to planting installation.
      b. Weight of Lime per 1000 square feet: 200 pounds maximum limit.
      c. Weight of Bonemeal per 1000 square feet: as per soil analysis.
      d. Weight of Superphosphate per 1000 square feet: 20 pounds or as specified by soil analysis.
      e. Weight of Commercial Fertilizer per 1000 square feet: as per soil analysis.
      f. Weight of Slow-Release Fertilizer per 1000 square feet: as per soil analysis.

B. Planting Soil for Grasses and Wildflowers: ASTM D 5268 topsoil, screened, sandy loam that is fertile, friable natural loam free from subsoil, less than five percent maximum clay content, brush, litter, roots, stones 3/4 inch or larger and any other foreign materials harmful to plant growth. Loam shall have an acidity range of pH 5.8 to 7.0 and shall contain not less than four percent or more than six percent organic material content as determined by the loss of ignition of oven-dried samples.

1. Mix ASTM D 5268 topsoil with the following soil amendments in the following quantities to produce planting soil:
    a. Ratio of soil mixture compositions shall be 50-percent Sand; Sand Borrow, MassDOT M1.04.0, Type A, 25-percent topsoil as specified above, 25-percent Leaf Mulch; Compost Topsoil, MASSDOT Item 751.7 mixed prior to planting installation.

2.07 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt marsh hay or threshed straw of winter wheat, rye, oats, or barley.

B. Fiber Mulch for hydro-seeding: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5. Size Range: 1/4 inch minimum to 3/4 inch maximum. Color: Uniform tan-beige range or green range to allow for easy visual metering during application but shall be non-injurious to plant growth.

C. No Hydroseed or Hydromulch with Tackifier shall be used on ”Grasses and Wildflowers”. The tackifier will “glue” and “smother” the seed and inhibit the ability for the naturalized seed from germinating. Use a cover crop or salt-marsh hay for mulching.

D. Nonasphaltic Tackifier for turfgrass hydro-seeding: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

E. Asphalt Emulsion for straw mulching: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

F. Water: Suitable for irrigation and free of substance harmful to plant growth. Hoses, pumps, sprinklers or other methods of transportation shall be furnished by General Contractor.

2.08 PESTICIDES AND HERBICIDES

A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.09 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, six inches long.

B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 pounds per square yard, with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, six inches long.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. North American Green, 5401 St. Wendel-Cynthiana Road, Poseyville, IN 47633, Telephone: 800.772.2040; Website: www.nagreen.com; BioNet Biodegradable Erosion Control Blankets; Short-Term.
    b. North American Green, 5401 St. Wendel-Cynthiana Road, Poseyville, IN 47633, Telephone: 800.772.2040; Website: www.nagreen.com; BioNet Biodegradable Erosion Control Blankets; Extended-Term.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
   3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   4. Uniformly moisten excessively dry soil that is not workable, and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination and replace with new planting soil.

3.02 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
   1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
   2. Protect grade stakes set until required to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.03 TURF AREA PREPARATION

A. Limit turf subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of six inches. Remove stones larger than two inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
   1. Apply soil amendments and/or fertilizer directly to subgrade before loosening.
   2. Thoroughly blend planting soil off-site before spreading.
   3. Spread planting soil in two equal lifts to a depth of six inches for new lawn and two inches for overseed, but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
      a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top four inches of subgrade. Spread the remainder of planting soil.

C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
   1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
   2. Loosen surface soil to a depth of at least six inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top four inches of soil. Till soil to a homogeneous mixture of fine texture.
      a. Apply soil amendments and/or fertilizer directly to surface soil before loosening.
   3. Remove stones larger than two inches in any dimension and sticks, roots, trash, and other extraneous matter.
   4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.

D. Remediation of Compacted or Poorly Drained Subsoil in Planted Areas: If the soils are deemed to be compacted or poorly draining, the General Contractor shall remedy the condition prior to proceeding with further work. Remove any vegetative growth on the surface of the work area. Remove any extraneous materials. Loosen subgrade with a backhoe bucket to a depth of 18 inches. After gathering subsoil in the bucket, drop soil onto the ground from a height of six feet

to break up the soil clumps. Position backhoe during work to prevent re-compaction of soils beginning the work in corners or against walls, or the center of isolated beds, and progressing outward towards the border's edge. After subgrade has been broken up, rototill entire area to a depth of six inches. Heavy clay soils shall be amended with organic material.

E. Finish Grading: Set sufficient grade stakes for checking finished grades. Stakes shall be set at the top and bottom of slopes. Grades shall be established which are accurate to 1/10th of a foot either way. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/4 inch of finish elevation. Limit finish grading to areas that can be planted in the immediate future.

F. Scarifying: After loam has been spread, it shall be carefully prepared by scarifying or harrowing and hand raking. All large stiff clods, lumps, brush, roots, stumps, litter and other foreign matter, and stones over one inch in diameter shall be removed from the loam. Loam shall also be free of smaller stones in excessive quantities as determined by the Owner's Representative.

G. Rolling: Roll the entire surface with a hand roller weighing not more than 100 pounds per foot of width. During the rolling, remove all ridges and all depressions caused by settlements or rolling shall be filled with additional loam and the surface shall be regarded and rolled until it presents a smooth and even finish to the required grade or to the shapes and configurations shown on the details.

H. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

I. Before planting, obtain Owner's Representative's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.04 PREPARATION FOR EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Turf Area Preparation" Article.

B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten per manufacturer's recommendation.

C. Fill cells of erosion-control mat with planting soil and compact before planting.

D. For erosion-control blanket or mesh, install from top of slope, working downward, per manufacturer's recommendation for site conditions. Fasten per manufacturer's recommendation.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.05 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds five mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
   1. Do not use wet seed or seed that is moldy or otherwise damaged.
   2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
   3. Apply fertilizer to the topsoil at a rate of 25 pounds per 1000 square feet. Work the soil into the top four inches of the topsoil.

B. Spread the seed mixture in two passes at 90 degrees to each other.

C. Sow seed at a total rate of three pounds per 1000 square feet on each pass for a total application of six pounds per 1000 square feet.

D. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

E. Protect seeded areas with slopes exceeding 3:1 with erosion control blankets or erosion control fiber mesh, installed and stapled and/or anchored according to manufacturer's written instructions.

F. Protect seeded areas with slopes not exceeding 6:1 by spreading straw mulch. It is the General Contractor's responsibility to place the mulch at its optimum thickness and to add or remove mulch to encourage seed germination, plant growth and to prevent erosion. Spread by hand, blower, or other suitable equipment.
   1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
   2. Or if required by Owner's Representative, bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gallons per 1000 square feet. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

G. Water with a fine spray. Watering shall be started seven days after completing the seeded area. Water shall be applied at a rate sufficient to ensure moist soil conditions to a minimum depth of one inch. Run-off and puddling shall be prevented.

3.06 HYDROSEEDING

A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
   1. Mix slurry with non-asphaltic tackifier per manufacturer's recommendation.
   2. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500 pounds per acre dry weight, and seed component is deposited at the rate of six pounds per 1000 square feet for lawn areas. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 pounds per acre. Apply fertilizer at the rate of three pounds per 1000 square feet.
   3. Remove all overspray and repair all surfaces that are rutted or otherwise damaged by the hydroseeding materials or vehicle to a condition satisfactory to the Owner's Representative.
   4. Take all necessary precautions to prevent overspray on structures, pavements and plantings adjacent to the seed areas.

3.07 TURF RENOVATION FOR DAMAGED AREAS

A. Renovate existing turf.

B. Renovate existing turf damaged by General Contractor's operations, such as storage of materials or equipment and movement of vehicles.
   1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
   2. Install new planting soil.

C. Remove vegetation from diseased or unsatisfactory turf areas; do not bury in soil.

D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from General Contractor's operations, and replace with new planting soil.

E. Mow, dethatch, core aerate, and rake existing turf.

F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides. Do not use pre-emergence herbicides.

G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

H. Till stripped, bare, and compacted areas thoroughly to a soil depth of six inches.

I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top four inches of existing soil. Install new planting soil to fill low spots and meet finish grades.

J. Apply seed for new turf.

K. Water newly planted areas and keep moist until new turf is established.

3.08 PROTECTION

A. Erect warning signs and barricades (consisting of stakes with plastic tape) to protect newly seeded areas from pedestrian, bicycle and vehicular traffic. Maintain barricades throughout the maintenance period until turf is accepted by the Owner's Representative. If requested by the Owner's Representative, General Contractor shall remove the barricades prior to acceptance of the newly planted areas.

3.09 TURF MAINTENANCE

A. The maintenance period for turf and grasses shall begin immediately after the seeding has occurred and shall continue until final acceptance by the Owner's Representative.

B. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, edging, replanting dead areas, disease and insect control, erosion repair, and performing other operations and consistent with good horticultural practices to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
   1. Fill in soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
   2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor to prevent displacement.
   3. Apply treatments to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

C. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of four inches.
   1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out a temporary watering system to avoid walking over muddy or newly planted areas.
   2. Water turf with fine spray at a minimum rate of one inch per week unless rainfall precipitation is adequate.

D. Mowing and Edging:
   1. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowing. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Mow turf areas a minimum of three times before acceptance by the Owner's Representative.
   2. At each mowing, all edges of walks, drives, plant beds and other border conditions shall be edge trimmed by hand or machine to produce a straight and uniform edge condition.
   3. Remove and discard from paved areas only clippings and debris generated by each mowing and edging operation legally off-site. Owner's Representative, if practical and aesthetic, may allow sweeping (not blowing) clippings back into grass. Mowers shall be equipped with mulching blades. Do not remove from grass areas any clippings that have been generated by mowing operations.
   4. Schedule initial and subsequent mowing to maintain the following grass height:
      a. Mow General Lawn Seed Mixture to a height of two inches.
      b. Mow Athletic Seed Mixture to a height of two inches.
      c. Mow Shade Lawn Seed Mixture to a height of two inches.
      d. Mow Low Maintenance Seed Mixture to a height of three to four inches.
      e. Mow Turf Slopes (15-degrees or more) to a height of three to four inches; hand-mowing side-to-side and turning uphill.

5. All mowing shall be scheduled on a weekly basis, depending on the month and weather, as designated by the Owner's Representative.

E. Turf Post-fertilization: Apply fertilizer after initial mowing and when grass is dry.
   1. The first application of fertilizer as specified herein occurs during the initial installation of turf seed.
   2. A second application of fertilizer as specified herein shall be applied to seeded areas at the time of the first mowing. This second application shall be applied at a rate that ensures a nitrogen application of at least 1/2 pound per 1000 square feet. Phosphorous and potassium shall be applied proportionally in accordance with the recommendations of the soil tests and the quantities previously integrated into the soil during the first application.
   3. A third application of nitrogen fertilizer shall be applied to seeded areas approximately two months after the second. This third application shall correspond to the following application rates dependent upon the month of application.
      a. May 1 through May 15: Use fertilizer that will provide actual nitrogen of at least one pound per 1000 square feet to turf area.
      b. June 15 through June 30: Use fertilizer that will provide actual nitrogen of at least one pound per 1000 square feet to turf area.
      c. August 15 through September 15: Use fertilizer that will provide actual nitrogen of at least one pound per 1000 square feet to turf area.
      d. November 1 through November 15: Use fertilizer that will provide actual nitrogen of at least 1 1/2 pounds per 1000 square feet to turf area.

F. Applying limestone
   1. The Installation Contractor shall return to the site at the beginning of the next seeding season and spread limestone across all lawn areas installed under this Contract. Limestone shall be spread at rates determined by the soil tests specified.

3.10 SATISFACTORY TURF

A. Request for Acceptance: In writing, request Owner's Representative observation for acceptance at least 10 days in advance of preferred acceptance date. Do not request observation for acceptance until work is 100 percent complete (not including maintenance) and in compliance with Contract requirements.

B. Partial Acceptance: Acceptance of partial areas or portions of the total work may be granted, at the Owner's option, if the area to be inspected is large, well-defined, and easily described. The Owner and Owner's Representative are not obliged to provide partial acceptance of the work.

C. Turf installations shall meet the following criteria as determined by Owner's Representative:
   1. Satisfactory Seeded Turf: At end of the one-year warranty period, a healthy, uniform, close stand of grass has been established, free of weeds, undesirable grass species, disease, insects and surface irregularities. For the purpose of establishing an acceptable standard for seeded areas, scattered bare spots not larger than one square foot will be permitted up to a maximum of three percent of any lawn area. At least 90 percent of the grass established shall be permanent grass species.

D. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.11 GRASSES AND WILDFLOWERS SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds five miles per hour. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
   1. Do not use wet seed or seed that is moldy or otherwise damaged.
   2. All existing vegetation shall be removed and weeds killed prior to seeding.

B. Sow seed at rate specified by seed supplier as per individual Grasses and Wildflowers mixes.

C. Seeding requires a well-tilled, finely graded surface. The brillion seeders heavy cast iron packing wheels should ensure firm seed to soil contact. The optimum seeding time is from May to June to provide more time for soil preparation and to optimize germination of warm season grasses.

D. Three to four weeks prior to top seeding, mix seed with an equal volume of moist (not wet) sawdust and refrigerate at 34 to 38 degrees Fahrenheit (do not freeze). Seed shall not dry out and shall be planted immediately after moist stratification.

E. Seed all areas as defined on the Drawings with a brillion, double-box agricultural seeder that is equipped with native grass bristle brushes in the larger front box rather than the standard steel wire agitators. Brush seed into top 1/16 inch of soil, roll lightly, and water with fine spray.

F. Protect seeded areas from hot, dry weather or drying winds by applying weed free straw, such as winter wheat or salt marsh hay mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of one inch and roll surface smooth. Do not apply any hydroseeding or hydromulch with tackifier to any Grasses and Wildflowers seeding without Landscape Architect acceptance of method and product(s).

G. Water newly planted areas and keep moist until Grasses and Wildflowers is established.

3.12 GRASSES AND WILDFLOWERS PERENNIAL PLUGGING

A. All existing vegetation shall be removed prior to perennial plugging. Mow and rake existing vegetation in late fall or early spring. Cultivate with a rototiller, cultivator, or similar tool to a depth of four inches to six inches every two to three weeks from spring to fall. Before planting, make sure all the existing weeds have been killed. This procedure may require two consecutive years of cultivating to kill noxious weeds and nonnative invasive vegetation.

B. The optimal plug planting time is from late August to late September to avoid competition with faster growing weeds and limited watering requirements during the first growing season. If planting in the late spring (second alternative), wait for one heavy spring rain to stimulate weed growth. Wait five to seven days and till the soil very lightly with a weed drag or rock rake, no more than one inch in depth. Do this in the mid-morning of a warm sunny day so that the heat will kill the weed seedlings. Plant immediately.

C. Plant as starter plugs in groups and at spacing as specified on the Documents. Plants will flower the following season if planted in the fall or the same season if planted in the spring.

D. Protect plugs from hot, dry weather or drying winds by applying weed free straw, such as winter wheat or salt marsh hay mulch within 24 hours after completing plugging operations. Soak areas, scatter mulch uniformly to a thickness of two inches and pull mulch away from the base of the plug plantings.

3.13 GRASSES AND WILDFLWOERS MAINTENANCE

A. Maintain and establish Grasses and Wildflowers by watering, weeding, mowing, trimming, replanting, and performing other operations to establish a healthy, viable Grasses and Wildflowers over two years of maintenance activities. Roll, regrade, and replant bare or eroded areas and remulch. Provide materials and installation the same as those used in the original installation.

1. Weed control during the first year is essential.
2. Fill in soil subsidence that may occur because of settling or other processes. Replace materials and Grasses and Wildflowers damaged or lost in areas of subsidence.
3. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor to prevent displacement.
4. During the first growing season, mow the entire area back to six-inches each time the seeded/plugged areas reach a height of 12-inches to 16-inches; typically, three-times during the first growing season. Use a flail mower, rotary mower or sickle bar mower. Be sure to mow before any weeds have set seed. Do not pull weeds during the first year.

5. In the fall of the first growing season, leave the dead vegetation and stubble standing to help insulate the seedlings and reduce winter frost heaving.
6. In the early spring of the second growing season, mow and rake all seeded areas to the ground. If biannual weeds are present, mow again at approximately 12-inches when the majority of the biannual weeds are in full flower, typically mid-June. Make sure to mow before they set seed.
7. Apply treatments allowed by conservation regulations to keep Grasses and Wildflowers and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
8. Fertilizer is typically not required or preferred in the Grasses and Wildflowers areas after establishment.

B. Watering: Install and maintain temporary piping, hoses, and Grasses and Wildflowers-watering equipment to convey water from sources and to keep Grasses and Wildflowers uniformly moist.
1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out a temporary watering system to avoid walking over muddy or newly planted areas.
2. Water seeded Grasses and Wildflowers areas two to three times a week for the first four weeks after planting unless rainfall precipitation is adequate. Continue to water one to two times per week through the first growing season. Thorough soakings are better than light sprinklings to encourage deep root growth.
3. Water plugged Grasses and Wildflowers areas two to three times a week for the first six weeks after planting unless rainfall precipitation is adequate. Continue to water one to two times per week through the first growing season. Thorough soakings are better than light sprinklings to encourage deep root growth.
4. One day of heavy rain can compensate for one time of watering.
5. Once plants are established in the second season, watering is typically not required in the Grasses and Wildflowers areas.

3.14 SATISFACTORY GRASSES AND WILDFLOWERS GRASS

A. Request for Acceptance: In writing, request Owner's Representative observation for acceptance at least 10 days in advance of preferred acceptance date. Do not request observation for acceptance until work is 100 percent complete (not including maintenance) and in compliance with Contract requirements.

B. Partial Acceptance: Acceptance of partial areas or portions of the total work may be granted, at the Owner's option, if the area to be inspected is large, well-defined, and easily described. The Owner and Owner's Representative are not obliged to provide partial acceptance of the work.

C. Grasses and Wildflowers installations shall meet the following criteria as determined by Owner's Representative:
1. Satisfactory Seeded Grasses and Wildflowers: At end of the two-year maintenance period, a healthy, uniform, close stand of Grasses and Wildflowers grass has been established, free of weeds, undesirable grass species, disease, insects and surface irregularities. For the purpose of establishing an acceptable standard for seeded areas, scattered bare spots not larger than one square foot in maximum dimension, with not more than one bare spot for each one square yard of Grasses and Wildflowers area.
2. Satisfactory Plugged Grasses and Wildflowers: At end of the two-year maintenance period, a healthy, uniform, close stand of Grasses and Wildflowers grass has been established, free of weeds, undesirable grass species, disease, insects and surface irregularities. For the purpose of establishing an acceptable standard for seeded areas, scattered bare spots not larger than one square foot in maximum dimension, with not more than one bare spot for each one square yard of Grasses and Wildflowers area.

D. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.15 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.16 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs to protect newly planted areas from traffic. Maintain fencing and barricades throughout the initial maintenance period and remove after plantings are established.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION

SECTION 32 93 00
PLANTS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes providing all labor, equipment, materials, incidental work and construction methods required to perform all planting installation and related items as indicated on the Contract Documents and/or as specified herein, and includes, but is not limited to, the following:
   1. Planting trees, shrubs, groundcover, bulbs and perennials.
   2. Planting soils.
   3. Tree stabilization.
   4. Landscape edgings.
   5. Existing tree pruning.
   6. Existing tree transplanting.
   7. Erosion-control material(s).
   8. Maintenance.

B. Related Sections:
   1. Section 01 56 39 "TEMPORARY TREE AND PLANT PROTECTION" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
   2. Section 31 10 00 "SITE CLEARING" for protection of existing trees and plantings, topsoil stripping and stockpiling, and site clearing.
   3. Section 31 13 00 “SELECTIVE TREE REMOVAL AND TRIMMING” for pruning of existing trees and inspections by Certified Arborist.
   4. Section 31 00 00 "EARTH MOVING” for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
   5. Section 31 25 00 “EROSION AND SEDIMENTATION CONTROLS” for earthwork stockpiles, cut and fill slopes, constructed and existing swales and ditches, and unestablished lawn and seeded embankments.
   6. Section 32 33 00 "SITE FURNISHINGS" for exterior unit planters.
   7. Section 32 92 00 "TURF AND GRASSES" for turf (lawn), grass and wildflowers planting, hydroseeding, and erosion-control materials.
   8. Section 33 41 00 “STORM UTILITY DRAINAGE PIPING” for below-grade drainage of landscaped areas, paved areas, and wall perimeters.
   9. Section 32 84 00 “IRRIGATION” for irrigation at the multiuse athletic field.
   10. Section 32 90 00 “UNDERDRAIN SYSTEM” for underdrains at the multiuse athletic field and play areas.

1.03 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required.
D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than minimum root spread according to ANSI Z60.1 for type and size of plant required.
E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
F. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
G. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.
H. Finish Grade: Elevation of finished surface of planting soil.
I. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
J. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
K. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
L. Planting Area: Areas to be planted.
M. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
N. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
O. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
P. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.
Q. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
R. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.
S. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, including soils.
   1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
   2. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to the Project.

3. Plant Photographs: Include color photographs in a digital format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting the true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

B. Samples for Verification: For each of the following:
   1. Trees and Shrubs: Plant material certificates of inspection by government authorities. Vendor/ grower certification of plants, identifying the zone of origin that the plants were grown in.
   2. Organic Mulch: One quart volume of each organic mulch required, in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
   3. Erosion Control Matting: Submit one copy of manufacturer's literature and one material sample.
   4. Antidessiccant: Submit manufacturer's product data.
   5. Mycorrhizal Fungal Inoculant: Submit manufacture's product data certifying that inoculant being supplied conforms to these Specifications. Submit the purchasing receipt showing the total quantity purchased for the Project prior to installation. Submit empty packets of fungal spore inoculant to the Owner's Representative for verification of use.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: Submit proof of qualified landscape Installer to the Owner's Representative in accordance with QUALITY ASSURANCE paragraph of this Section. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Product Certificates: At least 30 days prior to ordering materials, the General Contractor shall submit to the Owner's Representative samples, certifications, manufacturer's product data and certified test results for materials specified below. No materials shall be ordered or delivered until the required submittals have been reviewed and accepted by the Owner's Representative. Delivered materials shall closely match the accepted samples. Acceptance shall not constitute final acceptance. The Owner's Representative reserves the right to reject, on or after delivery, any materials that do not meet these Specifications:
   1. Fertilizer: Submit product literature of seeding fertilizer and certificates showing composition and analysis.
   2. Soil Additives: Submit product literature on all soil additives to be used on site.
   3. Manufacturer's certified analysis of standard products.
   4. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Material Test Reports: For sampling and testing of Loam Borrow from Off-Site Sources and from On-Site Sources shall be as specified in QUALITY ASSURANCE paragraph of this Section.

D. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful establishment of plants.

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: Three years' experience in landscape installation of similar quality, schedule requirement and construction detailing.
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time foreman or crew leader on Project site when work is in progress.
4. Personnel Certifications: Installer's foreman or crew leader shall be either a certified landscape professional or a certified horticulturalist:
   a. Landscape professional shall be a Massachusetts Certified Landscape Professional currently certified by the Associated Landscape Contractors of Massachusetts.
   b. Horticulturalist shall be a Massachusetts Certified Horticulturalist as currently certified by the Massachusetts Nursery and Landscape Association.
   c. Certified Ornamental Landscape Professional, designated COLP.
5. Pesticide Applicator: State of Massachusetts licensed, commercial.

B. Soil-Testing Laboratory Qualifications: An independent or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; buffer pH, soluble salts, and mineral and plant-nutrient content of the soil.
   1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
   2. The soil testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Owner's Representative. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
   3. Report suitability of tested soil for plant growth.
      a. Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 square feet or volume per cubic yard for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
      b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

D. Plants: Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1 "American Standard for Nursery Stock". A plant shall be dimensioned as it stands in its natural position. Provide legibly tagged, healthy, vigorous stock, grown in a recognized nursery in accordance with good horticultural practices and free of disease, insect, eggs, larvae and defects such as knots, sunscald, injuries, abrasions or disfigurement.
   1. Plant names indicated with "Standardized Plant Names" as adopted by the latest edition of the American Joint Committee on Horticultural Nomenclature. Names of varieties not listed conform generally with names accepted by the nursery trade. Provide stock true to botanical name and legibly tagged. Plants not legibly tagged will be rejected.
   2. Do not make substitutions. If specified landscape materials are not obtainable, submit proof of non-availability to the Owner's Representative, together with a proposal for use of an

equivalent material. Substitutions or changes on the plant species will not be permitted without prior written acceptance by the Owner's Representative.

E. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
   1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements six inches above the root flare for trees up to four-inch caliper size, and 12 inches above the root flare for larger sizes.
   2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

F. Plant Material Observation: Plant material shall be inspected according to State and Federal Laws. Notify the Owner's Representative to perform an inspection of plant materials prior to commencing planting operations. Owner's Representative may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Owner's Representative retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
   1. Notify Owner's Representative of sources of planting materials seven days in advance of delivery to site.

G. Allow Owner's representative option of travelling to Grower's facility to select plant materials from available stock.

H. Allow four weeks, after receipt of list of growers, to finish tagging plant materials.

I. Trees dug prior to tagging by Owner's Representative are subject to rejection.

J. Owner's Representative will confirm the plant materials satisfy the requirements of ANSI Z60.1 and all special conditions stated in Project Specifications and Drawings.

K. Unacceptable plant materials will not be tagged and a different Grower shall be selected by Installation Contractor at no expense to the Owner. A second tagging trip will then be scheduled.

L. Decision by Owner's Representative to forgo tagging trip does not release Installation Contractor from responsibility of obtaining plant materials which meet the standards and conditions stated on the Project Specifications and Drawings.

M. Pre-Construction Walk: Conduct pre-construction site walk at the Project site at a day and time specified by the Owner's Representative.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Fertilizer and Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable at time of first use. Any packaged materials that become caked or otherwise damaged will not be acceptable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

C. Bare Root Stock: Deliver bare-root stock plants freshly dug. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.

D. Plants: Provide freshly dug plants. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Spray plants with antidessicant and provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Digging and moving of plant materials: Plants required to balled and burlapped (B&B) shall be dug and moved with compact balls of soil encompassing the root system, firmly wrapped with burlap and laced with nursery twine or wire basket. Each root ball should be of sufficient width and depth to encompass the fibrous and feeding roots necessary to ensure the full recovery and development of the plant. Plants having a cracked or broken ball of soil will not be acceptable. All plants, from the time they are dug until they are planted, shall be kept shaded and otherwise protected. After digging, transport the plants immediately to the packing sheds or other cover. Adequately water both the foliage and the ball. Handle planting stock by root ball.

F. Take all precautions customary in good trade practice in preparing plants for moving. Workmanship that fails to meet the highest standards will be rejected. Summer dug materials will not be accepted. Spring (dormant) dug materials that are shipped “in-leaf” shall be sprayed with antidessicant. Dig, pack, transport and handle plants with care to ensure protection against injury. Inspection certificates required by law shall accompany each shipment invoice order, and upon arrival the certificate shall be filed with the Owner’s Representative. Water to maintain root systems to a moist condition. Handling procedures not conforming to these specifications shall result in rejection of plant material and Installation Contractor shall remove plants from site and provide replacements.

G. Store bulbs, corms, and tubers in a dry place at 60 to 65 degrees Fahrenheit until planting.

H. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist. The planting program shall be arranged that an excessive number of unplanted plants as determined by the Owner’s Representative are not stored on the site.

1. Heel-in bare-root stock. Soak roots that are in dry condition in water for two hours. Reject dried-out plants.
2. Set balled stock and container grown plants on ground and cover ball with soil, sawdust, or other acceptable material.
3. Do not remove container-grown stock from containers before time of planting.
4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water to maintain root systems in a moist, but not overly wet condition.
5. All plants that are being stored shall be kept adequately watered at all times.

1.08 PROJECT CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Interruption of Existing Services or Utilities: Do not interrupt services or utilities to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary services or utilities according to requirements indicated:

1. Notify Owner’s Representative no fewer than two days in advance of proposed interruption of each service or utility.

2. Do not proceed with interruption of services or utilities without Owner's Representative written permission.

C. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
   1. Spring Planting: April 1 through June 30.
   2. Fall Planting: August 15 through November 15.

D. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements. Plant frost tender trees and shrubs only after the danger of frost is past or sufficiently before frost season to allow for establishment before the first frost. Do not plant in frozen ground.

E. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
   1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

F. Existing Tree Pruning:
   1. Prior to the pruning of any existing trees on the Project site, the General Contractor shall retain the services of a Massachusetts Certified Arborist (MCA) to identify the tree species and evaluate the health, vigor and public safety aspects of the trees identified by the Owner's Representative to receive pruning. Upon the completion of the site visit, the Massachusetts Certified Arborist shall submit an Arborist Report detailing the pruning and management aspects that are required for the identified trees.
   2. Only upon acceptance of the Arborist Report by the Owner's Representative, the pruning of existing tree materials shall be done with Owner's permission and in the presence of the Owner's Representative.

1.09 WARRANTY

A. Warranty: Provide written warranty agreeing to remove and replace work that exhibits defects in materials or workmanship for the specified periods. "Defects" is defined to include but is not limited to; death, unsatisfactory growth, disease, abnormal foliage density, abnormal size, abnormal color, failure to thrive and other unsatisfactory characteristics.

B. Replacement: Replace each defective plant or work with same species, size, character, and quality of originally accepted work. With each replacement plant or material, provide a new one-year warranty for the replacement work. If a replacement is unacceptable during its one-year warranty, the General Contractor shall provide another replacement or, when accepted by Owner, equivalent cash payment.

C. Replacement Planting Season: Planting and reseeding for replacement and warranty work shall comply with the planting season contained herein.

D. Owner's Responsibilities and Warranty Exclusions: After completion of the General Contractor's maintenance responsibilities, the Owner is responsible for maintaining the work in reasonable compliance with the General Contractor's maintenance instructions. The Installation Contractor's warranty shall exclude problems due to improper or inadequate maintenance after the maintenance period or vandalism.

E. General Contractor Responsibilities: During the warranty period the General Contractor shall visit the site at one-month intervals to review the conditions of the accepted work. The General Contractor shall submit in writing his/her concerns regarding the Owner's maintenance practices and/or any vandalism. The Owner shall make reasonable efforts to correct the problems cited by the General Contractor, but the Owner shall not be held responsible for the

Installation Contractor's defects in materials or workmanship that result in decline or death to plants and lawns.

F. Warranty shall not include damage or loss of trees and shrubs caused by fires, floods, freezing rains, lightning storms, winds over 75 miles per hour, winter kill caused by extreme cold, severe winter conditions not typical of planting area, and acts of vandalism, or negligence on the part of the owner.

G. Failure of the General Contractor to make the required monthly review of the site during the warranty period and submit written notice to the Owner of maintenance defects shall negate the General Contractor's ability to make claim against the Owner for negligence of maintenance.

H. Warranty Period for Trees, and Shrubs: One Year from date of final acceptance.

I. Warranty Period for Perennials and Ground Covers: One Year from date of final acceptance.

1.10 MAINTENANCE SERVICE

A. Initial Maintenance Service for Trees, and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as indicated in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.

1. Maintenance Period: 60 days from date of final acceptance of trees, and shrubs.

B. Initial Maintenance Service for Perennials, Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as indicated in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.

1. Maintenance Period: 60 days from date of final acceptance of perennials, ground covers and other plants.

PART 2 PRODUCTS

2.01 PLANT MATERIAL

A. Plants: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1 and the "Standardized Plant Names" by the American Joint Committee on Horticultural Nomenclature. Botanical names take precedence over common names. Plant materials shall be nursery grown, true to the names indicated on the Contract Documents and in accordance with the names adopted by the American Joint Committee on Horticultural Nomenclature. No substitutions shall be permitted, without written acceptance by the Owner's Representative. Plant Materials shall be:

1. Hardy under climactic conditions similar to those in the locality of the Project. Only plant stock grown within Hardiness Zones 1 through 6b, as established by the USDA Plant Hardiness Zone Map, latest edition, will be accepted.
2. Plant materials shall be typical of the species or variety with normal, densely developed branches and vigorous, fibrous root systems densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
3. All plants shall have fully developed form without voids and open spaces. Plants held in storage will be rejected if they show signs of growth during storage.
4. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots will be rejected.
5. If at any time during the performance of the Contract, any plant shows signs of graft incompatibility, as determined by Owner's Representative, then the tree and shrub and all

similarity grafted plants of the same Genus/Species/Variety shall be rejected and removed from the site. Visual symptoms of graft incompatibility as cause for rejection include; development of over-growths by rootstock or scion resulting in the development of shoulders or inverted shoulders, suckering of the rootstock combined with poor growth or dieback of scion, any mechanical weakness between scion and rootstock, and marked difference in bark pattern and structure between scion and rootstock.

6. Pruning wounds and damage from handling with a diameter of more than one inch will not be acceptable. Smaller wounds shall show a vigorous growth of bark on all edges.
7. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated or accepted by the Owner's Representative.

B. Quality: Provide tree and shrub size, genus, species and variety shown and scheduled for landscape work and complying with recommendations and requirements of ANSI Z60.1 "American Standard for Nursery Stock".

C. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Owner's Representative. If the use of larger plants is acceptable, increase the spread of roots or root ball in proportion to the size of the plant.

D. Plant Measurements: Plants shall meet the requirements for spread and height indicated in the Plant Schedule. The measurement for height shall be taken from the crown of the roots to the average height of the top branches of the plant, and not the tallest leader. Poorly stemmed or thin plants will not be accepted. Side branches shall be generous, well twigged and evergreen plants shall be well bushed to the ground. Plants shall be in a moist, vigorous condition, free from deadwood, bruises, or other root or branch injuries. Take caliper measurements for deciduous trees six inches above the ground level up to and including four inches caliper size, and 12 inches above the ground for larger sizes.

E. Deciduous Trees: Provide trees of height and caliper as indicated in the Plant Schedule, single stemmed with straight trunk, well-branched crown and intact single leader, with branching height 1/3 to 1/2 of tree height and with branching configuration recommended by ANSI Z60.1 for type of species required. Multiple leaders shall conform to all standards noted above and in this Section. Shade trees shall have no branching lower than 6.5 feet from finished grade. Flowering trees for use in areas away from pedestrian traffic shall have the first branch of their crowns be no higher than four feet from finished grade. All deciduous trees shall be balled and burlapped (B&B)

F. Evergreen Trees: Provide trees of height as indicated in the Plant Schedule, measured from the trunk flair at the natural ground line of the tree to the midpoint of the terminal leader, single stemmed with no double leaders or twin heads permitted, well-branched to the ground and with branching configuration recommended by ANSI Z60.1 for type of species required. Terminal and top whorl buds of evergreen trees shall be in healthy and whole condition at time of harvest. No evergreen tree shall be pruned after the Owner's Representative or General Contractor has tagged the tree in the nursery. All trees shall have healthy, vigorous needles of normal size, color, shape, texture for the particular species and variety. All evergreen trees shall be balled and burlapped (B&B)

G. Shrubs: Provide plants of the height or spread as indicated in the Plant Schedule, and with not less than the minimum number of canes required by ANSI Z60.1 for type and height of shrub required. Container grown stock shall be grown in a container for sufficient length of time for the root system to have developed to hold its soil together, firm and whole. Not plants shall be loose in the container. Container stock shall not be pot bound. Canes, trunk(s) and branches shall be well formed, branching uniformly distributed close to ground. Scars shall be free of rot

and not exceed 1/4 the diameter of the wood beneath in greatest dimension unless completely healed, except pruning scars. Shrubs shall show no signs of frost or winter damage to the foliage. Foliage shall not be in a state of drought stress. Leaves or needles shall show no signs of wilt or desiccation due to weather stress at any season of the year. All shrubs shall be container grown (Cont.).

H. Ground Cover: Provide plants of the size, pot size, age and condition as indicated in the Plant Schedule, and with not less than the minimum number of canes, runners, eyes, or fans required by ANSI Z60.1 for the type and size of ground cover required.

I. Perennials: Provide plants of the size, pot size, age and condition as indicated in the Plant Schedule, and with not less than the minimum number of runners, eyes, or fans required by ANSI Z60.1 for the type and size of perennials required.

J. Root-Ball: All ball and burlapped plants to have firm, natural balls of earth, of sufficient diameter and depth to encompass the fibrous and feeding root system necessary for full recovery of the plant. Cracked or mushroomed balls are not acceptable. Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible, and all girdling roots removed before planting. All container grown plants shall have an extensive, symmetrically balanced fibrous root system without curling or spiraling of the roots along the walls of rigid containers. All parts of the fibrous root system for balled and burlapped and container grown plants shall be moist and fresh with a white color when washed of soil. The root systems of all plants shall be free of disease, insect pests, eggs or larvae.

K. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on Drawings.

L. If formal arrangements or consecutive order of plants is shown on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

M. Perennials, Ground Covers and Other Plants: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. All parts of the fibrous root system for balled and burlapped and container grown plants shall be moist and fresh with a white color when washed of soil. The root systems of all plants shall be free of disease, insect pests, eggs or larvae. Provide only plants that are acclimated to outdoor conditions before delivery.

2.02 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.
2. Provide lime in form of ground dolomitic limestone.

2.03 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 6.5 to 8.0; moisture content 35 to 55 percent by weight; 100 percent passing through 3/8 inch or smaller sieve; soluble salt content of five to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 40 percent dry weight.
2. Nutrient Content: The material shall contain some nitrogen, phosphorous, potassium, calcium, magnesium, sodium and micronutrients including iron, copper, boron, manganese and molybdenum so that heavy application of fertilizers is not required to sustain plant

growth. Also, the nutrients shall be present in appropriate agricultural and horticultural proportions to prevent ion antagonism.

3. Heavy Metals: Concentrations of zinc, mercury, cadmium, lead, nickel, chromium, and copper shall be below EPA and State of Massachusetts standards for applications to soils with human activity.
4. Pesticide Residue: Composted organic materials shall not contain any pesticide residues of any kind.

B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.04 FERTILIZERS

A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of four percent nitrogen and23 percent phosphoric acid.

B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium. Fertilizer shall be a commercial product complying with the State and United States fertilizer laws. Deliver to the site in the original unopened containers that bear the manufacturer's certificate of compliance covering analysis. Fertilizer shall contain not less than the percentages of weight of ingredients recommended and shall be adjusted per the soil analysis.

1. Composition: one pound per 1000 square feet of actual nitrogen, four percent phosphorous, and two percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

D. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium. Fertilizer shall be a commercial product complying with the State and United States fertilizer laws. Deliver to the site in the original unopened containers that bear the manufacturer's certificate of compliance covering analysis. Fertilizer shall contain not less than the percentages of weight of ingredients as recommended by the soil analysis.

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

E. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

2.05 PLANTING SOILS

A. Planting Soil for Trees, Shrubs, Ground Covers, and Perennials: ASTM D 5268 topsoil, screened, sandy loam that is fertile, friable natural loam free from subsoil, clay, brush, litter, roots, stones 3/4 inch or larger and any other foreign materials harmful to plant growth. Loam shall have an acidity range of pH 5.8 to 7.0 and shall contain not less than four percent or more than six percent organic material content as determined by the loss of ignition (LOI) of samples which have been oven-dried to a constant weight at a temperature of 221 degrees Fahrenheit (105 degrees Celsius).

1. Mix ASTM D 5268 topsoil with the following soil amendments in the following quantities to produce planting soil:
   a. Ratio of soil mixture compositions shall be one part topsoil as specified above, one-part organic matter, and one-part native soil mixed prior to planting installation.

b. Weight of Lime per 1000 square feet: 200 pounds maximum limit.
c. Weight of Bonemeal per 1000 square feet: as per soil analysis.
d. Weight of Superphosphate per 1000 square feet: 20 pounds or as specified by soil analysis.
e. Weight of Commercial Fertilizer per 1000 square feet: as per soil analysis.
f. Weight of Slow-Release Fertilizer per 1000 square feet: as per soil analysis.

B. Planting Soil for Naturalized Areas: Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil. Soil shall consist of one to two percent organic matter with a blend of sand, silt, and minimal clay (dry sandy loam), consist of well-sorted particles less than one inch diameter with continuous pore space and have a pH range from 5.8 to 7.0. Soil shall be free from subsoil, clay, brush, litter, roots, stones 3/4 inches or larger and any other foreign materials harmful to plant growth.
1. Supplement with trees, shrubs, perennials and ground covers planting soil when quantities are insufficient.
2. Mix existing, native surface topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
a. Ratio of soil mixture compositions shall be one part topsoil as specified above, one-part organic matter, and one-part native soil mixed prior to planting installation.
b. Weight of Lime per 1000 square feet: 200 pounds maximum limit.
c. Weight of Bonemeal per 1000 square feet: as per soil analysis.
d. Weight of Superphosphate per 1000 square feet: 20 pounds or as per soil analysis.
e. Weight of Slow-Release Fertilizer per 1000 square feet: as per soil analysis.

2.06 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
1. Type: Shredded and aged pine bark mulch; aged a minimum of six months. The mulch shall be dark brown in color, between 1/2 inch and 2 1/2 inches in any direction, free from chunks and pieces thicker than 1/4 inch. Mulch shall be free of stringy material, viable, noxious weed seeds and insect life, and shall not contain, in the judgment of the Owner's Representative, an excess of fine particles.
2. Size Range: 2 1/2 inch maximum, 1/2 inch minimum.
3. Color: Natural, Dark Brown.

2.07 PESTICIDES

A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.08 TREE STABILIZATION MATERIALS

A. Stakes and Web Guys (ArborTie®):
1. Upright and Web Guy Stakes: Rough-sawn, sound, new cedar posts, free of knots, holes, cross grain, and other defects, two-by-two-inch nominal by ten-foot length, pointed at one end; three stakes per tree. The top four inches of all stakes shall be taped with WHITE duct tape or painted for identification purposes.

2. Web Guys and Ties: Shall be ArborTie or approved equal, a flat woven polypropylene material; 3/4-inch wide. ArborTie is a product from Deep Root Partners, L.P.; 1-800-458-7668 or fax 1-800-277-7668.
3. Guying material shall be secured by loosely connecting the ArborTie or equivalent around the central leader of tree.
4. Staking systems that are not taped or are improperly anchored will be considered incomplete and will not be paid for.
5. Plant locations in park areas to incorporate tree protection guards at the base of the tree. Guards are to be ARBORGARD+ tree trunk protectors or approved equal. ARBORGARD+ is a product of Deep Root Partners, L.P.; (800) 458-7668 or fax (800) 277-7668.

2.09 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include Manufacturer's recommended steel wire staples, six inches long.

B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 pounds per square yard, with 50 to 65 percent open area. Include Manufacturer's recommended steel wire staples, six inches long.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. North American Green, 5401 St. Wendel-Cynthiana Road, Poseyville, IN 47633, Telephone: 800.772.2040; Website: www.nagreen.com; BioNet Biodegradable Erosion Control Blankets; Short-Term.
      b. North American Green, 5401 St. Wendel-Cynthiana Road, Poseyville, IN 47633, Telephone: 800.772.2040; Website: www.nagreen.com; BioNet Biodegradable Erosion Control Blankets; Extended-Term.

2.10 MISCELLANEOUS PRODUCTS

A. Mycorrhizal Fungi:
   1. Dry, granular inoculant containing at least 5300 spores per pound of vesicular-arbuscular mycorrhizal fungi and 95 million spores per pound of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

B. Slow-Release Watering Bag (Treegator Bag®):
   1. 20-gallon bag to be constructed out of UV-treated polyethylene and reinforced with nylon webbing. Sides are to be made watertight with durable 1/4-inch-thick heat seals.
   2. Bag is to be secured to the tree with heavy-duty nylon zippers, sewn on to each side.
   3. Two water release holes at the bottom of each corner, designed to achieve five to nine-hour release rate.
   4. Plant locations throughout site to incorporate Treegator Bags or approved equal. Treegator Bag is a product of Treegator Slow-Release Watering Bag; (866) 873-3428 or fax (919) 556-9852, or approved equal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Verify that the finished grades in the planting areas have been established before starting the planting operation.
   3. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.

4. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
5. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination and replace with new planting soil.

3.02 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways. Protect planting areas with slopes exceeding 3:1 with erosion control blankets or erosion control fiber mesh, installed and stapled / anchored according to manufacturer's written instructions.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Owner’s Representative's acceptance of layout before excavating or planting. Make minor adjustments.

1. The locations shall be as shown on the Drawings unless otherwise indicated. However, due to underground obstructions or for other reasons, it may be necessary to modify the plant locations, subject to review by the Owner’s Representative before the relocation.
2. The Owner’s Representative reserves the right to interchange the plants or to shift the plant locations if it is possible in his/her judgment to procure a better effect by the changes.

D. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.

1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

E. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

3.03 PLANTING AREA ESTABLISHMENT

A. Loosen subgrade of planting areas to a minimum depth of 18 inches. Remove stones larger than 1 1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply soil amendments and /or fertilizer directly to subgrade before loosening.
2. Thoroughly blend planting soil off-site before spreading.
3. Spread planting soil in two equal lifts to a depth of 12 inches but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
    a. Spread approximately one-half the thickness of planting soil over loosened subgrade. Mix thoroughly into top four inches of subgrade. Spread remainder of planting soil.

B. Remediation of Compacted or Poorly Drained Subsoil in Planted Areas: If the soils are deemed to be compacted or poorly draining, the General Contractor shall remedy the condition prior to proceeding with further work. Remove any vegetative growth on the surface of the work area. Remove any extraneous materials. Loosen subgrade with a backhoe bucket to a depth of 18 inches. After gathering subsoil in the bucket, drop soil onto the ground from a height of six feet to break up the soil clumps. Position backhoe during work to prevent re-compaction of soils beginning the work in corners or against walls, or the center of isolated beds, and progressing outward towards the border’s edge. After subgrade has been broken up, rototill entire area to a depth of six inches. Heavy clay soils shall be amended with organic material.

C. Finish Grading: Set sufficient grade stakes for checking finished grades. Stakes shall be set at the top and bottom of slopes. Grades shall be established which are accurate to 1/10th of a foot either way. Grade planting areas to a smooth, uniform surface plane with loose uniformly fine texture. Grade to within plus or minus 1/4 inch of finish elevation. Limit finish grading to areas that can be planted in the immediate future

D. Before planting, obtain Owner's Representative's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

E. Application of Mycorrhizal Fungi: Broadcast dry product uniformly over prepared soil at application rate indicated by product manufacturer.

3.04 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.

1. Excavate approximately three times as wide as ball diameter for balled and burlapped stock.
2. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
3. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
4. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
5. Maintain required angles of repose of adjacent materials as shown on the Drawings. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
6. Maintain supervision of excavations during working hours.
7. Keep excavations covered or otherwise protected overnight or after working hours.
8. If drain tile is shown on Drawings or required under planting areas, excavate to top of porous backfill over tile.

B. Subsoil and topsoil removed from excavations may be used as planting soil upon acceptance by Owner's Representative.

C. Obstructions: Notify Owner's Representative if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. Hardpan Layer: Drill six-inch- diameter holes, 24 inches apart, into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

D. Drainage: Notify Owner's Representative if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow percolating before positioning trees and shrubs.

3.05 TREE AND SHRUB

A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Set balled and burlapped stock plumb and in center of planting pit or trench with root flare set at such a level that after settlement, they will remain at their natural grade elevation in proper relationship to the finished grade.

1. Use planting soil for backfill.
2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Add 10-10-10 fertilizer to the surface of the soil ring under the mulch at a rate of one pound per caliper inch of trees and one pound per square yard of plant bed unless otherwise directed.
5. Continue backfilling process. Water again after placing and tamping final layer of soil. Thoroughly water all plants within 24 hours after they have been planted.
6. Create shallow watering basins around all trees and shrubs as detailed to retain and conserve moisture. Maintain the basins until the plants have established themselves or until instructed by the Owner's Representative to remove them.

D. Set container grown stock plumb and in center of planting pit or trench with root flare at such a level that after settlement, they will remain at their natural grade elevation in proper relationship to the finished grade.
   1. Use planting soil for backfill.
   2. Carefully remove root ball from container without damaging root ball or plant.
   3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   4. Add 10-10-10 fertilizer to the surface of the soil ring under the mulch at a rate of one pound per caliper inch of trees and one pound per square yard of plant bed unless otherwise directed.
   5. Continue backfilling process. Water again after placing and tamping final layer of soil. Thoroughly water all plants within 24 hours after they have been planted.
   6. Create shallow watering basins around all trees and shrubs as detailed to retain and conserve moisture. Maintain the basins until the plants have established themselves or until instructed by the Owner's Representative to remove them.

E. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.
   1. Protect planted areas with slopes exceeding 3:1 with biodegradable erosion control blankets or erosion control fiber mesh, installed and stapled / anchored according to Manufacturer's written instructions.

3.06 TREE AND SHRUB PRUNING

A. Remove only dead, dying, split or broken branches. Do not prune for shape.

B. Do not prune the terminal leaders of the trees. On multiple leader plants, preserve the leader best promoting the symmetry of the plant. Prune branches at a point beyond a lateral bud, or a distance of not less than 1/2 the diameter of the supporting branch.

C. At the discretion of the Owner's Representative, remove 1/3 of the length of all candles on evergreen plants.

D. Prune, thin, and shape trees, and shrubs according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Owner's Representative, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to

retain natural character. Do not remove more than 10 percent of the foliage on any individual specimen and only after acceptance by the Owner's Representative.

E. All cuts shall be cleanly made with sharp tools as close to the parent trunk or limb as possible. Do not apply pruning paint to wounds.

3.07 TREE STABILIZATION

A. Trees in lawn areas, and in grass strips and in pits with grates shall not be staked and guyed. See Contract Documents for trees to be staked and guyed.

B. Install trunk stabilization immediately after trees have been planted as follows unless otherwise indicated. When high winds or other conditions that may affect tree survival or appearance occur, perform immediate staking.

C. Staking and Wire Guying:

1. Drive the stakes and posts 120 degrees apart from each other to a minimum depth of three feet below grade in undisturbed earth and to a minimum of four feet below grade in areas of fill. Stakes to extend at least five feet above grade. Set stakes to avoid penetrating root balls or masses
2. Use three stakes per tree. Space stakes equally around trees.
3. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
4. Attach flags to each guy wire, 30 inches above grade.
5. Staking and Guying Wire shall be removed by the General Contractor at the end of the warranty period.

3.08 EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Planting Area Establishment" Article.

B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.

C. Fill cells of erosion-control mat with planting soil and compact before planting.

D. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.09 MISCELLANEOUS PRODUCTS

A. Slow-Release Watering Bag.

1. Watering Bag shall be installed to manufacturer specifications.
2. Each bag shall be filled according to manufacturer specifications at least one time per week.
3. Bags are to be kept in working conditions and are to be replaced if missing or damaged for the extent of the establishment and guarantee periods.
4. Bags to be removed by General Contractor at the end of the warranty period.

3.10 EXISTING TREE PRUNING

A. Pruning shall be done with Owner's permission and in the presence of the Owner's Representative in accordance with the Massachusetts Certified Arborist (MCA) Report and workmanship requirements of "Pruning Standards" to preserve the natural character of the trees.

3.11 GROUND COVER AND PERENNIAL PLANTING

A. Set out and space ground cover and plants other than trees and shrubs as indicated on Drawings in even rows with triangular spacing.

B. Use planting soil for backfill.
C. Dig holes large enough to allow spreading of roots.
D. For rooted cutting plants supplied in flats, plant each in a manner that will minimally disturb the root system but to a depth not less than two nodes.
E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
G. Install and fill slow-release watering bag.
H. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.12 PLANTING AREA MULCHING

A. Mulch backfilled surfaces of planting areas and other areas indicated.
   1. Trees and Tree-like Shrubs in Turf Areas:
      a. Apply organic mulch ring of two-inch average thickness, with canopy drip-line radius around trunks or stems. Do not place mulch within two inches of trunks or stems.
      b. Thoroughly water mulched area. Rake to provide a uniform finished surface. Treat plant areas with weed retardant in accordance with manufacturer's instructions after all planting and mulching is complete.
   2. Organic Mulch in Planting Areas:
      a. Apply two-inch average thickness of organic mulch over whole surface of planting area and finish level with adjacent finish grades. Do not place mulch within two inches of trunks or stems.
      b. Thoroughly water mulched area. Rake to provide a uniform finished surface. Treat plant areas with weed retardant in accordance with manufacturer's instructions after all planting and mulching is complete.

3.13 EDGING INSTALLATION

A. Shovel-Cut Edging: Separate mulched areas from turf areas with a 45-degree, four inch deep, shovel-cut edge as shown in Drawings.

3.14 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations to establish healthy, viable plantings. Spray or treat to keep trees and shrubs free of insects and disease.
B. Fill in soil subsidence that may occur because of settling or other processes. Restore planting saucer and adjacent material and remove dead material.
C. Replace mulch materials damaged or lost in areas of subsidence.
D. Tighten and repair wires and stakes.
E. Correct defective work as soon as possible after deficiencies become apparent and weather and season permit.
F. Apply treatments to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated past management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.
G. Water trees, plants and seasonal planting beds within the first 24 hours of initial planting, and not less than twice per week until final acceptance. Monitor and fill slow-release watering bags. Coordinate watering by irrigation system with Owner's Representative.
H. Maintenance shall also include follow-up, at the end of the warranty period.
   1. Remove and renew wood mulch saucer.
   2. Remove stakes from trees.

3. Remove slow-release watering bags from trees.
4. Fertilize trees and shrubs.

3.15 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Pre-Emergent Herbicides (Selective and Non-Selective): Apply to tree, shrub, and ground-cover areas in accordance with manufacturer's written recommendations. Do not apply to seeded areas.

C. Post-Emergent Herbicides (Selective and Non-Selective): Apply only to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.16 CLEANUP AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect plants from damage due to landscape operations and operations of other Site Contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

C. After installation and before mulching of planting beds, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.17 DISPOSAL

A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION

SECTION 33 05 13
MANHOLES AND STRUCTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The Construction Manager, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section will also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

B. The Construction Manager will either perform the work of this section with its own forces or will subcontract such work to a subcontractor who will furnish a performance and payment bond for the complete scope of work and listing the Town of Wilmington as the co-oblige. Such bond will be procured from a surety that is currently licensed to do business in Massachusetts and is currently listed on the United States Treasure Department circular 570. A copy of such bond will be submitted to the Town of Wilmington's Project Manager for acceptance and will be in place prior to the subcontractor commencing any work on the project.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Install precast concrete manholes, catch basins, frames and covers, grates, manhole rungs, platforms, and appurtenances all as shown on the Drawings and as specified herein.

B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 31 00 00 - Earth Moving
2. Section 33 41 00 - Storm Utility Drainage Piping
3. Section 33 31 00 - Sanitary Utility Sewerage Piping

1.03 REFERENCES

A. American Concrete Institute:

1. ACI 318 - Building Code Requirements for Structural Concrete.
2. ACI 530/530.1 - Building Code Requirements for Masonry Structures and Specifications for Masonry Structures.

B. ASTM International:

1. ASTM A48/A48M - Standard Specification for Gray Iron Castings.
2. ASTM A615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
3. ASTM C32 - Standard Specification for Sewer and Manhole Brick
4. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
5. ASTM C55 - Standard Specification for Concrete Brick.

6. ASTM C62 - Standard Specification for Building Brick (Solid Masonry Units Made From Clay or Shale).
7. ASTM C150 - Standard Specification for Portland Cement
8. ASTM C207 - Standard Specification for Hydrated Lime for Masonry Purposes
9. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
10. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.
11. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.
12. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
13. ASTM D4097 - Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks
14. ASTMD4101 - Standard Specification for Propylene Plastic Injection and Extrusion Materials

C. American Association of State Highway and Transportation Officials (AASHTO)

D. Occupational Safety and Health Administration (OSHA)

1.04 DESIGN REQUIREMENTS

A. Equivalent strength: Based on structural design of reinforced concrete as outlined in ACI 318.

B. Design of Lifting Devices for Precast Components: In accordance with ASTM C913.

C. Design of Joints for Precast Components: In accordance with ASTM C913; maximum leakage of 0.025 gallons per hour per foot of joint at 3 feet of head.

1.05 SUBMITTALS

A. Section 01 30 00 – Administrative Requirements: Requirements for submittals.

B. Shop Drawings: Indicate manhole locations, elevations, and sizes and elevations of penetrations.

C. Product Data: Submit cover and frame construction, features, configuration, dimensions.

1.06 QUALITY ASSURANCE

A. The quality of all materials, the process of manufacture, and the finished sections will be subject to inspection and acceptance by the Engineer or other representative of the Town of Wilmington. Such inspection may be made at the place of manufacture, or on the work after delivery, or at both places and the materials will be subject to rejection at any time on account of failure to meet any of the requirements specified herein; even though samples may have been accepted as satisfactory as the place of manufacture. Material reject after delivery to the job will be marked for identification and will be removed from the job at one. All materials that have been damaged after delivery will be rejected, and if already installed, will be acceptably repaired, if permitted, or removed and replaced, entirely at the Construction Manager’s expense.

B. At the time of inspection, the materials will be carefully examined for compliance with the applicable ASTM standard specification and this Section with the accepted manufacturer's drawings. All manhole sections will be inspected for general appearance, dimension, scratch strength, blisters, cracks, roughness, soundness, and other surface or structural imperfections. The surface will be dense and close-textured.

C. Imperfections in manhole sections may be repaired, subject to the acceptance of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs will be carefully inspected before final acceptance. Cement mortar used for repairs will have a minimum compressive strength of 4,000 psi at seven days and 5,000 psi at 28 days, when tested in three-inch x six-inch cylinders stored in the standard manner. Epoxy mortar may be utilized for repairs subject to the acceptance of the Engineer.

1.07 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years documented experience.

1.08 DELIVERY, STORAGE AND HANDLING

A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.

B. Comply with precast concrete manufacturer's instructions for unloading, storing, and moving precast manholes.

C. Store precast concrete manholes to prevent damage to Town of Wilmington's property or other public or private property. Repair property damaged from materials storage.

D. Mark each precast structure by indentation or waterproof paint showing date of manufacture, manufacturer, and identifying symbols and numbers shown on Drawings to indicate its intended use.

1.09 ENVIRONMENTAL REQUIREMENTS

A. Section 01 60 00 - Product Requirements.

B. Maintain materials and surrounding air temperature to minimum 50 degrees Fahrenheit prior to, during, and 48 hours after completion of masonry work.

C. Cold Weather Requirements: ACI 530.

PART 1 - PRODUCTS

2.01 PRECAST CONCRETE MANHOLE SECTIONS

A. Precast concrete barrel sections and transition top sections will conform to ASTM C478 and meet the following requirements:

1. Manholes will have a minimum 48-inch interior diameter with a wall thickness of not less than five inches.
2. Top sections will be eccentric except that barrel sections will be used where shallow pipe cover requires a top section less than four feet.

3. Barrel sections will have tongue and groove joints. Manholes will be manufactured in the configuration shown on the Drawings with the bell of the manhole section pointing down.
4. All sections will be cured by an accepted method and will not be shipped or subjected to loading until the concrete compressive strength has attained 3,000 psi and not before five days after fabrication or repair, whichever is longer.
5. Precast concrete barrel sections with top slabs and precast concrete transition sections will be designed for a minimum of HS-20 loading plus the weight of the soil above at 120 pcf.
6. The date of manufacture and the name and trademark of the manufacturer will be clearly marked on the inside of each precast section.
7. Precast concrete bases will be constructed of and installed as shown on the Drawings. The thickness of the bottom slab of precast bases will not be less than the manhole barrel sections or top slab, whichever is greater.
8. Knockout panels will not be permitted.

2.02 CATCH BASINS

A. Precast reinforced concrete catch basin sections will conform to the applicable requirements of ASTM C478, latest revision.

B. Basin will be precast reinforced concrete four feet in diameter with penetrations cast into the basin for pipe connection; knockout panels will not be permitted. Basins will have a minimum wall thickness of five inches and a minimum bottom thickness of six inches. Basins will have a sump of four feet. Top sections will be a flat slab and have a minimum of eight inches for support of cast iron frame and grate. The hole in the top section will be 24 inches square size to accommodate frame and cover and be eccentric. The hole in the top section will be located over the side opposite to the hooded outlet to facilitate future cleaning operations.

C. All concrete will have a minimum compressive strength of 4,000 psi and a live load design base for all catch basins will be HS-20 loading.

D. All catch basins will be fitted with a hooded outlet. The hoods are to be positioned so they will not interfere with future cleaning operations. The hooded outlet cover will be fabricated from marine grade fiberglass, stainless steel (18-8) attachment hardware, pressure sensitive oil resistant foam rubber gasket, PVC Schedule 40 fittings, and pipe for anti-siphon device.

E. Bedding material under catch basins and drain manholes will conform to the requirements for of the Specifications for pipe bedding. A minimum of 12 inches of 3/4-inch crushed stone is required to provide a uniform base. If the material at the elevation that catch basins are to be set on is not suitable to support them, then this material will be removed to a depth that will support the structure. The material accepted by the Engineer will be used to replace the removed material and be compacted before setting the base.

F. Catch basin frames and grates/covers will be set at a finished elevation one inch below finish pavement elevation.

G. ADA compliant grates are required in pedestrian areas. If gratings have elongated openings, then they will be placed so that the long dimension is perpendicular to the dominant direction of travel. Walking surfaces should be slip resistant.

2.03 BRICK MASONRY.

A. The bricks will be good, sound, hard and uniformly burned, regular and uniform in shape, of compact size and texture and satisfactory to the Engineer. Underburned or salmon brick will not be acceptable and only whole brick will be used unless otherwise permitted. In case bricks are rejected by the Engineer, they will be immediately removed from the site of the work and satisfactory bricks used thereafter.
   1. Bricks for the channels and sleeves will comply with ASTM C32 for sewer brick; Grade SS (from clay or shale) except that the mean of five tests for absorption will not exceed eight percent and no individual brick will exceed 11 percent.
   2. Bricks for building up and leveling the manhole frames will comply with ASTM C62.

B. Mortar used in the brickwork will be composed of one part Type II Portland cement conforming to ASTM C150 and sand to which a small amount of hydrated lime not to exceed 10 lbs. to each bag of cement will be added.

C. The sand used will be washed, cleaned, screened, sharp and well graded as to different sizes and with no grain larger than will pass a No. 4 sieve. It will be free from vegetable matter, loam, organic or other materials of such nature or quantity to render it unsatisfactory.

D. The hydrated lime will also conform to ASTM C207.

2.04 FRAMES, COVERS AND GRATES

A. Manufacturers:
   1. All manufacturers producing such products will be considered.
   2. Substitutions: Section 01 60 00 - Product Requirements.

B. Manhole frames and covers will be of good quality, strong, tough, even grained cast iron, smooth, free from scale, lumps, blisters, sand holes and defects of any kind that render them unfit for the service for which they are intended. Manhole covers and frame seats will be machined to a true surface. Castings will be thoroughly cleaned and subject to hammer inspection. Cast iron will conform to ASTM A48, Class 35, H-20 loading.

C. Manhole covers will have a diamond pattern, pick holes, and the word ‘SEWER’, DRAIN', or as appropriate, cast in three-inch letters.

D. Inlet frames and grates will be of good quality, strong, tough, even grained cast iron, smooth, free from scale, lumps, blisters, sand holes and defects of any kind that render them unfit for the service for which they are intended. Catch basin grates and frame seats will be machined to a true surface. Castings will be thoroughly cleaned and subject to hammer inspection. Cast iron will conform to ASTM A48, Class 35, H-20 loading.

E. Grates, if located in a walking area, will have spaces no greater than 1/2-inch-wide in one direction. If gratings have elongated openings, then they will be placed so that the long dimension is perpendicular to the dominant direction of travel.

2.05 JOINTING PRECAST MANHOLE SECTIONS

A. Tongue and groove joints will be sealed with either a round rubber o-ring gasket or a preformed flexible joint sealant. The o-ring will conform to ASTM C443.

B. Joints will be designed and manufactured so that the completed joint will withstand an internal water pressure of 10 psi without leakage or displacement of the gasket or sealant.

2.06 MANHOLE RUNGS

A. Manhole rungs will conform to the requirements of ASTM C478 and be of the following types:

1. Manhole rungs will be steel reinforced copolymer polypropylene plastic. Rungs will be 14 inches wide. Copolymer polypropylene will conform to ASTM D4101. Steel reinforcing will be 1/2-inch diameter, grade 60 conforming to ASTM A615 and will be continuous throughout the rung. The portion of the legs to be embedded in the precast section will have fins and be tapered to insure a secure bond.

2.07 PIPE CONNECTION TO MANHOLE

A. Manhole pipe connections may be accomplished in the following ways:

1. The ‘Lock Joint Flexible Manhole Sleeve’ will be cast in the precast manhole base. The steel strap will be protected from corrosion with a bituminous coat.
2. ‘A-Lok’ will be a rubber like gasket cast in the precast manhole base. The rubber gasket will be case into a formed opening in the manhole.
3. ‘Kor-N-Seal’ joint will be installed as recommended by the manufacturer. The stainless-steel clamp will be protected from corrosion with a bituminous coat.

B. Clear Cover Opening: 24-inch diameter, or as otherwise indicated on Drawings.

C. Steps: 12-inch-wide, 16 inches on center vertically, set into manhole, or as otherwise indicated on Drawings.

2.08 DAMPPROOFING

A. The dampproofing will be Hydrocide 648 by Sonneborn Building Products, Dehydratine by A.C. Horn, Inc., Meadows Trowel Mastic, or accepted equal.

2.9 CONFIGURATION

A. Shaft Construction: Concentric with eccentric cone top section; lipped male/female joints; sleeved to receive pipe sections.

B. Shape: Cylindrical.

C. Clear Inside Dimensions: 48 inches, or as otherwise indicated on Drawings.

D. Design Depth: As indicated on Drawings.

E. Clear Cover Opening: 24-inch diameter, or as otherwise indicated on Drawings.

F. Steps: 12-inch-wide, 16 inches on center vertically, set into manhole, or as otherwise indicated on Drawings.

2.10 BEDDING MATERIALS

A. Bedding and Cover: 3/4-inch Crushed Stone in accordance with Section M2.01.4 of the MHD Standard Specifications.

B. Soil Backfill from Around Manhole: In pavement areas where controlled density fill is not specified, provide Ordinary Fill to the sub-base of the pavement, and then provide the required sub-base material for the pavement section. In grassed areas where controlled density fill is not specified, provide Ordinary Fill to a point six inches below finished grade, then Manufactured Topsoil to finished grade.

PART 2 - EXECUTION

3.01 EXAMINATION

A. Verify items provided by other sections of Work are properly sized and located.

B. Verify built-in items are in proper location, and ready for roughing into Work.

C. Verify correct size of manhole excavation.

3.02 PREPARATION

A. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections.

B. Do not install structures where site conditions induce loads exceeding structural capacity of structures.

C. Inspect precast concrete structures immediately prior to placement in excavation to verify structures are internally clean and free from damage. Remove and replace damaged units.

3.03 INSTALLATION

A. Excavation and Backfill:

1. Excavate for manholes to location and depth shown in accordance with Section 31 00 00 – Earth Moving and as otherwise specified herein. Provide clearance around sidewalls of structure for construction operations.
2. When groundwater is encountered, prevent accumulation of water in excavations. Place manholes in dry trench.
3. Where possibility exists of watertight structure becoming buoyant in flooded excavation, anchor structure to avoid flotation.

B. Place base pad, trowel top surface level.

C. Install manholes supported at proper grade and alignment on crushed stone bedding as shown on Drawings.

D. Backfill and compact excavations for manholes in accordance with Section 31 00 00 – Earth Moving.

E. Form and place manhole cylinder plumb and level, to correct dimensions and elevations.

F. Cut and fit for sleeves.

G. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour to form continuous drainage channel, as indicated on Drawings.

H. Set cover frames and covers level without tipping, to correct elevations.

I. Coordinate with other sections of Work to provide correct size, shape, and location.

3.04 PRECAST CONCRETE INSTALLATION

A. Lift precast components at lifting points designated by manufacturer.

B. When lowering precast structures into excavations and joining pipe to units, take precautions to ensure interior of pipeline and structure remains clean.

C. Set precast structures bearing firmly and fully on crushed stone bedding, compacted in accordance with State of MHD specifications.

D. Assemble multi-section structures by lowering each section into excavation. Lower, set level, and firmly position base section before placing additional sections.

E. Remove foreign materials from joint surfaces and verify sealing materials are placed properly. Maintain alignment between sections by using guide devices affixed to lower section.

F. Joint sealing materials may be installed on site or at manufacturer's plant.

G. Verify installations satisfy required alignment and grade.

H. Cut structure to receive piping without creating openings larger than required to receive pipe. Fill annular space with mortar.

I. Cut pipe to finish flush with interior of structure.

J. Shape inverts through manhole as shown on Drawings.

3.05 FRAME AND COVER INSTALLATION

A. Set frames using mortar and masonry. Install radially laid sewer brick with 1/4-inch-thick vertical joints at inside perimeter. Lay sewer brick in full bed of mortar and completely fill joints. Where more than one course of sewer brick is required, stagger vertical joints. No more than three courses of sewer brick will be permitted.

B. Set frame and cover two inches above finished grade for manholes with covers located within unpaved areas to allow area to be graded away from cover beginning 1 inch below top surface of frame.

3.06 FIELD QUALITY CONTROL

A. Sections 01 40 00 - Quality Requirements, 01 60 00 - Product Requirements and 01 70 00 – Execution and Closeout Requirements.

B. Vertical Adjustment of Existing Manholes:

1. Where required, adjust top elevation of existing manholes to finished grades shown on Drawings.
2. Reset existing frames, grates and covers, carefully removed, cleaned of mortar fragments, to required elevation in accordance with requirements specified for installation of castings.
3. Remove concrete without damaging existing vertical reinforcing bars when removal of existing concrete wall is required. Clean vertical bars of concrete and bend into new concrete top slab or splice to required vertical reinforcement, as indicated Drawings.

3.07 LEAKAGE TESTS

A. Leakage tests will be made and observed by the Engineer on each manhole. The test will be as described below:

B. Vacuum Test (required on all new manholes):

1. The test will be made using an inflatable compression band, vacuum pump, and appurtenances specifically designed for testing manholes. Test procedures will be in accordance with the equipment manufacturer's recommendations. Contactor will be fully familiar with the vacuum testing equipment and provide a minimum of four hours of instruction by a factory authorized representative at the outset of the project.
2. Each manhole will be test immediately after assembly including the connection of pipes and prior to backfilling.
3. All lift holes will be plugged with non-shrink grout and all pipes entering the manhole will be plugged and braced to prevent the plug from being drawn into the manhole.
4. After test equipment is in place the test will be run at the following rate and test times:
    a. For four-foot diameter manholes:
        1) Initial test pressure – 10 inches Hg
        2) Test Time – one-inch Hg drop to 9 inches Hg in one minute allowable for 0 feet to 10 feet deep manholes.
    b. If the pressure drop exceeds one-inch Hg in the specified time the manhole will be repaired in accordance with accepted procedures and retested.
    c. If a manhole fails to meet a one-inch Hg drop in the specified time after repairs the unit will be water exfiltration tested as specified below and repaired.

C. Exfiltration Test (required as described above):
1. Assemble manhole in place; fill and point all lifting holes and exterior joints within 6 feet of the ground surface with an accepted non-shrinking mortar. Test prior to placing the shelf and invert before filling and pointing the horizontal joints below 6 feet of depth. Lower groundwater table below bottom of manhole for the duration of the test. Plug all pipes and other openings into the manhole and brace to prevent blowout.
2. Fill manhole with water to the top of the cone section. If the excavation has not been backfilled and no water in observed moving down the surface of the manhole, the manhole is satisfactorily watertight. If the test, as described above is unsatisfactory to the Engineer, or if the manhole excavation has been backfilled, continue the test. A period of time may be permitted to allow for absorption. Following this period, refill manhole to the top of the cone, if necessary, and allow at least eight hours to pass. At the end of the test period, refill the manhole to the top of the cone again, measuring the volume of water added. Extrapolate the refill amount to a 24-hour leakage rate. If the manhole fails this requirement, but the leakage does not exceed three gallons per vertical foot per day, repairs by accepted methods may be as directed by the Engineer. If leakage due to a defective joint exceeds this amount, the manhole will be rejected. Uncover the rejected manhole to disassemble, reconstruct, or

replace it as directed by the Engineer. Retest the manhole, and if satisfactory, fill and point the interior joints.

3. No adjustment in the leakage allowance may be made for unknown causes such as leaking plugs, absorptions, or other. It will be assumed that all loss of water during the test is a result of leaks through the joints or through the entrance.
4. An infiltration test may not be substituted for an exfiltration test if the groundwater table is above the highest joint in the manhole. If there is no leakage into the manhole as determined by the Engineer, the manhole will be considered watertight. If the Engineer is not satisfied, testing will be performed as described herein.

3.08 CLEANING

A. All new manholes will be thoroughly cleaned of all silt, debris, and foreign matter of any kind, prior to final inspection.

END OF SECTION

SECTION 33 10 00
WATER UTILITIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The Construction Manager, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section will also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

B. The Construction Manager will either perform the work of this section with its own forces or will subcontract such work to a subcontractor who will furnish a performance and payment bond for the complete scope of work and listing the Town of Wilmington as the co-oblige. Such bond will be procured from a surety that is currently licensed to do business in Massachusetts and is currently listed on the United States Treasure Department circular 570. A copy of such bond will be submitted to the Town of Wilmington's Project Manager for acceptance and will be in place prior to the subcontractor commencing any work on the project.

1.02 SUMMARY

A. Section Includes:
   1. Pipe and fittings for site water line including water mains and laterals.
   2. Valves.
   3. Hydrants.
   4. Backflow preventers.
   5. Underground pipe markers.
   6. Bedding and cover materials.

B. Related Sections:
   1. Section 31 20 00 - Earth Moving.
   2. Section 31 10 00 - Site Clearing.
   3. Section 32 12 16 - Asphalt Paving.

1.03 REFERENCES

A. American Association of State Highway and Transportation Officials:
   1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 10 lb. Rammer and an 18 in. Drop.

B. American Society of Mechanical Engineers:
   1. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
   2. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

C. American Society of Sanitary Engineering:
   1. ASSE 1012 - Backflow Preventer with Intermediate Atmospheric Vent.
   2. ASSE 1013 - Reduced Pressure Principle Backflow Preventers.

D. ASTM International:
   1. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
   2. ASTM C858 - Standard Specification for Underground Precast Concrete Utility Structures.
   3. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3).
   4. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/ft3).
   5. ASTM D1785 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.

6. ASTM D2241 - Standard Specification for Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series).
7. ASTM D2466 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40.
8. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings.
9. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
10. ASTM D3035 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
11. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

E. American Welding Society:
1. AWS A5.8 - Specification for Filler Metals for Brazing and Braze Welding.

F. American Water Works Association:
1. AWWA C104 - American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
2. AWWA C105 - American National Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.
3. AWWA C111 - American National Standard for Rubber-Gasket
4. Joints for Ductile-Iron Pressure Pipe and Fittings.
5. AWWA C151 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.
6. AWWA C500 - Metal-Seated Gate Valves for Water Supply Service.
7. AWWA C502 - Dry-Barrel Fire Hydrants.
8. AWWA C504 - Rubber-Sealed Butterfly Valves.
9. AWWA C508 - Swing-Check Valves for Waterworks Service, 2 in. (50 mm) Through 24in. (600 mm) NPS.
10. AWWA C509 - Resilient-Seated Gate Valves for Water-Supply Service.
11. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
12. AWWA C606 - Grooved and Shouldered Joints.
13. AWWA C700 - Cold-Water Meters - Displacement Type, Bronze Main Case.
14. AWWA C701 - Cold-Water Meters - Turbine Type, for Customer Service.
15. AWWA C702 - Cold-Water Meters - Compound Type.
16. AWWA C706 - Direct-Reading, Remote-Registration Systems for Cold-Water Meters.
17. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. through 12 in., for Water Distribution.
18. AWWA C901 - Polyethylene (PE) Pressure Pipe and Tubing, 1/2 in. through 3 in., for Water Service.
19. AWWA M6 - Water Meters - Selection, Installation, Testing, and Maintenance.

G. Underwriters Laboratories Inc.:
1. UL 246 - Hydrants for Fire - Protection Service.

1.04 SUBMITTALS

A. 01 30 00 – Administrative Requirements.

B. Product Data: Submit data on pipe materials, pipe fittings, valves, hydrants, and accessories.

C. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.05 CLOSEOUT SUBMITTALS

A. Section 01 70 00 – Execution and Closeout Requirements.

B. Project Record Documents: Record actual locations of piping mains, valves, connections, thrust restraints, and invert elevations.

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.06 QUALITY ASSURANCE

A. Perform Work in accordance with MHD and MA DEP standards, including the potable water supply construction permit issued for this project.

B. Maintain one copy of each document on site.

C. Valves: Manufacturer's name and pressure rating marked on valve body.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Deliver and store valves in shipping containers with labeling in place.

PART 2 - PRODUCTS

2.01 WATER PIPING

A. Pipe will be ductile iron push on joint pipe manufactured in accordance with the requirements of ANSI/AWWA C151/A21.51 and will be thickness Class 52 with a minimal wall thickness of 0.31 inch for six-inch pipe, 0.33 inch for eight-inch pipe, 0.35 inch for 10-inch pipe, and 0.37 inch for 12-inch pipe. Pipe thickness will be designated in accordance with ANSI/AWWA C150/A21.50 and will be based on laying connections and internal pressure as specified in the project plans. The rated working pressure will be a minimum of 350 psi. Push on joints for such pipe will be in accordance with ANSI A21.11/AWWA C111. Only in special circumstances will mechanical joints be allowed with the prior acceptance of the Engineer. Pipe will have cement mortar lining twice the normal thickness and tar coating in accordance with ANSI A21.4-90/AWWA C104. Pipe lengths will be standard 18 feet or 20 feet unless otherwise accepted. Bell joint end will have a rubber gasket to assure a permanent seal. The spigot end will have a slight bevel for easy passage through gasket.

B. Ductile iron water pipe will be installed in a flat bottom trench, backfilled lightly with a selected material removed in excavation with nothing larger than two inches in diameter. This material will be consolidated to centerline of pipe; after this is done the same materials will be used to provide a 12-inch cover over the top of the installed main.

C. Ductile iron water pipe will not be laid with a deflection of more than 12 inches.

2.02 HYDRANTS

A. Break flange type, (AWWA C502, latest revision), steamer connection four-inch, 2-2¼ inch side hose connections, national standard threads, positive drain, open left with pentagon operating nut, inlet 6 inches, seven-inch diameter barrel and mechanical joint hub. Hydrants will be restrained back to main, thrust block behind, 3/4-inch stone from bottom of hydrant boot to 8 inches over drain port, and 5-1/4-inch valve opening. All hydrants will be set with steamer facing the street or parking lots with a minimum of 15 inches from finish grade to bottom of steamer connection. All hydrants will be painted per Town of Wilmington Water Department requirements.

B. Hydrants will be designed for 250 psi working pressure and will conform in every respect to the specifications adopted by the AWWA. Hydrants will be given two coats of quality paint after installation.

C. Hydrants will be identical to present Town of Wilmington Fire and/or Water Department requirements.

D. Installation: No hydrant will be located within 20 feet of a driveway curb cut. The maximum allowed distance for hydrant back from face of berm is eight feet with a minimum distance of two feet. Bury depth will be 5’-6”.

E. There will be no plantings such as, but not limited to, shrubs or bushes, planted within 10 feet of any hydrant.

2.03 SERVICE BOXES

A. Plug cover to be in cement or asphalt, the word 'WATER' will be cast into the cover, the box will be of a length in height to accommodate any bury depth with 1-foot adjustment height. The overall height is to be 4-1/2 to 5-1/2 feet unless otherwise accepted by the engineer. The service box will be reinforced at arch and pipe ring area and will accommodate up to a one-inch curb stop. Service box rod will have a heavy ductile iron yoke with a brass copper pin. Service boxes will be identical to present Town of Wilmington Water Department requirements.

2.04 VALVE BOXES

A. Valve boxes will be cast iron, tar coated, two piece adjustable sliding type with a top flange and a minimum inside shaft diameter of 5-1/4 inches. Boxes will have the word 'WATER' clearly cast into the cover. Bell end of the lower sections will in all cases be sufficiently large enough to fit over the stuffing boxes of the valves. Valve boxes will be buried 5 feet or deeper to accommodate installation and have a minimum of 12-inch overlap so there is 1 foot adjustment. A positive centering cap made of high strength plastics should be placed over the valve onto which the valve box will be centered. Valve boxes will be identical to present Town of Wilmington Water Department requirements.

2.05 GATE VALVES

A. Manufacturers: will be A.F.C. Series 2500 Resilient Seat, Mueller Resilient Seat, Metro Seat #5460 and #5860. Gate boxes will be identical to present Town of Wilmington Water Department requirements.

B. 2-1/2 inch and Smaller: Brass or Bronze body, non-rising stem, inside screw, single wedge or disc, compression ends, with control rod, extension box and valve key. Open right. Epoxy coated.

C. Three inch and Larger: AWWA C500, Iron body, bronze trim, non-rising stem with square nut, single wedge, flanged ends, control rod, extension box and valve key. Open right. Epoxy coated.

2.06 BACKFLOW PREVENTERS

A. Manufacturers: Any manufacturer whose product meets the requirements of the specifications, and the requirements of the Town of Wilmington Water Department, will be considered.

B. Furnish materials in accordance with MHD and MA DEP standards.

C. Reduced Pressure Backflow Preventers:

1. Comply with ASSE 1013.
2. Bronze body, with bronze internal parts and stainless-steel springs.
3. Two independently operating, spring loaded check valves; diaphragm type differential pressure relief valve located between check valves; third check valve opening under back pressure in case of diaphragm failure; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks.

D. Double Check Valve Assemblies: Comply with ASSE 1012; Bronze body with corrosion resistant internal parts and stainless-steel springs; two independently operating check valves with intermediate atmospheric vent.

2.07 UNDERGROUND PIPE MARKERS

A. Trace Wire: Magnetic detectable conductor, brightly colored plastic covering, imprinted with "Water Service" in large letters.

2.08 BEDDING AND COVER MATERIALS

A. Bedding: 1-1/2-inch stone in accordance with Section M2.01.1 of the MHD Standards

B. Cover: 3/4-inch Crushed Stone in accordance with Section M2.01.4 of the MHD Standards

C. Soil Backfill from Above Pipe to Finish Grade: Ordinary Fill as specified in Section 31 00 00 – EARTH MOVING.

D. Bituminous Asphalt Patch: Refer to patching requirements under Section 32 12 16 - ASPHALT PAVING.

2.9 JOINT RESTRAINT PRODUCTS

A. Wedge Action Retaining Joints may be used wherever accepted by the Town of Wilmington and will be manufactured of ductile iron conforming to ASTM A536. The mechanical joint restraint will be Megalug Series 1100 or equal accepted by DPW.

B. Concrete for Thrust Blocks: 4,000 psi concrete in accordance with Section M4.02.00 of the MHD Standards.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify building service connection and municipal utility water main size, location, and invert are as indicated on Drawings.

3.02 PREPARATION

A. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare pipe connections to equipment with flanges or unions.

3.03 BEDDING

A. Excavate pipe trench in accordance with Section 31 00 00 – EARTH MOVING for Work of this Section.

B. Form and place concrete for pipe thrust restraints at change of pipe direction. Place concrete to permit full access to pipe and pipe accessories. Provide square footage of thrust restraint bearing on subsoil per detail.

C. Place bedding material at trench bottom, level fill materials in one continuous layer not exceeding 8-inch compacted depth; compact to 95 percent.

D. Backfill around sides and to top of pipe in accordance with Section 31 00 00 – EARTH MOVING.

E. Maintain optimum moisture content of fill material to attain required compaction density.

F. Place fill materials in accordance with Section 31 00 00 – EARTH MOVING and Section 32 12 16 - ASPHALT PAVING.

3.04 INSTALLATION - PIPE

A. Maintain 10-foot horizontal separation of water piping from sewer piping unless site constraints prohibit.

B. Install pipe to indicated elevation to within tolerance of 5/8 inch.

C. Route pipe in straight line.

D. Install pipe to allow for expansion and contraction without stressing pipe or joints.

E. Form and place concrete for thrust restraints at each elbow or change of direction of pipe main.

F. Establish elevations of buried piping with not less than 5.5 feet of cover. If cover is less than 5.5 feet, the pipe will be insulated with two inches of extruded polystyrene insulation. The pipe will maintain a minimum of four feet of cover.

G. Install trace wire continuous over top of pipe.

H. Backfill trench in accordance with Section 31 00 00.

I. Install Work in accordance with MHD and MA DEP standards.

3.05 UNDERGROUND PIPE MARKERS

A. Manufacturers:

1. Any manufacturers of such products will be considered.

2. Substitutions: Refer to Section 01 60 00 - PRODUCT REQUIREMENTS.

B. Plastic Ribbon Tape: Bright colored, imprinted with "WATER" in large letters, minimum six inches wide by four mil. thick, manufactured for direct burial service.

C. Trace Wire: Magnetic detectable conductor, brightly colored plastic covering, imprinted with "WATER SERVICE" in large letters.

3.06 INSTALLATION - VALVES

A. Set valves on compacted soil.

B. Center and plumb valve box over valve. Set box cover flush with finished grade.

C. Install Work in accordance with MHD and MA DEP standards.

3.07 SERVICE CONNECTIONS

A. Install water service in accordance with double check valve backflow preventer.

B. Install water service to the building. Connect to building water service.

C. Install Work in accordance with Mass State Plumbing Code.

3.08 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. CLOSEOUT SUBMITTALS

1. Section 01 70 00 – Execution and Closeout Requirements.
2. Disinfection Report:
    a. Type and form of disinfectant used.
    b. Date and time of disinfectant injection start and time of completion.
    c. Test locations.
    d. Name of person collecting samples.
    e. Initial and 24-hour disinfectant residuals in treated water in ppm for each outlet tested.
    f. Date and time of flushing start and completion. Disinfectant residual after flushing in ppm for each outlet tested.
3. Bacteriological Report:
    a. Date issued, project name, and testing laboratory name, address, and telephone number.
    b. Time and date of water sample collection.
    c. Name of person collecting samples.
    d. Test locations.
    e. Initial and 24-hour disinfectant residuals in ppm. for each outlet tested.
    f. Coliform bacteria test results for each outlet tested.
    g. Certify water conforms, or fails to conform, to bacterial standards of MA DEP standards for drinking water.
    h. Water Quality Certificate: Certify water conforms to quality standards of MA DEP, suitable for human consumption.
4. QUALITY ASSURANCE
    a. Perform Work in accordance with AWWA C651 (equivalent to State standards).
    b. Maintain one copy of each document on site.
5. QUALIFICATIONS
    a. Water Treatment Firm: Company specializing in disinfecting potable water systems specified in this section with minimum three years documented experience.
    b. Testing Firm: Company specializing in testing and examining potable water systems, accepted by Commonwealth of Massachusetts.
    c. Submit bacteriologist's signature and authority associated with testing.

6. DISINFECTION CHEMICALS
    a. Chemicals: Chlorine solution used for disinfecting springs, wells, and other water systems will consist of a solution of water and liquid chlorine, sodium hypochlorite, calcium hypochlorite, or chloride of lime.
    b. Liquid forms of chlorine or sodium hypochlorite and powder forms of calcium hypochlorite or chloride of lime will be used according to the instructions supplied by the manufacturer and as recommended by the Massachusetts Department of Health.
    c. If sodium hypochlorite is already in solution as a laundry bleach containing 5.25 percent sodium hypochlorite, it will be used at the rate of one part per 12,000 parts of water to be disinfected. The dosage should be sufficient to produce a chlorine taste in the water.
7. EXAMINATION
    a. Verify existing conditions before starting work.
    b. Verify piping system has been cleaned, inspected, and pressure tested.
    c. Perform scheduling and disinfecting activity with start-up, water pressure testing, adjusting, and balancing, demonstration procedures, including coordination with related systems.
8. INSTALLATION
    a. Provide and attach required equipment to perform the Work of this section.
    b. Perform disinfection of water distribution system and installation of system and pressure testing.
    c. Introduce treatment into piping system at a concentration of 50 mg Cl/L.
    d. Maintain disinfectant in system for 24 hours.
    e. Flush, circulate, and clean until required cleanliness is achieved; use municipal domestic water.
    f. Replace permanent system devices removed for disinfection.
9. Disinfection, Flushing, and Sampling:
    a. Disinfect pipeline installation in accordance with AWWA C651. Use of liquid chlorine is not permitted.
    b. Upon completion of retention period required for disinfection, flush pipeline until chlorine concentration in water leaving pipeline is no higher than that generally prevailing in existing system or is acceptable for domestic use.
    c. Legally dispose of chlorinated water. When chlorinated discharge may cause damage to environment, apply neutralizing chemical to chlorinated water to neutralize chlorine residual remaining in water.
    d. After final flushing and before pipeline is connected to existing system, or placed in service, employ an accepted independent testing laboratory to sample, test and certify water quality suitable for human consumption.

3.09 FIELD QUALITY CONTROL

A. Sections 01 40 00 - QUALITY REQUIREMENTS and 01 70 00 – Execution and Closeout Requirements.

B. Pressure test system. Repair leaks and re-test.
    1. After completion of pipeline installation, including backfill, but prior to final connection to existing system, conduct, in presence of Architect/Engineer, concurrent hydrostatic pressure and leakage tests in accordance with AWWA C600.
    2. Provide equipment required to perform leakage and hydrostatic pressure tests.
    3. Test Pressure: Not less than 200 psi or 50 psi in excess of maximum static pressure, whichever is greater.

4. Conduct hydrostatic test for at least two-hour duration. Submit FM Global certificate for underground leak pressure test to CM.
5. No pipeline installation will be accepted when pressure varies by more than five psi at completion of hydrostatic pressure test.
6. Before applying test pressure, completely expel air from section of piping under test. Provide corporation cocks so air can be expelled as pipeline is filled with water. After air has been expelled, close corporation cocks and apply test pressure. At conclusion of tests, remove corporation cocks removed and plug resulting piping openings.
7. Slowly bring piping to test pressure and allow system to stabilize prior to conducting leakage test. Do not open or close valves at differential pressures above rated pressure.
8. Examine exposed piping, fittings, valves, hydrants, and joints carefully during hydrostatic pressure test. Repair or replace damage or defective pipe, fittings, valves, hydrants, or joints discovered, following pressure test.
9. When leakage is detected, locate source, and make repairs. Repeat test until specified leakage requirements are met.

C. Compaction Testing for Bedding: In accordance with ASTM D1557.

D. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

E. Frequency of Compaction Tests: As directed by Engineer.

END OF SECTION

SECTION 33 31 00
SANITARY UTILITY SEWERAGE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The Construction Manager, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section will also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
   1. Install and test polyvinyl chloride (PVC) sewer pipe, complete as shown on the Drawings and as specified herein.
   2. Pipe or piping refers to all pipe, fittings, material, and appurtenances required to construct PVC gravity and pressure sewer pipe complete, in place.

B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
   1. Section 31 00 00 - Earth Moving: Soil for backfill in trenches.

1.03 REFERENCES

A. American Association of State Highway and Transportation Officials:
   1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 10 lb. Rammer and an 18 inch. Drop.

B. ASTM International:
   1. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Rigid Poly (Vinyl Chloride) (CPVC) Compounds
   2. ASTM D1785 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.
   3. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
   4. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   5. ASTM D2466 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40.
   6. ASTM D2564 - Standard Specification for Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems.
   7. ASTM D2729 - Standard Specification for Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
   8. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings.
   9. ASTM D6938- Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
   10. ASTM D3034 - Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
   11. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes using Flexible Elastomeric Seals

12. ASTM D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
13. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

1.04 DEFINITIONS

A. Bedding: Fill placed under, beside and directly over pipe, prior to subsequent backfill operations.

1.05 SUBMITTALS

A. Section 01 30 00 - Administrative Requirements.
B. Product Data: Submit data indicating pipe material used, pipe accessories, and fittings.
C. Manufacturer's Installation Instructions: Indicate special procedures required to install Products specified.
D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.06 CLOSEOUT SUBMITTALS

A. Section 01 70 00 – Execution and Closeout Requirements.
B. Project Record Documents: Record location of pipe runs, connections, manholes, cleanouts, and invert in and invert out elevations.
C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.07 QUALITY ASSURANCE

A. All PVC sewer pipe will be from a single manufacturer. The supplier will be responsible for the provision of all test requirements specified in ASTM D3034 as applicable. In addition, all PVC pipe to be installed under this Contract may be inspected at the plant for compliance with these Specifications by an independent testing laboratory provided by the Town of Wilmington. The Construction Manager will require the manufacturer’s cooperation in these inspections. The cost of plant inspection of all pipe accepted for this Construction Manager, plus the cost of inspection of a reasonable amount of disapproved pipe, will be borne by the Town of Wilmington.
B. Inspections of the pipe may also be made by the Engineer or other representatives of the Town of Wilmington after delivery. The pipe will be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though the sample pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery will be marked for identification and will be removed from the job at once.

1.08 DELIVERY, STORAGE, AND HANDLING

A. All items will be bundled or packaged in such a manner as to provide adequate protection of the ends during transportation to the site. Any pipe damaged in shipment will be replaced as directed by the Engineer.
B. PVC items deteriorate in sunlight and are slightly brittle, especially at lower temperatures, so care will be taken in loading, transporting, and unloading items to prevent damage to the items. All items will be examined before installation and no piece will be installed which is found to be defective. Handling and installation of pipe and fittings will be in accordance with the manufacturer’s instructions, references standards, and as specified herein.
C. Any pipe or fitting showing a crack, or which has received a blow that may have caused an incident fracture, even though no such fracture can be seen, will be marked as rejected and removed at once from the work site.
D. While stored, the pipe will be adequately supported from below at not more than three-foot intervals to prevent deformation. The pipe will not be stacked higher than 6 feet.
E. Pipe and fittings will be stored in a manner which will keep them at ambient outdoor temperatures and out of the sunlight. Temporary shading to meet this requirement will be provided. Simple covering of the pipe and fittings which allows temperature buildup, or direct or indirect sunlight will not be permitted.

F. If any defective item is discovered after it has been installed, it will be removed and replaced with an exact replacement item in a satisfactory manner by the Construction Manager, at the Construction Manager's own expense. All pipe and fittings will be thoroughly cleaned before installation and the interior will be kept clean until testing.

G. In handling the items, use special devices and methods as to achieve the results specified herein. No un-cushioned devices will be used in handling the item.

1.09 PRE-INSTALLATION MEETINGS

A. Convene a minimum of one week prior to commencing work on this section.

1.10 FIELD MEASUREMENT

A. Verify field measurements and elevations are as indicated.

1.11 COORDINATION

A. Coordinate the Work with abandonment of existing septic tanks and associated piping, and abandonment of existing leaching fields.

PART 2 - PRODUCTS

2.01 SANITARY SEWAGE GRAVITY PIPE

A. Plastic Pipe: ASTM D3034, Type PSM, SDR 35, Poly Vinyl Chloride (PVC) material; inside nominal diameter of 8-inch, bell, and spigot style rubber ring sealed gasket joint.
   1. Fittings: PVC.
   2. Push On Joints: ASTM F477, elastomeric gaskets per ASTM D3212, securely locked into place to prevent displacement during assembly.
   3. All fittings and accessories for sewer will have bell and/or spigot configurations compatible with the pipe.

2.02 UNDERGROUND PIPE MARKERS

A. Manufacturers:
   1. Any manufacturers of such products will be considered.
   2. Substitutions: Refer to Section 01 60 00 - Product Requirements.

B. Plastic Ribbon Tape: Bright colored, imprinted with "Sewer Line" in large letters, minimum 6 inches wide by 4 mil. thick, manufactured for direct burial service.

2.03 MANHOLES

A. In accordance with Section 33 05 13 - Manholes and Structures

2.04 BEDDING AND COVER MATERIALS

A. Bedding and Cover: 3/4-inch crushed stone in accordance with Section M2.01.4 of the MHD Standard Specifications.

B. Soil Backfill from Above Pipe: In pavement areas where controlled density fill is not specified, provide Ordinary Fill to the sub-base of the pavement, and then provide the required sub-base material for the pavement section. In grassed areas where controlled density fill is not specified, provide Special Borrow per MassDOT Spec. M1.02.0 to a point 6 inches below finished grade, then Manufactured Topsoil to finished grade.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on the Drawings.

3.02 PREPARATION

A. Correct over excavation with coarse aggregate.

B. Remove large stones or other hard matter which could damage pipe or impede consistent backfilling or compaction.

3.03 BEDDING

A. Excavate pipe trench in accordance with Section 31 00 00 – Earth Moving.

B. Place bedding material at trench bottom, level materials in continuous layer not exceeding six inches.

C. Maintain optimum moisture content of bedding material to attain required compaction density.

3.04 INSTALLATION OF PVC PIPE AND FITTINGS

A. No single piece of pipe will be laid unless it is straight. The centerline of the pipe will not deviate from a straight line drawn between the centers of the opening at the ends of the pip by more than 1/16 inch per foot of length. If a piece of pipe fails to meet this required check for straightness, it will be rejected and removed from the site. Laying instructions of the pipe will be explicitly followed.

B. If any defective pipe is discovered after it has been installed, it will be removed and replaced with a sound pipe in a satisfactory manner at no additional cost to the Town of Wilmington. All pipe and fittings will be thoroughly cleaned before installation, will be kept clean until they are used in the work, and when laid will conform to the lines and grades required. PVC pipe and fittings will be installed in accordance with requirements of the manufacturer, ASTM D2321 or as otherwise provided herein.

C. As soon as the excavation is complete to normal grade of the bottom of the trench, bedding will be placed, compacted, and graded to provide firm, uniform, and continuous support for the pipe. Bell holes will be excavated so that only the barrel of the pipe bears upon the bedding. The pipe will be lad accurately to the lines and grades indicated on the Drawings. Blocking under the pipe will not be permitted. Bedding will be placed evenly on each side of the pipe to mid-diameter and hand tools will be used to force the bedding under the haunches of the pipe and into the bell holes to give firm, continuous support for the pipe. The initial three feet of backfill above the bedding will be placed in one-foot layers and carefully compacted, where controlled density fill is not specified. Generally, the compaction will be done evenly on each side of the pipe and compaction equipment will not be operated directly over the pipe until sufficient backfill has been placed to ensure that such compaction equipment will not have a damaging effect on the pipe. Equipment used in compacting the initial three feet of backfill will be accepted by the pipe manufacturer prior to use.

D. All pipe will be sound and clean before installation. When installation is not in progress, including lunchtime, the open ends of the pipe will be closed by watertight plug or other accepted means. Good alignment will be preserved during installation. The deflection at joints will not exceed that recommended by the manufacturer. Fittings, in addition to those shown on the plans, will be provided, if required, in crossing utilities which may be encountered upon opening the trench.

E. When cutting pipe is required, the cutting will be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of the pipe to be used with a bell will be beveled to the manufactured spigot end.

F. The Engineer may examine each bell and spigot end to determine whether any preformed joint has been damaged prior to installation. Any pipe having defective joint surfaces will be rejected, marked as such and immediately removed from the job site.

G. Each length of the pipe will have the assembly mark aligned with the pipe previously laid and held securely until enough backfill has been placed to hold the pipe in place. Joints will not be ‘pulled’ or ‘cramped.’

H. Before any joint is made, the pipe will be checked to assure that a close joint with the next adjoining pipe has been maintained and that the inverts are matched and conform to the required grade. The pipe will not be driven down to grade by striking it.

I. Precautions will be taken to prevent flotation of the pipe in the trench.

J. When moveable trench bracing such as trench boxes, moveable sheeting, shoring or plates are used to support the sides of the trench, care will be taken in placing and moving the boxes or supporting bracing to prevent movement of the pipe bedding and the backfill. Trench boxes, moveable sheeting, shoring or plates will not be allowed to extend below the top of the pipe. If trench boxes, moveable sheeting, shoring or plates have been installed below the top of the pipe, they will be moved slowly taking care not to disturb pipe, bedding,

or backfill. As trench boxes, moveable sheeting, shoring, or plates are moved, pipe bedding will be placed to fill any voids created and the backfill will be re-compacted to provide uniform side support for the pipe.

3.05 JOINTING PVC PIPE (PUSH ON TYPE)

A. Joints will be made in strict accordance with the manufacturer's instructions. Pipe will be laid with bell ends looking ahead (upgradient of the spigot end). A rubber gasket will be inserted in the groove of the belled end and the joint surfaces cleaned and lubricated. The plain edge of the pipe to be entered will then be inserted in alignment with the bell of the pipe to which is it to be jointed and pushed home with a come-along or by other means. Check that the reference mark on the spigot is flush with the end of the bell.

3.06 JOINTING PVC SEWER PIPE AND FITTINGS

A. PVC sewer pipe and fittings will be jointed in accordance with the recommendations of the latest ASTM standards and detailed instructions of the manufacturer. The pipe manufacturer will furnish information and supervise the installation of at least the first five joints.

B. All manhole connections will be as shown on the Drawings except that concrete and mortared connections will be equipped with an integral o-ring or other sealant such that a positive watertight seal is established.

3.07 SERVICE CONNECTIONS

A. Service connections will be installed at a minimum slope of two percent at the locations and to the limits determined by the Engineer in the field. In each case the end will be capped, backed with a #2 reinforcing rod welded to a six-inch x six and a quarter-inch steel plate extending to six inches below the finished ground surface as shown on the Drawings.

B. Service connections will be 8-inch diameter PVC unless otherwise shown on the Drawings.

C. Service connections will be made at a point 10 feet outside the foundation of the building in accordance with the Uniform Plumbing Code. If the existing building surface is in structurally deficient condition or constructed of a material not accepted by the plumbing inspector, the Construction Manager will stop work immediately and contact the Engineer.

3.08 INSTALLATION - MANHOLES

A. In accordance with Section 33 05 13 – Manholes and Structures

3.09 FIELD QUALITY CONTROL

B. Refer to Sections 01 40 00 - Quality RequirementsPerform test on site sanitary sewage system in accordance with municipal standards.

C. Request inspection by Engineer prior to and immediately after placing bedding and piping. Provide minimum 24-hour notice. The Board of Health will inspect all work prior to issuing its acceptance. The Board of Health will be given a minimum of 24 hours advance notice when requesting an inspection. The Construction Manager will comply with all inspection requirements of the Town of Wilmington.

D. Compaction Testing: In accordance with ASTM D1557.

E. When tests indicate Work does not meet specified requirements, remove work, replace, and retest.

F. Frequency of Compaction Tests: As directed by Engineer.

3.10 PROTECTION OF FINISHED WORK

A. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

3.11 TESTING (GRAVITY PIPELINES)

A. Deflection testing of pipe will be specified as follows:

1. Pipe deflection measured not less than 90 days after the backfill has been completed as specified will not exceed 5 percent. Deflection will be computed by multiplying the amount of deflection (nominal diameter less minimum diameter when measured) by 100 and dividing by the nominal diameter of the pipe.
2. Deflection will be measured by a rigid mandrel (Go/No Go) device cylindrical in shape with a minimum of nine or ten evenly spaced arms or prongs. Drawings of the mandrel

with complete dimensions will be submitted to the Engineer for each diameter of pipe to be tested. The mandrel will be hand pulled through all sewer lines.

3. Any section of sewer not passing the mandrel will be uncovered at no additional cost to the Town of Wilmington and the bedding and backfill replaced to prevent excessive deflection. Repaired pipe will be retested at no additional cost to the Town of Wilmington. Retested pipe will not deflect more than 5 percent.

B. Low pressure air testing of pipe will be specified as follows:

1. For making the low-pressure air tests, use equipment specifically designed and manufactured for the purpose of testing sewer pipelines using low-pressure air. The equipment will be provided with an air regulator valve or air safety so set that the internal air pressure in the pipeline cannot exceed 8 psig.
2. The leakage test using low pressure air will be made on each manhole-to-manhole section of pipelines after placement of the backfill.
3. Pneumatic plugs will have a sealing length equal to or greater than the diameter of the pipe to be tested. Pneumatic plugs will resist internal test pressures without requiring external bracing or blocking.
4. All air used will pass through a single control panel.
5. Low-pressure air will be introduced into the sealed line until the internal air pressure reaches four psig greater than the minimum pressure exerted by the groundwater that may be above the invert at the pipe at the time of the test. However, the internal air pressure in the sealed line will not be allowed to exceed eight psig. When the maximum pressure exerted by the groundwater is greater than four psig, conduct only an infiltration test, as specified below.
6. Testing will be in accordance with the requirements of ASTM F1417-11AR19E01. The following italicized text contains selected text from ASTM F1417 (Gravity Sewer Lines).
   - The section of the line to be tested is plugged. Air, at low pressure, is introduced into the plugged line. The line passes the test if the rate of air loss, as measured by pressure drop, does not exceed a specified amount in a specified time.
   - Pressure drop may be determined by using Table 1 or calculated by use of the formulas below.

TABLE 1: Minimum Specified Time Required for a 0.5 psig Pressure Drop for Size and Length of Pipe Indicated for Q = 0.0015 (NOTE-Consult with pipe and appurtenance manufacturer for maximum test pressure for pipe size greater than 30 inch in diameter.)

Pipe Dia	Minimum Time, min:sec	Length for Min. Time, ft	Time for Longer Length, s	Specification Time for Length (L) Shown, min:s							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	1:53	597	0.190 L	1:53	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	0.427 L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3.12
8	3:47	298	0.760 L	3:47	3:47	3:47	3:47	3:48	4:26	5.04	5.42
10	4:43	239	1.187 L	4:43	4:43	4:43	4:57	5:56	6:55	7.54	8.54
12	5:40	199	1.709 L	5:40	5:40	5:42	7:08	8:33	9:58	11.24	12.50
15	7:05	159	2.671 L	7:05	7:05	8:54	11:08	13:21	15:35	17.48	20.02
18	8:30	133	3.846 L	8:30	9:37	12:49	16:01	19:14	22:26	25.38	28.51
21	9:55	114	5.235 L	9:55	13:05	17:27	21:49	28:11	30:32	34.54	39.16
24	11:20	99	6.837 L	11:24	17:57	22:48	28:30	34:11	39:53	45.35	51.17
27	12:45	88	8.653 L	14:25	21:38	28:51	36:04	43:18	50:30	57.42	64.54

30	14:10	80	10.683 L	17:48	26:43	35:37	44:31	53:25	62:19	71.13	80.07
33	15:35	72	12.926 L	21:33	32:19	43:56	53:52	64:38	75:24	86.10	96.57
36	17:00	66	15.384 L	25:39	38:28	51:17	64:06	76:55	89:44	102.34	115.23

- Calculate all test times by the following formula: T= 0.085 DK/Q, where: T = shortest time allowed for the air pressure to drop 1.0 psig, K = 0.000419 DL but not less than 1.0, Q = leak rate in cubic feet/minute/square feet of internal surface = 0.0015 CFM/SF, D = measured average inside diameter of sewer pipe (see Method D 2122 and Practice D 3567), inch., and L = length of test section, feet.
- Table 1 contains the specified minimum times required for a 1.00 psig pressure drop from a starting pressure of 3.5 psig to a final pressure of 2.5 psig using a leakage rate of 0.0015 ft3/min/ft2 of internal surface.

C. Infiltration testing of pipe will only be carried out when the depth of groundwater is so great that low pressure air testing cannot be adequately performed; otherwise low-pressure air testing will be performed as specified above. The procedure for infiltration testing of pipe is as follows:
   1. For making the infiltration tests, underdrains, if used, will be plugged and other groundwater drainage will be stopped to permit groundwater to return to its normal level insofar as practicable.
   2. Upon completion of a section of the sewer, dewater it and conduct a satisfactory test to measure the infiltration for at least 24 hours. The amount of infiltration, including manholes, tees, and connections, will not exceed 200 gallons per inch diameter per mile of sewer per 24 hours.

END OF SECTION

SECTION 33 41 00
STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The Construction Manager, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section will also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

B. The Construction Manager will either perform the work of this section with its own forces or will subcontract such work to a subcontractor who will furnish a performance and payment bond for the complete scope of work and listing the Town of Wilmington as the co-oblige. Such bond will be procured from a surety that is currently licensed to do business in Massachusetts and is currently listed on the United States Treasure Department circular 570. A copy of such bond will be submitted to the Town of Wilmington's Project Manager for acceptance and will be in place prior to the subcontractor commencing any work on the project.

1.02 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and incidentals required to install high density polyethylene pipe, fittings and appurtenances as indicated and as specified herein.

1.03 RELATED WORK

A. Section 31 00 00 - Earth Moving

B. Section 33 05 13 - Manholes and Structures

C. Provision of waste management: Section 01 74 19, Construction of Waste Management Plan.

1.04 SUBMITTALS

A. Submit the name of the pipe and fitting suppliers and Shop Drawings, showing layout details of reinforcement, joint, method of manufacture, and installation of pipe, specials, and fittings for the entire job.

B. Prior to each shipment of pipe submit certified test reports and a notarized affidavit stating that all pipe meets requirements of ASTM D1238 & ASTM D1505.

1.05 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
2. ASTM D1248 - Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.
3. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
4. ASTM D2657 - Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings.
5. ASTM D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.
6. ASTM D3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Materials
7. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe and (SDR-PR) Based on Outside Diameter.
8. ASTM C507 - Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe

B. Where reference is made to one of the above standards, the revision in effect at the time of the bid opening will apply.

PART 2 - PRODUCTS

2.01 HIGH DENSITY POLYETHYLENE (HDPE) PIPE

A. High Density Polyethylene (HDPE) Pipe resins will be high molecular weight, high density

polyethylene with a cell classification number of 424420C in accordance with ASTM D3350.

B. HDPE will have a smooth interior and annular exterior corrugations, 12 inch through 60-inch piping will meet ASTM F2648 and will be either AASHTO Type 'S' or Type 'D'.

C. Pipe will be joined using a bell & spigot joint meeting ASTM F2648. The joint will be soil-tight and gaskets, when applicable, will meet the requirements of ASTM F477. Gaskets will be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. A joint lubricant supplied by the manufacturer will be used on the gasket and bell during assembly.

D. Pipe will support an HS-20 live load with a maximum deflection of five percent of the minimum pipe diameter.

E. Pipe will be furnished in standard laying lengths not exceeding 25 feet.

F. All single pipe high density polyethylene pipe and fittings will be made from the same resin.

G. Pipe will comply with the requirements for test methods, dimensions and markings found in AASHTO Designations M252 and M294.

2.02 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete sewer pipe and fittings will be ASTM C76 or ASTM C655, and ASTM C507 for vertical reinforced-concrete elliptical pipe.

1. Bell-and-spigot ends and rubber gasketed joints with ASTM C443.
2. Class III pipe will be used for typical installations.
3. Class V pipe will be used where cover is two ft. or less, where indicated on the plans, for vertical reinforced-concrete elliptical pipe, and where recommended by the manufacturers.

2.03 POLYVINYL CHLORIDE (PVC):

A. Pipe and Fittings, Type PSM PVC Pipe, will conform to ASTM D3034, Type PSM, SDR 35. Pipe and fittings will have elastomeric gasket joints providing a watertight seal when tested in accordance with ASTM D 3212. Gaskets will conform to ASTM F 477. Solvent welded joints will not be permitted.

2.04 UNDERGROUND PIPE MARKERS

A. Manufacturers:

1. Any manufacturers of such products will be considered.
2. Substitutions: Refer to Section 01 60 00 - Product Requirements.

B. Plastic Ribbon Tape: Bright colored, imprinted with "Storm Drain Line" in large letters, minimum 6 inches wide by four mil. thick, manufactured for direct burial service.

2.05 PIPE IDENTIFICATION

A. The following will be continuously indent printed on the pipe and spaced at intervals not exceeding five feet.

1. Name and/or trademark of the pipe manufacturer.
2. Nominal pipe size.
3. Dimension ratio.
4. The letters PE followed by the polyethylene grade in accordance with ASTM D1248, followed by the hydrostatic design basis in 100's of psi., e.g., PE 3408.
5. Manufacturing standard reference, e.g., ASTM F714.
6. A production code from which the date and place of manufacture can be determined.

PART 3 - EXECUTION

3.01 INSTALLATION - PIPE

A. High Density Polyethylene (HDPE) Pipe will be installed in accordance with the instruction of the manufacturer, as indicated and as specified herein.

B. Polyvinyl Chloride (PVC) Pipe will be installed in accordance with the instruction of the manufacturer, as indicated and as specified herein.

C. Pipe will be laid to lines and grade as indicated with bedding and backfill as indicated.

D. When laying is not in progress, the open ends of the pipe will be closed by fabricated plugs, or by other accepted means. All plugs will be OD fitting type plugs. No plugs will be allowed that require insertion of the plug into the pipe.

E. Pipe will be stored on clean level ground to prevent scratching or gouging. The handling of the pipe will be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. The maximum allowable depth of cuts, scratches, or gouges on the exterior of the pipe is 10 percent of the wall thickness. The interior pipe surface will be free of cuts, gouges, or scratches.

F. Sections of pipe with cuts, scratches, or gouges deeper than allowed will be removed completely and replaced and the ends of the pipeline rejoined at no additional cost to the Town of Wilmington.

G. Single pipe systems will be jointed by the method of thermal butt fusion, as outlined in ASTM D2657. All joints will be made in strict compliance with the manufacturer's recommendations.

H. All HDPE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction.

3.02 TESTING

A. HDPE storm drain pipe installations will be mandrel tested to ensure that the pipe has maintained a circular shape in cross section throughout installation. The pipe will remain within 5 percent of a true circular shape. Pipe deflection beyond five percent will be repaired by reinstallation.

3.03 CLEAN UP

A. Prior to Final Completion of the Work, thoroughly clean all the new pipelines and remove all dirt, stones, and pieces of wood or other materials.

END OF SECTION

SECTION 33 49 23
STORM DRAINAGE RETENTION STRUCTURES

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

A. Attention is directed to the Contract and General Conditions and all Sections within Division 01 - General Requirements which are hereby made a part of this Section of the Specifications.

B. The Construction Manager will either perform the work of this section with its own forces or will subcontract such work to a subcontractor who will furnish a performance and payment bond for the complete scope of work and listing the Town of Wilmington as the co-oblige. Such bond will be procured from a surety that is currently licensed to do business in Massachusetts and is currently listed on the United States Treasure Department circular 570. A copy of such bond will be submitted to the Town of Wilmington's Project Manager for acceptance and will be in place prior to the subcontractor commencing any work on the project.

1.02 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and incidentals required to install high density polyethylene groundwater recharge chambers, fittings, manifolds, and appurtenances as indicated and as specified herein.

1.03 RELATED WORK

A. Section 31 00 00, Earth Moving

B. Section 33 05 13, Manholes and Structures

C. Section 33 41 00, Storm Utility Drainage Piping.

1.04 SUBMITTALS

A. Submit the name of the recharge unit and fitting suppliers and Shop Drawings, showing layout details of reinforcement, joint, method of manufacture, and installation of recharge units, specials, and fittings for the entire job.

B. Prior to each shipment of recharge units, submit certified test reports and a notarized affidavit stating that all recharge units meet the requirements of ASTM D1238 and ASTM D1505.

1.05 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM)

1. ASTM D1238 – Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
2. ASTM D1248 - Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.
3. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
4. ASTM D2657 - Standard Practice for Heat Fusion Joining Polyolefin Recharge units and Fittings.
5. ASTM D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Recharge units Materials.
6. ASTM D3350 - Standard Specification for Polyethylene Plastic Recharge units and Fittings Materials
7. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Recharge units and (SDR-PR) Based on Outside Diameter.

B. Where reference is made to one of the above standards, the revision in effect at the time of the bid opening will apply.

PART 2 - PRODUCTS

2.01 DENSITY POLYETHYLENE RECHARGE UNITS

A. High Density Polyethylene (HDPE) recharge unit resins will be high molecular weight, high density polyethylene with a cell classification number of 345434C in accordance with ASTM D3350.

B. All polyethylene recharge units will meet the requirements of ASTM F714.

C. The recharge units will be jointed with, butt head fusion joints. All joints will be made in strict compliance with the manufacturer's recommendations.

D. Recharge units will be furnished in standard laying lengths not exceeding 25 feet.

E. All high-density polyethylene recharge units and fittings will be made from the same resin.

2.02 RECHARGE UNITS IDENTIFICATION

A. The following will be continuously indent printed on the recharge units.

1. Name and/or trademark of the recharge unit manufacturer.
2. Nominal size.
3. Dimension ratio.
4. The letters PE followed by the polyethylene grade in accordance with ASTM D1248, followed by the hydrostatic design basis in 100's of psi, e.g., PE 3408.
5. Manufacturing standard reference, e.g., ASTM F714.
6. A production code from which the date and place of manufacture can be determined.

2.03 CHAMBER PARAMETERS

A. The chamber will be vacuum thermoformed of high molecular weight high density polyethylene (HMWHDPE).

B. The chamber will be arched in shape.

C. The chamber will be open-bottomed.

D. The chamber will be joined using an interlocking overlapping rib method. Connections must be fully shouldered overlapping ribs, having no separate couplings or separate end walls.

E. The nominal chamber dimensions of the recharge units will be capable of storing the required volume for recharge in the area at the depths noted on the plans.

F. The chambers will be fitted with either an external or an internal manifold to evenly distribute the stormwater. If internal manifolds are used the chambers will have two side portals to accept feed connectors for the internal manifold.

G. The nominal dimensions of each internal manifold side portal will be manufacturer's specifications.

H. The nominal chamber dimensions of an external manifold will be per manufacturer's recommendations.

I. The chambers will have discharge holes bored into the sidewalls of the unit's core to promote lateral conveyance of water.

J. The endwall of the chamber, when present, will be an integral part of the continuously formed unit.

K. The starter unit must be formed as a whole chamber having one fully formed integral endwall and one partially formed integral endwall.

L. The intermediate unit must be formed as a whole chamber having one fully open endwall and one partially formed integral endwall.

M. The end unit must be formed as a whole chamber having one fully formed integral endwall and one fully open end wall and having no separate end plates or end walls.

N. Internal manifold feed connectors must be formed as a whole chamber having two open end walls and having no separate end plates or separate end walls. The unit will fit into the side portals of the chamber and act as cross feed connections.

O. Chambers must have horizontal stiffening flex reduction steps between the ribs.

P. The chamber will be designed to withstand AASHTO H-25 load rating when installed according to manufacturer's recommended installation instructions.

Q. Heavy duty units are designated by a colored stripe formed into the part along the length of the chamber.

R. The chamber will have a raised integral cap at the top of the arch in the center of each unit to be used as an optional inspection port or clean out.

S. The units may be trimmed to custom lengths by cutting back to any corrugation on the large rib end.

PART 3 - EXECUTION

3.01 GENERAL

A. High Density Polyethylene (HDPE) recharge units hall be installed in accordance with the instruction of the manufacturer, as indicated and as specified herein.

B. Recharge units will be laid to lines and grade as indicated with bedding and backfill as indicated.

C. When laying is not in progress, the open ends of the recharge units will be closed by fabricated plugs, or by other accepted means. All plugs will be OD fitting type plugs. No plugs will be allowed that require insertion of the plug into the recharge units.

D. Recharge units will be stored on clean level ground to prevent scratching or gouging. The handling of the recharge units will be in such a manner that the recharge units are not damaged by dragging it over sharp and cutting objects. The maximum allowable depth of cuts, scratches, or gouges on the exterior of the recharge units is 10 percent of the wall thickness. The interior of the recharge unit surfaces will be free of cuts, gouges, or scratches.

E. Sections of recharge units with cuts, scratches, or gouges deeper than allowed will be removed completely and replaced and the ends of the recharge units rejoined at no additional cost.

F. Single recharge units systems will be jointed by the method of thermal butt fusion, as outlined in ASTM D2657. All joints will be made in strict compliance with the manufacturer's recommendations.

G. All HDPE recharge units must be at the temperature of the surrounding soil at the time of backfilling and compaction.

3.02 INSTALLATION

A. Installing Construction Managers are expected to comprehend and use the most current installation instructions prior to beginning a system installation.

B. Contact manufacturer at least thirty days prior to system installation to arrange for a pre-construction meeting.

C. All system designs shall be certified by a registered professional engineer licensed in the Commonwealth of Massachusetts.

D. Use these installation instructions as a guideline only. Actual design may vary. Refer to accepted construction drawings for job-specific details. Be sure to follow the engineer's drawings as your primary guide.

E. System cover/backfill requirements will vary based on chamber model. Please refer to Engineer's drawings.

F. Any discrepancies with the system sub-grade soil's bearing capacity must be reported to the Engineer.

G. Filter fabric must be used as specified in the Contract drawings.

H. Manufacturer requires the Construction Managers to refer to the manufacturer's installation instructions, concerning vehicular traffic. Responsibility for preventing vehicles that exceed the manufacturer's requirements from traveling across or parking over the chamber system lies solely with the Construction Managers throughout the entire site construction process.

I. The placement of warning tape, temporary fencing, and/or appropriately located signs is

required. Acceptable vehicle loading criteria is HS-20 loading.

J. Underground Pipe Markers
   1. Any manufacturers of such products will be considered.
   2. Substitutions: Refer to Section 01 60 00 - Product Requirements.
   3. Plastic Ribbon Tape: Bright colored, imprinted with "STORM" in large letters, minimum six inches wide by four mil. thick, manufactured for direct burial service.
   4. Trace Wire: Magnetic detectable conductor, brightly colored plastic covering, imprinted with "STORM" in large letters.

K. Erosion and sediment-control measures must meet state and local codes and the design engineer's specifications throughout the entire site construction process.

L. Underground recharge systems must be designed and installed in accordance with the manufacturer's minimum requirements.

3.03 CLEANING

A. Prior to Final Completion of the Work, thoroughly clean all the new recharge units and remove all dirt, stones, and pieces of wood or other materials.

END SECTION