SECTION 09 51 13 - ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Acoustical panels.
2. Metal suspension system.
3. Metal edge moldings and trim.

B. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Acoustical panels.
2. Metal suspension system.
3. Metal edge moldings and trim.

B. Samples: For each exposed product and for each color and texture specified, 6 inches (150 mm) in size.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension-system members.
2. Structural members to which suspension systems will be attached.
3. Method of attaching hangers to building structure.

    a. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment devices whose installation is specified in other Sections.

4. Carrying channels or other supplemental support for hanger-wire attachment where conditions do not permit installation of hanger wires at required spacing.
5. Size and location of initial access modules for acoustical panels.
6. Items penetrating finished ceiling and ceiling-mounted items including the following:

    a. Lighting fixtures.
    b. Diffusers.
    c. Grilles.
    d. Speakers.
    e. Sprinklers.
    f. Access panels.

g. Perimeter moldings.

7. Show operation of hinged and sliding components covered by or adjacent to acoustical panels.
8. Minimum Drawing Scale: 1/8 inch = 1 foot (1:96).

B. Qualification Data: For testing agency.

C. Product Test Reports: For each acoustical panel ceiling, for tests performed by a qualified testing agency.

D. Evaluation Reports: For each acoustical panel ceiling suspension system and anchor and fastener type, from ICC-ES.

E. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Acoustical Ceiling Units: Full-size panels equal to 2 percent of quantity installed.
2. Suspension-System Components: Quantity of each exposed component equal to 2 percent of quantity installed.
3. Hold-Down Clips: Equal to 2 percent of quantity installed.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical panels, suspension-system components, and accessories to Project site and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

1. Pressurized Plenums: Operate ventilation system for not less than 48 hours before beginning acoustical panel ceiling installation.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Source Limitations for Ceiling System: Obtain each type of acoustical ceiling panel and its supporting suspension system from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: Class A in accordance with ASTM E1264.
2. Smoke-Developed Index: 50 or less.

B. Fire-Resistance Ratings: Comply with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from UL or from the listings of another qualified testing agency.

2.3 ACOUSTICAL PANELS

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

1. USG Corporation: #22122 Radar Firecode.
2. Armstrong Ceiling & Wall Solutions: #1824 Fine Fissured.

B. Acoustical Panel Standard: Provide manufacturer's standard panels in accordance with ASTM E1264 and designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.

C. Classification: Provide panels as follows:

1. Type and Form, Type III: Mineral base with painted finish; Form 2, water felted.

D. Color: White.

E. Light Reflectance (LR): 82%.

F. Ceiling Attenuation Class (CAC): 35.

G. Noise Reduction Coefficient (NRC): .70.

H. Edge/Joint Detail: Angled Tegular 15/16.”.

I. Thickness:

1. 3/4 inch (19 mm).

J. Modular Size: 24 by 48 inches (610 by 1220 mm).

K. Antimicrobial Treatment: Manufacturer's standard broad spectrum, antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested in accordance with ASTM D3273, ASTM D3274, or ASTM G21 and evaluated in accordance with ASTM D3274 or ASTM G21.

2.4 METAL SUSPENSION SYSTEM

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

1. Armstrong Ceiling & Wall Solutions.
2. USG Corporation.

Metal Suspension-System Standard: Provide manufacturer's standard, direct-hung, metal suspension system and accessories in accordance with ASTM C635/C635M and designated by type, structural classification, and finish indicated.

1. High-Humidity Finish: Where indicated, provide coating tested and classified for "severe environment performance" in accordance with ASTM C635/C635M.

C. Wide-Face, Single-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet electrolytically zinc coated, with prefinished flanges of width indicated.

1. Structural Classification: Heavy-duty system.
2. Face Finish: Painted white.

2.5 ACCESSORIES

A. Attachment Devices: Size for five times the design load indicated in ASTM C635/C635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.

1. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing in accordance with ASTM E488/E488M or ASTM E1512 as applicable, conducted by a qualified testing and inspecting agency.

    a. Type: Postinstalled expansion anchors.
    b. Corrosion Protection, Carbon Steel: Components zinc plated in accordance with ASTM B633, Class SC 1 (mild) service condition.
    c. Corrosion Protection, Stainless Steel: Components complying with ASTM F593 and ASTM F594, Group 1 Alloy 304 or 316.
    d. Corrosion Protection, Nickel-Copper Alloy: Components fabricated from nickel-copper-alloy rods complying with ASTM B164 for UNS No. N04400 alloy.

2. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing in accordance with ASTM E1190, conducted by a qualified testing and inspecting agency.

B. Wire Hangers, Braces, and Ties: Provide wires as follows:

1. Zinc-Coated, Carbon-Steel Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper.
2. Stainless Steel Wire: ASTM A580/A580M, Type 304, nonmagnetic.
3. Nickel-Copper-Alloy Wire: ASTM B164, nickel-copper-alloy UNS No. N04400.
4. Size: Wire diameter sufficient for its stress at three times hanger design load (ASTM C635/C635M, Table 1, "Direct Hung") will be less than yield stress of wire, but not less than 0.106-inch- (2.69-mm-) diameter wire.

C. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.

D. Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.

E. Angle Hangers: Angles with legs not less than 7/8 inch (22 mm) wide; formed with 0.04-inch- (1-mm-) thick, galvanized-steel sheet complying with ASTM A653/A653M, G90 (Z275) coating designation; with bolted connections and 5/16-inch- (8-mm-) diameter bolts.

F. Hold-Down Clips: Manufacturer's standard hold-down.

2.6 METAL EDGE MOLDINGS AND TRIM

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

1. Armstrong Ceiling & Wall Solutions.
2. USG Corporation.

Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension-system runners.

1. Edge moldings to fit acoustical panel edge details and suspension systems indicated and match width and configuration of exposed runners unless otherwise indicated.
2. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.

C. Extruded-Aluminum Edge Moldings and Trim: Where indicated, provide manufacturer's extruded-aluminum edge moldings and trim of profile indicated or referenced by manufacturer's designations, including splice plates, corner pieces, and attachment and other clips, complying with seismic design requirements.

1. Clear Anodic Finish: AAMA 611, AA-M12C22A31, Class II, 0.010 mm or thicker.
2. Baked-Enamel or Powder-Coat Finish: Minimum dry film thickness of 1.5 mils (0.04 mm). Comply with ASTM C635/C635M and coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.

B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders unless otherwise indicated, and comply with layout shown on reflected ceiling plans.

B. Layout openings for penetrations centered on the penetrating items.

3.3 INSTALLATION OF ACOUSTICAL PANEL CEILINGS

A. Install acoustical panel ceilings in accordance with ASTM C636/C636M and manufacturer's written instructions.

1. Fire-Rated Assembly: Install fire-rated ceiling systems in accordance with tested fire-rated design.

B. Suspend ceiling hangers from building's structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
4. Secure wire hangers to ceiling-suspension members and to supports above with a minimum of three tight turns. Connect hangers directly to structure or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both the structure to which hangers are attached and the type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
8. Do not attach hangers to steel deck tabs.
9. Do not attach hangers to steel roof deck. Attach hangers to structural members.
10. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards.

C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.

D. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.

1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
2. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends. Miter corners accurately and connect securely.
3. Do not use exposed fasteners, including pop rivets, on moldings and trim.

E. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

F. Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide precise fit.

1. Arrange directionally patterned acoustical panels as follows:

a. As indicated on reflected ceiling plans.

2. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension-system runners and moldings.
3. For reveal-edged panels on suspension-system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
4. For reveal-edged panels on suspension-system members with box-shaped flanges, install panels with reveal surfaces in firm contact with suspension-system surfaces and panel faces flush with bottom face of runners.
5. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.
6. Install hold-down clips in areas indicated; space in accordance with panel manufacturer's written instructions unless otherwise indicated.

   a. Hold-Down Clips: Space 24 inches (610 mm) o.c. on all cross runners.
7. Protect lighting fixtures and air ducts in accordance with requirements indicated for fire-resistance-rated assembly.

3.4 ERECTION TOLERANCES

A. Suspended Ceilings: Install main and cross runners level to a tolerance of 1/8 inch in 12 feet (3 mm in 3.6 m), non-cumulative.

B. Moldings and Trim: Install moldings and trim to substrate and level with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3 mm in 3.6 m), non-cumulative.

3.5 CLEANING

A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage.

B. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION 09 51 13

SECTION 09 65 13 - RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Thermoplastic-rubber base.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color and texture specified, not less than 12 inches (300 mm) long.

C. Product Schedule: For resilient base and accessory products. Use same designations indicated on Drawings.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Furnish not less than 10 linear feet (3 linear m) for every 500 linear feet (150 linear m) or fraction thereof, of each type, color, pattern, and size of resilient product installed.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store resilient products and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F (10 deg C) or more than 90 deg F (32 deg C).

1.6 FIELD CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F (21 deg C) or more than 95 deg F (35 deg C), in spaces to receive resilient products during the following periods:

   1. 48 hours before installation.
   2. During installation.
   3. 48 hours after installation.

B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F (13 deg C) or more than 95 deg F (35 deg C).

C. Install resilient products after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 THERMOPLASTIC-RUBBER BASE

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

1. Armstrong Flooring, Inc.
2. Armstrong World Industries, Inc.
3. Johnsonite; a Tarkett company.
4. Nora by Interface.
5. Roppe Corporation; Roppe Holding Company.

B. Product Standard: ASTM F1861, Type TP (rubber, thermoplastic).

1. Group: I (solid, homogeneous).
2. Style and Location:
   a. Style B, Cove: Provide in areas with resilient floor coverings.

C. Thickness: 0.125 inch (3.2 mm).

D. Height: 4 inches (102 mm).

E. Lengths: Coils in manufacturer's standard length.

F. Outside Corners: Job formed.

G. Inside Corners: Job formed.

H. Colors: Match Existing.

2.2 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland-cement-based or blended hydraulic-cement-based formulation provided or approved by resilient-product manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by resilient-product manufacturer for resilient products and substrate conditions indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient products.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Installation of resilient products indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.

B. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

C. Do not install resilient products until materials are the same temperature as space where they are to be installed.

1. At least 48 hours in advance of installation, move resilient products and installation materials into spaces where they will be installed.

D. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient products.

3.3 RESILIENT BASE INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient base.

B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.

C. Install resilient base in lengths as long as practical without gaps at seams and with tops of adjacent pieces aligned.

D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.

E. Do not stretch resilient base during installation.

F. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient base with manufacturer's recommended adhesive filler material.

G. Job-Formed Corners:

1. Outside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 3 inches (76 mm) in length.

a. Form without producing discoloration (whitening) at bends.

2. Inside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 3 inches (76 mm) in length.

a. Miter corners to minimize open joints.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting resilient products.

B. Perform the following operations immediately after completing resilient-product installation:

1. Remove adhesive and other blemishes from surfaces.

2. Sweep and vacuum horizontal surfaces thoroughly.
3. Damp-mop horizontal surfaces to remove marks and soil.

C. Protect resilient products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover resilient products subject to wear and foot traffic until Substantial Completion.

END OF SECTION 09 65 13

SECTION 09 65 19 - RESILIENT TILE FLOORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Vinyl composition floor tile.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of resilient floor tile.

   1. Include floor tile layouts, edges, columns, doorways, enclosing partitions, built-in furniture, cabinets, and cutouts.
   2. Show details of special patterns.

C. Samples: Full-size units of each color, texture, and pattern of floor tile required.

D. Product Schedule: For floor tile. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of floor tile to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Floor Tile: Furnish one box for every 50 boxes or fraction thereof, of each type, color, and pattern of floor tile installed.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are competent in techniques required by manufacturer for floor tile installation and seaming method indicated.

1. Engage an installer who employs workers for this Project who are trained or certified by floor tile manufacturer for installation techniques required.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store floor tile and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F (10 deg C) or more than 90 deg F (32 deg C). Store floor tiles on flat surfaces.

1.9 FIELD CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F (21 deg C) or more than 95 deg F (35 deg C), in spaces to receive floor tile during the following periods:

1. 48 hours before installation.
2. During installation.
3. 48 hours after installation.

B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F (13 deg C) Insert temperature or more than 95 deg F (35 deg C) Insert temperature.

C. Close spaces to traffic during floor tile installation.

D. Close spaces to traffic for 48 hours after floor tile installation.

E. Install floor tile after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For resilient floor tile, as determined by testing identical products according to ASTM E648 or NFPA 253 by a qualified testing agency.

1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

2.2 VINYL COMPOSITION FLOOR TILE

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

1. American Biltrite.
2. Armstrong Flooring, Inc.
3. Armstrong World Industries, Inc.
4. Congoleum Flooring.
5. Johnsonite; a Tarkett company.

B. Tile Standard: ASTM F1066, Class 3, surface pattern.

C. Wearing Surface: Smooth.

D. Thickness: 0.125 inch (3.2 mm).

E. Size: 12 by 12 inches (305 by 305 mm).

F. Colors and Patterns: Match existing color and pattern(s).

2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland-cement-based or blended hydraulic-cement-based formulation provided or approved by floor tile manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by floor tile and adhesive manufacturers to suit floor tile and substrate conditions indicated.

C. Floor Polish: Provide protective, liquid floor-polish products recommended by floor tile manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of floor tile.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to floor tile manufacturer's written instructions to ensure adhesion of resilient products.

B. Concrete Substrates: Prepare according to ASTM F710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by floor tile manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by floor tile manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 10 pH.
4. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.

    a. Anhydrous Calcium Chloride Test: ASTM F1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/92.9 sq. m) in 24 hours.
    b. Relative Humidity Test: Using in-situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.

C. Access Flooring Panels: Remove protective film of oil or other coating using method recommended by access flooring manufacturer.

D. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

E. Do not install floor tiles until materials are the same temperature as space where they are to be installed.

1. At least 48 hours in advance of installation, move resilient floor tile and installation materials into spaces where they will be installed.

F. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient floor tile.

3.3 FLOOR TILE INSTALLATION

A. Comply with manufacturer's written instructions for installing floor tile.

B. Match floor tiles for color and pattern by selecting tiles from cartons in the same sequence as manufactured and packaged, if so numbered. Discard broken, cracked, chipped, or deformed tiles.

1. Lay tiles to match existing.

C. Scribe, cut, and fit floor tiles to butt neatly and tightly to vertical surfaces and permanent fixtures including built-in furniture, cabinets, pipes, outlets, and door frames.

D. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on floor tiles as marked on substrates. Use chalk or other nonpermanent marking device.

E. Install floor tiles on covers for telephone and electrical ducts, building expansion-joint covers, and similar items in installation areas. Maintain overall continuity of color and pattern between pieces of tile installed on covers and adjoining tiles. Tightly adhere tile edges to substrates that abut covers and to cover perimeters.

F. Adhere floor tiles to substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting floor tile.

B. Perform the following operations immediately after completing floor tile installation:

1. Remove adhesive and other blemishes from surfaces.
2. Sweep and vacuum surfaces thoroughly.
3. Damp-mop surfaces to remove marks and soil.

C. Protect floor tile from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Floor Polish: Remove soil, adhesive, and blemishes from floor tile surfaces before applying liquid floor polish.

1. Apply two coat(s).

E. Cover floor tile until Substantial Completion.

END OF SECTION 09 65 19

SECTION 09 91 23 - INTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Primers.
2. Water-based finish coatings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.

1. Include preparation requirements and application instructions.
2. Indicate VOC content.

B. Samples for Verification: For each type of paint system and each color and gloss of topcoat.

1. Submit Samples on rigid backing, 8 inches (200 mm) square.
2. Apply coats on Samples in steps to show each coat required for system.
3. Label each coat of each Sample.
4. Label each Sample for location and application area.

C. Product Schedule: Use same designations indicated on Drawings and in the Interior Painting Schedule to cross-reference paint systems specified in this Section. Include color designations.

1.4 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. Paint Products: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).

1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste from storage areas daily.

1.6 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).

B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures of less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Benjamin Moore & Co.
2. Sherwin-Williams Company (The).

B. Source Limitations: Obtain each paint product from single source from single manufacturer.

2.2 PAINT PRODUCTS, GENERAL

A. Material Compatibility:

1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

B. Colors: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:

1. Concrete: 12 percent.
2. Masonry (Clay and CMUs): 12 percent.
3. Wood: 15 percent.
4. Gypsum Board: 12 percent.
5. Plaster: 12 percent.

C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

D. Plaster Substrates: Verify that plaster is fully cured.

E. Spray-Textured Ceiling Substrates: Verify that surfaces are dry.

F. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

G. Proceed with coating application only after unsatisfactory conditions have been corrected.

1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.

E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceeds that permitted in manufacturer's written instructions.

F. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer.
1. SSPC-SP 3.

G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

H. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

I. Aluminum Substrates: Remove loose surface oxidation.

J. Wood Substrates:

1. Scrape and clean knots, and apply coat of knot sealer before applying primer.
2. Sand surfaces that will be exposed to view, and dust off.
3. Prime edges, ends, faces, undersides, and backsides of wood.
4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

3.3 INSTALLATION

A. Apply paints according to manufacturer's written instructions.

1. Use applicators and techniques suited for paint and substrate indicated.
2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

E. Painting Fire-Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:

1. Paint the following work where exposed in equipment rooms:

a. Equipment, including panelboards and switch gear.
b. Uninsulated metal piping.
c. Uninsulated plastic piping.
d. Pipe hangers and supports.
e. Metal conduit.
f. Plastic conduit.
g. Tanks that do not have factory-applied final finishes.
h. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
i. .

2. Paint the following work where exposed in occupied spaces:

a. Equipment, including panelboards.
b. Uninsulated metal piping.
c. Uninsulated plastic piping.
d. Pipe hangers and supports.
e. Metal conduit.
f. Plastic conduit.
g. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
h. Other items as directed by Architect.
i. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.4 FIELD QUALITY CONTROL

A. Dry-Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry-film thickness.

1. Contractor shall touch up and restore painted surfaces damaged by testing.
2. If test results show that dry-film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats

as needed to provide dry-film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

1. Do not clean equipment with free-draining water and prevent solvents, thinners, cleaners, and other contaminants from entering into waterways, sanitary and storm drain systems, and ground.
2. Dispose of contaminants in accordance with requirements of authorities having jurisdiction.
3. Allow empty paint cans to dry before disposal.
4. Collect waste paint by type and deliver to recycling or collection facility.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 INTERIOR PAINTING SCHEDULE

A. Concrete Unit Masonry Substrates:

2 coats over filler, with total DFT not less than 2.5 mils, excluding filler.

1. Filler Coat: Acrylic-latex Block Filler. Apply filler coat at a rate to ensure complete coverage with pores filled. (Prime only bare or damaged substrates.)
   a. Sherwin-Williams: PrepRite ProBlock Latex Block Filler.

2. First and Second Finish Coats: Interior Zero-VOC Acrylic Satin Coating.
   a. Sherwin-Williams: SuperPaint Interior Acrylic.

END OF SECTION 09 91 23

SECTION 23 00 10 - HVAC GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
Every item of labor, materials, equipment and appurtenances for installing complete new Heating, Ventilating and Air Conditioning Systems included in Division 23 of the Specifications.

1.2 DRAWINGS

A. The mechanical Drawings are diagrammatic in nature and show the general arrangement of all ductwork, piping, equipment and appurtenances and shall be followed as closely as actual building construction and the work of other trades will permit. Because of the small scale of the mechanical Drawings, it is not feasible to indicate all offsets, fittings and accessories that may be required. The Contractor shall investigate the construction conditions affecting the work and provide fittings and accessories as required to meet actual conditions.

B. Where discrepancies in scope of work as to which Trade provides specific items, such as starters, disconnects, flow switches, electrical control components, etc. exist, such conflicts shall be reported to the Engineer. If such action is not taken, the Contractor, as applicable, shall furnish such items as part of his work, for complete and operable systems and equipment, as determined by the Engineer.

1.3 REGULATIONS AND STANDARDS

A. The completed installation and all materials and equipment shall conform to local ordinances and codes, other regulations and standards listed herein or in related sections. These are intended as a minimum and shall be exceeded if required by the specifications or the Drawings. In the event of conflict between the codes, standards, or regulations, and information contained in the Contract Documents, the applicable code, standards, or regulation shall take precedence.

B. Refer to Division 1 and Supplementary Instructions to Bidders for construction permitting requirements.

1.4 INSPECTION CERTIFICATES

A. The Contractor shall furnish three copies of certificates of final acceptance to the Engineer from all inspection authorities having jurisdiction.

1.5 SUBSTANTIAL COMPLETION INSPECTION

A. The Engineer will visit the site for the purpose of conducting a substantial completion inspection once the following items have been met by the Contractor:
1. All HVAC systems shall be complete, operational and under automatic control.
2. HVAC systems cleaning, balancing, and testing as described in Section 23 05 93 shall be complete and the final report shall be approved by the Engineer.
3. Letters, signed by representatives of the manufacturer, for the boiler, chiller, cooling tower, heat pump, and air conditioning unit shall be provided attesting that their respective equipment has been

started, tested, and set to operate safely and at the control points required as an integral part of the systems in which they are installed.

4. A letter, signed by a representative of the temperature controls manufacturer as described in Section 23 09 00, shall be provided attesting that the installation of the temperature controls system is complete, proper control of all equipment, valves, dampers, and the like has been verified, set points have been established to provide proper control of installed equipment, and graphics are accurate with real time data.
5. The Contractor shall provide certification from an authorized official of the equipment manufacturer(s) stating that all refrigerant piping as described in Section 23 20 00 and specialties have been installed in accordance with the manufacturer's recommendations.
6. The noise and vibration control supplier as described in Section 23 05 48 shall provide a letter stating that all items have been installed properly and that all equipment is adequately isolated and/or restrained.
7. The Contractor shall attest by letter that all equipment has been wired and tested to verify that the indicated sequence of motor control is established, that all safety controls function properly, that all motor protective devices are sized correctly, and that the systems are operating at the proper set points.

B. All discrepancies noted in the substantial completion report shall be corrected prior to the final inspection. The Contractor shall provide a detailed item-by-item description of all corrections made for each item on the substantial completion discrepancy list prior to scheduling final inspection by the Engineer. Additional visits required after the final inspection, for the reason that previously documented discrepancies had not been corrected at the time of the final inspection, will be made at the Contractor's expense.

1.6 ASBESTOS

A. Asbestos Free Materials: The intention of these Drawings and specifications is that there are no asbestos-containing materials installed on this project. To the best of the Architects and Engineers knowledge, none of the material or equipment specified herein or shown on the Drawings contains asbestos. The Contractor shall make every effort to prevent any asbestos materials from being installed in or used on the construction of the project. At the completion of the project, the Contractor shall certify by letter that to the best of his knowledge, no asbestos-containing materials were used for or in the construction of this project.

B. Existing Materials:
1. Contractor shall review the Owners asbestos management plan to ensure suspected asbestos containing materials are under surveillance.
2. Discovery: If during the construction of this project, work involving friable asbestos is suspected, or encountered, all work in this area shall be discontinued and the Owner or the Owner's representative, shall be notified immediately and the Owner with his own forces or by separate contract shall be responsible for complete investigation, removal, and disposition of the friable asbestos hazard in accordance with applicable laws and regulations. If the Contractor claims that delay or additional cost is involved because of such action by the Owner, he shall make such claim as provided elsewhere in the Contract Documents.
3. Removal: All work involving the removal of friable asbestos will be done under a separate contract.

1.7 MATERIALS AND WORKMANSHIP

A. Equipment and material used in the project shall be new and undamaged. The mechanical installation shall fit into the space allotted and shall allow adequate and acceptable clearances for entry, servicing and maintenance. Similar types of equipment shall be the products of the same manufacturer unless specified otherwise. Work shall be performed by mechanics or tradesmen skilled in the trade involved.

B. All ductwork, piping and conduit shall be installed in a neat and organized manner, parallel to other work and the nearest building elements, unless specifically shown otherwise on the Drawings.

C. Equipment and materials shall be suitable for use in the environment in which they are installed. Equipment exposed to outside conditions shall be adequately protected from the weather, manufactured from materials suitable for outdoor use, and designed specifically for use in outdoor environments.

1.8 SUBMITTALS

A. Submit shop drawings, product data and samples in accordance with Division 1 for all items as specified in related sections of these specifications. One (1) electronic (PDF) copy of the submittal shall be submitted. One (1) electronic (PDF) copy of the submittal will be returned to the Contractor. If additional copies are required, they will be the responsibility of the Contractor. Where drawings are submitted, the Contractor shall submit a minimum of two (2) sets of full scale prints. One (1) copy will be marked and returned to the Contractor, and the Contractor shall be responsible for all additional copies required for his use. All submittal data shall be correctly identified to show project name, and the exact model, style or size of item being submitted. Improperly identified submittals will not be reviewed by the Engineer. Each item submitted for review shall bear the Subcontractor's stamp which states that they have reviewed the submission, that it is complete, and that in their opinion it meets the contract requirements. Contractor's stamp shall identify the specification section, paragraph, and page number for which the submittal is being made. Shop drawings will be reviewed only for general compliance with the Contract Documents. Review will not include correctness of details, proper configuration, utility connections, dimensions, sizes, quantities, and the like. Any submission which has not been reviewed and stamped by the M/E Subcontractor will not be reviewed by the Engineer. No reviews prior to award of Contract will be considered or accepted. Re-submissions of shop drawings, product data and samples shall include the entire original submittal. **Partial submittals will not be reviewed by the Engineer.**

B. Submissions will be stamped by the Engineer in one of the following ways:

"No Exceptions Taken"	No exceptions are taken and subject to compliance\ with the Contract Documents.
"Make Corrections Noted"	Minor corrections are noted and a re-submittal is not required subject to compliance with the corrections and the Contract Documents.
"Correct and Resubmit "	The submitted material, method or system meets the intent of the specifications, yet has insufficient data to determine compliance with the Contract Documents. Re-submittal is required.
"Rejected"	The submitted material, method or system does not meet the intent of the specifications, or has insufficient data to determine compliance with the Contract Documents.

C. Submission Procedures:

1. If a submission is satisfactory to the Engineer, the Engineer will annotate the submission, "No Exceptions Taken" or "Make Corrections Noted" and transmit the electronic copy to the Contractor. If a resubmission is required, the Engineer will annotate the submission "Correct and Resubmit" or "Rejected" and transmit the electronic copy to the Contractor for appropriate action.
2. The Contractor shall revise and resubmit submissions as required by the Engineer until submissions are acceptable to the Engineer.
3. Approval of a working and/or shop drawings by the Engineer will constitute acceptance of the subject matter for which the drawing was submitted and not for any other structure, material, equipment or appurtenances indicated as shown.
4. The Engineer's review of the Contractor's submissions shall in no way relieve the Contractor of any of his responsibilities under the Contract. An approval of a submission shall be interpreted to mean that the Engineer has no specific objections to the submitted material, subject to conformance with the Contract Documents.
5. Where as-built drawings, record drawings and specifications are available and when provided to the Contractor for use in performing the work, the Contractor shall verify the content of such drawings and specifications, the suitability of their use in performing the work and their accuracy for the purposes in which the Contractor intends to use any record or historical documents which may be obtained. In no case shall the Contractor assume that such documents reflect a true and accurate record of the construction. Acceptance of any such materials, records, and/or drawings shall in no way result in additional cost to the Owner should an error and/or omission in these documents result in additional costs to the Contractor.

6. When major equipment being submitted is a different manufacturer or model than the basis of design, the shop drawing shall include sketches of the proposed equipment and associated service clearances overlaid against other equipment and architectural features.

7. All scheduled EER, IEER, 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.

8. On the first pages of all submittals, the Contractor shall provide a table showing all individual specification section paragraphs and drawings that apply to the equipment/component and a statement for each paragraph and drawing that the requirements have been met. The table shall be similar in format to the following, but shall include all relevant specification paragraphs and drawings:

Section 23 07 00 (example)	
1.2 A	Comply
1.2 B	Comply
1.3 A	Comply
1.3 B	Comply
1.3 C	Comply
1.4 A	Comply
1.4 A.1	Comply
1.4 A.2	Comply
Drawing M0.01	Comply

D. Equivalents: Manufacturers, trade names, and model numbers indicated herein and on Drawings shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition. Unless definitely stated otherwise and upon complying with Division 1, the Contractor may use any article which, in his judgment is equal to that specified and is accepted by the Engineer. Where three (3) or more manufacturers are named in the specifications for any item, the Contractor shall use one of the named manufacturers. No others will be reviewed or accepted. Manufacturers listed first in these specifications and on Drawings were used as a basis of design. It will be the responsibility of the Contractor to verify all connections, physical sizes, capacities, etc. of all other manufacturer's items, both named or proposed. If the equipment necessitates changes in ductwork, piping, wiring or other building systems from that indicated on the Drawings, the Contractor shall be responsible for all additional costs included and notify other trades. Where such changes are required, detail drawings indicating all required changes shall be submitted for review at the same time the manufacturers drawings are submitted for approval.

E. Shop drawings, diagrams, catalog data and such other data necessary to fully describe and substantiate compliance with these specifications shall be submitted for all equipment and materials where specifically required by specification and all items identified with an [S] behind the product title. Submittals not required by the Contract Documents will not be reviewed.

F. Operation and Maintenance manual(s) shall be submitted in accordance with Division 1 and shall include a complete product index in each volume, installation and maintenance data, sequence of controls, parts lists, a copy of all approved shop drawings and the name, address and telephone number of supplier or nearest representative. All mechanical devices, equipment and systems marked [O/M] in these specifications shall be included and all other such mechanical items that will require servicing before the duration of its useful life has been reached. Manual(s) shall be presented to the Engineer for review and transmittal to the Owner before final payment is recommended.

1.9 WARRANTY

A. The Contractor shall provide a warranty for a period of one year for all work provided under the Contract to include, but not necessarily limited to, all systems, equipment, materials, and workmanship. This shall not be construed to limit any extended warranty periods of longer than one year for specific items or systems specified elsewhere in the Contract Documents.

B. The warranty period shall commence on the date of acceptance by the Owner and shall cover all parts and labor as required to fulfill the warranty at no cost to the Owner.

C. Refer to Division 1 for additional warranty requirements.

D. Information on all warranties shall be included in the O&M Manuals specified herein to be provided to the Owner.

E. In phased construction, warranties shall not begin until substantial completion of the FINAL phase. Contractor shall maintain all new equipment and systems until that time. Owner will maintain all existing equipment and systems. Where new systems are connected to existing, the Contractor and Owner shall determine coordination of maintenance responsibilities at the preconstruction meeting.

1.10 CUTTING AND PATCHING OF EXISTING PAVEMENT AND CONCRETE

A. Pavement and concrete removed for trenching shall be saw cut before removal. All paving removed for trenches shall be restored to original condition with materials that match adjacent surfaces, as close as possible. The Contractor shall be responsible for any sinking of the backfill or pavement which may occur within one year from acceptance by the Owner.

1.11 EXISTING UNDERGROUND UTILITIES

A. The location of underground utilities shown on the Drawings shall be considered approximate, and any locations may not be indicated or known. Care shall be exercised by the Contractor during construction to locate and protect the known and unknown utilities, and to prevent disrupting the affected utility. The Contractor shall be responsible for repairing damage to any utility caused by his work.

B. Where any existing utilities are damaged, they shall be repaired as directed by the Engineer, with materials approved by the local utility company or the Owner, at no additional cost to the Owner.

1.12 VERIFYING MEASUREMENTS AND CONDITIONS

A. The exactness of grades, elevations, dimensions, or locations given on the Drawings, is not guaranteed by the Engineer. The Contractor shall, therefore, satisfy himself as to the accuracy of all grades, elevations, dimensions and locations. In all cases of interconnection of his work with existing or other work, he shall verify at the site all dimensions relating to such existing or other work. Any errors due to the Contractor's failure to so verify all such grades, elevations, locations, or dimensions shall be promptly rectified by him without cost to Owner.

B. The Contractor shall base his bid on site examinations performed by him. This requirement is mandatory. The Contractor shall visit the site of the proposed project where work is scheduled to be performed, visit the existing buildings scheduled to be renovated, inspect piping systems where new-to-existing connections shall be made, etc., and ascertain for himself the amount of work required to fulfill the intent of his Contract and the complexity of the installation. The Contractor shall not hold the Engineer, his Consultants, agents or employees responsible for or bound by, any schedule, estimate or for any plan thereof. The Contractor shall study all Contract Documents to determine exactly the extent of work to be provided under each Section, and in installing new equipment and systems and coordinating the work with the other Trades and existing conditions.

1.13 INTERRUPTION OF UTILITY SERVICES

A. It is necessary that close liaison be maintained with the Administrative Authorities in all matters affecting interruptions of any utility services serving the facility and existing buildings. Prior to interrupting any utility service, the Administrative Authorities shall be consulted and interruptions for connections made at a time (or times) suitable to the Administrative Authorities. Work shall be laid out and planned to limit the interruption times to a minimum.

1.14 COORDINATION OF WORK

A. General: The Contract Documents indicate the extent and general arrangement of the mechanical systems. The Contractor shall be responsible for the coordination and proper relation of the mechanical work to the building structure and to the work of other trades. No additional compensation or extension of completion time will be granted for extra work caused by the lack of coordination.

B. Cooperation: The Contractor shall provide dimensions and locations of all openings, shafts and similar items to the proper trades and install work as required so as not to interfere with, or delay, the building construction.

C. Locations of lines and equipment shall be determined from actual field measurements. The outlines of the building shown on the mechanical Drawings are intended only as a guide to indicate relative locations of the mechanical work. Refer to architectural and structural Drawings for building construction details. The Contractor shall determine the exact routing and location of his systems prior to fabrication or installation of any system component. Accurate measurements and coordination shall be completed to verify dimensions and characteristics for the installation of each system.

D. Unless necessitated by equipment access or otherwise indicated in the Contract Documents, all piping, ductwork, and conduit concealed above ceilings and in finished or utility spaces shall be routed as high as possible.

E. Offsets, transitions and changes of direction in all systems shall be made as required to maintain proper headroom and pitch of sloping lines whether or not indicated on the drawings. The Contractor shall provide manual air vents and drains as required for his work to affect these offsets, transitions and changes in direction, as applicable.

F. Cutting and Patching: See Division1.

G. Roughing-In: Verify the locations of other buildings machines, door swings, block coursing, alignment of tile end and other similar features before roughing-in for mechanical equipment components and/or controls.

H. Damage to Other Work: Each Contractor is responsible for damage to other work caused by his work or workmen. Repairing of damaged work shall be done by the Contractor who installed the work, and as directed by the Architect-Engineer; the cost of which shall be paid for by the Contractor responsible for the damage.

1.15 EQUIPMENT INSTALLATION

A. General: Equipment shall be installed in accordance with manufacturer's instructions to conform with the details and application indicated. Where manufacturer's recommendations or installation instructions require options or accessories not specified, they shall be included and installed by the Contractor.

B. Supports: Provide necessary supports for all equipment and appurtenances as required; this includes but is not limited to frames or supports for items such as tanks, compressors, boilers, plumbing fixtures, pumps, valves, fans, and other similar items requiring supports. Floor mounted equipment in Equipment Rooms shall be set on 4-inch high concrete foundation pads unless shown otherwise. All pads shall be poured such that the top of the pad is level. Foundation drawings, bolt setting information and foundation bolts shall be furnished by the subcontractors furnishing the equipment for all equipment required to have concrete foundations. Concrete for foundations shall be provided by mechanical subcontractor unless indicated otherwise. Except where indicated in Section 23 05 48, all equipment shall be anchored to concrete pads. Rooftop equipment, ductwork, and piping shall be set on pre-manufactured curbs anchored to the roof and flashed into the roofing system. Rooftop equipment, ductwork, piping, etc. shall be

anchored to the curb except where vibration isolation is installed between the curb and the equipment. Unless otherwise noted, outdoor equipment (on grade) shall be installed on 4-inch thick cast-in-place concrete equipment pads.

C. Service Area: All equipment and appurtenances shall be located to permit adequate service clearance in accordance with manufacturer's recommendations and as otherwise required. Service clearance shall include but not be limited to service and removal of filters, coils, motors, controls and removal of equipment sections. Service clearance shall include adequate space for rodding and removing tubes from boilers, chillers, and heat exchangers. All piping, ductwork, and other equipment shall be located outside of the service area or shall be flanged for easy removal to facilitate equipment service. All equipment shall be located with sufficient distance from building features, structural components, and the equipment of other trades. Service clearance in front of electrical panels shall be minimum as required by National Electric Code (NEC) where applicable. Equipment requiring service and located above ceiling shall be located within two feet of the ceiling vertically to allow for proper maintenance access.

D. Temporary Requirements: Temporary filters shall be provided for all fans that are operated during construction. Return openings, grilles, and registers shall be provided with temporary filters to prevent the intrusion of dust and particulate into the return air ductwork. Temporary filter shall have a minimum efficiency of MERV 8 in accordance with ASHRAE 52.2. Openings in equipment shall be kept plugged at all times until connection is made to the system. The ends of all pipes, ducts and equipment openings shall be kept plugged or capped properly with approved devices. Approved devices are items such as specially molded plastic caps, pipe plugs, test plugs and sheet metal caps.

E. All equipment indicated to be installed exposed within finished spaces shall be installed such that all conduit, piping, and appurtenances are concealed. Air conditioning units utilizing gravity condensate drains shall be installed at an elevation necessary for the specified pipe slope.

1.16 EXISTING EQUIPMENT

A. General: Care shall be exercised to protect all existing equipment to be reused. The Contractor shall remove from operation all equipment that is shown to be reused and provide adequate protection including but not limited to prevention of corrosion, protection of seals, prevention of leaking, and prevention of internal/external contamination. All electronic components shall be protected from weather and moisture, deterioration and loss of programming.

1.17 SLEEVES AND INSERTS

A. General: Sleeves and inserts shall be provided and correctly located in the structure, as require for the work.

B. Inserts shall be steel and proper size for loads encountered.

C. Sleeves shall be provided for all pipes passing through concrete or masonry walls, partitions, concrete beams or slabs installed during construction of the wall, partition, beam or slab. Sleeves through existing concrete walls and slabs may be omitted if wall or slab can be core drilled and properly sealed in a manner acceptable to the Engineer. Sleeves placed horizontally in walls or in any position in beams shall be standard weight ASTM A53 steel pipe of length equal to thickness of wall or beam. Those placed vertically in non-waterproof floors shall be 20 gauge galvanized sheet steel of length equal to thickness of slab, flared and nailed to the form, or fastened to reinforcing fabric and filled with sand during pouring to prevent deformation. Sleeves occurring in floors of rooms where hose bibs or floor drains occur, and in pipe spaces, shall be standard weight steel pipe projecting 2" above the finished floor except in Equipment Rooms they shall project four (4) inches above floor. Sleeves in floors with waterproof membrane shall be provided with flanges or flashing rings and shall be clamped or flashed into membrane. All sleeves (and core drilled openings) shall be of sufficient diameter to clear bare or covered pipes by 1/4" all around except sleeves on lines subject to movement by expansion which shall clear the bare pipe or insulation on insulated pipe at least one inch all around. Pipes through exterior walls below grade and above footings shall be installed in sleeves having a minimum size of two larger pipe diameters and sealed watertight with flexible synthetic rubber seals. Sleeve shall have anchor and water stop plate. The entire assembly shall be tightened and adjusted and made watertight. Sleeves for pipes and conduit, penetrating fire (and smoke) rated partitions, walls and floors shall be sealed in accordance with the terms of U.L. Listed Through-Penetration Firestop Systems XHEZ as published in the U.L. Fire Resistance Directory. Penetrations shall exactly conform to details of the Firestop System indicated for the type of partition, wall

and floor construction encountered. All penetrations through nonfireresistance rated floor assemblies and through the ceiling membrane of nonfireresistance rated roof assemblies shall be fireblocked with tightly packed mineral-wool insulation secured in place. All penetrations through equipment room walls and other areas of noise or heat generation shall be tightly sealed with mineral fiber rope. All penetrations through draftstop partitions shall be sealed to maintain the integrity of the partition. All firestopping and draftstopping of sleeves for mechanical work shall be provided under Division 23.

1.18 WOODEN STRUCTURE

A. Where piping, ductwork and conduit are supported from wooden structure, all connections shall be made in strict accordance with this Section. For spacing of piping and ductwork supports, see Section 23 05 00.

B. Engineered wooden trusses shall not be drilled or cut under any circumstances. Where equipment or piping is supported from trusses, the Contractor shall provide steel supports bearing at panel points and spanning a minimum of two trusses. Any wooden blocking shall be fire retardant lumber in accordance with ASTM E-84 and shall bear the mark of an approved testing agency.

C. All connections to wooden framing shall be made thru shear hangers at the face of wooden members. All connections shall be made by screws.

D. Hangers for multiple pipes or ducts shall be staggered to distribute weight on trusses as evenly as possible.

1.19 PENETRATIONS THROUGH PRE-CAST HOLLOW-CORE SLAB SYSTEM

A. General: Contractor shall coordinate work with the pre-cast system. Refer to architectural and structural documents for details. Installation of work shall be in strict accordance with the pre-cast system manufacturer's recommendations, as approved by the Architect.

B. Openings: Holes in the slabs made in the field shall be made by the trade involved. Openings shall be made only through hollow cells, shall not exceed the width of the hollow cells, and shall not penetrate the webs between the cells or the pre-stressed strands unless prior approval is obtained from the Architect and the slab manufacturer. Holes shall not exceed 6" diameter without approval. Certain holes for pipe and duct shafts may be pre-cut. See structural Drawings for locations.

C. Cutting holes: Holes may be drilled or cut and trimmed with a chisel. Generally, holes will be made by cutting the outline of the hole through the lower portion of the slab from the underside and then cutting out the top side. All holes shall be made prior to the installation of the topping slab.

D. Sleeves: Sleeves are not required through pre-cast system slabs except where required to support packing material at hollow cores. Sleeves are required to be placed through concrete topping slab on top of the pre-cast slabs.

E. Supports: Hangers shall be supported from inserts or approved sockets, or toggle bolts in core slab construction. Hanger spacing shall be such that weight on hanger does not exceed 250 pounds for any one hanger. All hanger rods shall be minimum 3/8 inch in diameter. Where hanger rods must extend through slab, they shall be secured by two bolts over steel washers or plates on top of the slab in the floor fill or roof insulation space. Washers or plates shall not be less than 2" size and 1/4" thick. Larger plates are required for larger pipe supports. Cumulative thickness of plates, washers and bolts shall be 1/4" less than thickness of topping slab.

F. Explosives: Inserts set with explosives shall not be used.

1.20 ESCUTCHEONS

A. Where pipes pass through floors, walls or ceilings in finished rooms, they shall be fitted with chromium plated escutcheons of suitable pattern to effectively cover the rough opening. Where sleeves project above floors, special deep type escutcheons shall be provided.

1.21 ACCESS DOORS

A. Provide for all concealed valves, controls, dampers, junction boxes, equipment, or any item requiring access. Doors shall be of sufficient size and so located that the concealed items may be serviced or completely removed and replaced. Doors required for Mechanical work shall be furnished as a part of this Division to the General Contractor for installation. The Mechanical Contractor shall provide locations of all access doors such that service may be safely performed from a ladder, lift, or platform without the need for support from the ceiling system. Doors in acoustic tile ceilings shall be furnished in multiples of tile sizes. Doors are not required in exposed grid type ceilings where tiles are removable. Doors shall be metal access doors with cam lock, style to match ceiling or wall construction. Doors occurring in rated construction shall be fire rated U.L. labeled access doors correlated to preserve the integrity of the rated construction. Doors leading to concealed spaces shall be provided with means to open from the inside. Doors shall be prime finish steel except those in toilets, shower rooms, locker rooms, kitchens and other similar areas shall be stainless steel with brushed finish.

1.22 ELECTRICAL WIRING AND EQUIPMENT

A. Wiring, low voltage (100 volts or less) control wiring shall be provided as a part of (Section 23 09 00 Instrumentation and Control for HVAC) (Division 23) in strict accordance with Division 26 and shall be in accordance with manufacturer's recommendations to comply with the sequence of control indicated. Verify that wiring of all motors and controls required by equipment furnished is accomplished for the correct sequence of operation.

B. Wiring, line voltage (101 volts or higher) power or control wiring shall be furnished and installed under Division 26.

C. Disconnects shall be provided for each item of equipment under Division 26 unless specified otherwise in other sections.

D. Miscellaneous manual or automatic control and protective or signal devices required for the sequence of operation indicated for mechanical equipment shall be provided under the section of the specifications where the item of equipment is specified unless indicated otherwise.

1.23 PROTECTION FROM MOVING PARTS

A. Belts, pulleys, chains, gears, shafts, couplings and other rotating or moving parts located so that any person may come in close proximity thereto shall be fully enclosed or properly guarded.

1.24 RECORD OF UNDERGROUND LINES

A. On completion of the project, the Contractor shall prepare and submit to the Engineer a drawing on tracing paper and one blue line print to show the location of any underground lines installed in locations different from those on the Architect-Engineer's Drawings. The location of cleanouts, and the distance from the building to outside sewers, mains, and manholes shall be dimensioned.

1.25 CHARTS AND DIAGRAMS

A. General: Material as listed below shall be provided by the Contractor and shall be mounted in separate hardwood frames where directed in the field or folded and stored in a plastic document folder and located in the control cabinets. All charts, diagrams and schemes shall be photographic positives prepared from original tracings. A copy of charts and diagrams shall be included with O/M manuals.

B. Automatic Temperature Control Diagrams identified as to name, sequence of operation, location and number of systems. Components of a control system shall be identified as to location, function, temperature setting and manufacturer's part number.

C. Electric Sequence Control Diagrams of entire Mechanical system.

D. Charts for identification of valves.

1.26 INSTRUCTION OF OWNER'S REPRESENTATIVE

A. Contractors shall instruct the representative of the Owner in the proper operation and maintenance of all elements of the Mechanical systems. Competent representatives of the Contractor shall spend such time as necessary to fully prepare the Owner to operate and maintain the Mechanical and Electrical systems.

1.27 COMMISSIONING OF HVAC SYSTEMS:

A. Commissioning of this project will be coordinated and managed by the Owner's Commissioning Agent. Refer to the Commissioning Plan and Division 1 for the scope and requirements for commissioning of mechanical systems.

1.28 CONSTRUCTION STATUS REPORT

A. Each item of discrepancies noted on Construction Status Report prepared by the Engineer shall be answered in detail in writing by the Contractor before payment can be recommended.

1.29 GRAPHICS DATABASE

A. This project's Computer Aided Design & Drafting (CADD) drawing files may be obtained through the Architect/Engineer for use in preparing computer graphics specific to this project. See Appendix A at the end of this Section for Letter of Indemnification and ordering instructions.

1.30 DEMOLITION

A. Contractor shall visit site before bidding to determine extent of demolition.

B. Removal of Ducts, Piping and Equipment: Remove all ductwork and piping connections, plugging outlets, etc., such that are not required for present equipment and fixtures, or are not reused or needed for reconnecting new equipment and fixtures. Remove all equipment, fixtures, etc., indicated to be removed, or not reused or needed after the renovations are complete.

C. Where piping, conduit, ductwork or other similar items passing through rated assemblies are removed; the assemblies shall be patched in accordance with UL so as to maintain the integrity of the assembly.

D. Where demolition of equipment, pipes, conduit, ducts or other components occurs in a finished space, all ceilings, floors, walls, and casework or other affected building elements shall be patched to match existing finishes and construction.

E. The Owner will select and retain such existing equipment and materials which are indicated to be removed and not reused, as he desires. All other existing equipment and materials indicated to be removed and not reused shall become the property of the Contractor, who shall promptly remove them from the premises. All existing equipment and fixtures indicated to be relocated shall be disconnected, removed, relocated and reconnected. All equipment and fixtures shall be protected from damage during demolition.

F. Miscellaneous: In all altered portions of the buildings, the Contractor shall remove or alter as necessary all existing mechanical work that is not coordinated to operate with the new construction. Demolition shall not begin until the work schedule is approved by the owner. The work shall be scheduled to prevent any disruption to the normal operations of the building.

G. General Scope of Demolition: The scope of work involves the replacement, with similar, of three unit ventilators along with their associated piping, fittings, controls, and roof mounted condensers in the classroom area. The ductwork and rooftop unit over the Library space shall also be replaced with similar. Duct and air terminals downstream of the rooftop unit will be demolished and new duct and air terminals will be installed.

1.31 ALTERNATES

A. See Specifications Section Bidding Requirements under Division 1 for description of Bid Alternates. The project contains one (1), electrical discipline, alternate involving the replacement of the existing lights over the Library space and its ancillary storage spaces.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION – NOT USED

END OF SECTION 23 00 10

APPENDIX A
LETTER OF INDEMNIFICATION

Project Name: Belview Elementary School - Renovations

Project Location: 3187 Peppers Ferry Rd NW, Radford, VA 24141

The Contractor may obtain from Ascent Engineering Group a CD-ROM or electronic mail version of the projects Revit / CADD database. All seals, details, schematics, tables, controls, etc. will be deleted. All drawings will be provided in Autocad™ 2014 format.

Ascent Engineering Group reserves all rights to the original drawing files.

The Recipient agrees, to the fullest extent permitted by the law, to hold harmless and indemnify Ascent Engineering Group, as defined in the Bid Documents, from and against all claims, liabilities, losses, damages, and costs, including but not limited to attorney's fees, arising out of or in any way connected with the use, modification, misinterpretation, misuse, or reuse by the Recipient or others of the machine readable information and data provided by Ascent Engineering Group under this Agreement. The foregoing indemnification applies, without limitation, to any use of the project documentation on other projects, for additions to this project, or for completion of this project by others, excepting only such use as may be authorized, in writing, by Ascent Engineering Group.

The electronic drawing files are not part of the Contract Documents for the Project. The Recipient assumes all risks associated with the use of the transmitted files. Ascent Engineering Group will not be responsible for any differences in the information included in the transmitted files and the information shown on the Contract Documents. Modifications to the Contract Documents made before or during construction may or may not be included in the transmitted electronic drawing files.

The Recipient further agrees that the drawing files will only be used in graphics preparation for the above-referenced project.

Company Name of Recipient: _____

Recipient's Designated Representative: _____

Title: _____

Signature: _____

Address: _____

Return to: Ascent Engineering Group
5228 Valleypointe Parkway, Suite 4
Roanoke, VA 24019
AEG #

SECTION 23 01 00 - OPERATION AND MAINTENANCE OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
1. To aid the continued instruction of operating and maintenance personnel, and to provide a source of information regarding the products incorporated into the work, furnish and deliver the data described in this section and in pertinent other sections of these specifications.

C. Related Sections:
1. Section 23 00 10 – HVAC General Requirements
2. Section 23 05 00 – Common Work Results for HVAC
3. Section 23 20 00 – HVAC Piping
4. Section 23 30 00 – HVAC Air Distribution
5. Section 23 70 00 – Central HVAC Equipment
6. Section 23 80 00 – Decentralized HVAC Equipment

1.2 SUBMITTALS

A. Unless otherwise directed in other sections, or in writing by the Engineer, submit three copies of the final manual to the Engineer for approval prior to indoctrination of operation and maintenance personnel.

B. Operation and Maintenance manual(s) shall be submitted in accordance with Division 1 and shall include a complete product index in each volume, installation and maintenance data, sequence of controls, parts lists, a copy of all approved shop drawings and the name, address and telephone number of supplier or nearest representative. All mechanical devices, equipment and systems marked [O/M] in these specifications shall be included and all other such mechanical items that will require servicing before the duration of its useful life has been reached. Motor driven equipment shall include data for the motor. Manual(s) shall be presented to the Engineer for review and transmittal to the Owner before final payment is recommended.

1.3 QUALITY ASSURANCE

A. In preparing data required by this section, use only personnel who are thoroughly trained and experienced in the operation and maintenance of the described items, completely familiar with the requirements of this section, and skilled communicating the essential data.

PART 2 - PRODUCTS

2.1 INSTRUCTION MANUALS

A. Where instruction manuals are required to be submitted under other sections of these specifications, prepare in accordance with the provisions of this section.

B. Format:
1. Hard Copy

a. Size: 8-1/2" x 11"
b. Paper: White bond, at least 20 lb. weight.
c. Text: Typed (Hand printed or written is not acceptable)
d. Drawings: 11" x 8-1/2" preferable; bind in with text; foldouts are acceptable; larger drawings are acceptable if folded to fit within the manual and provide a drawing pocket inside rear cover or bind in with text.
e. Fly Sheets: Separate each portion of the manual with neatly prepared Fly Sheets or tabbed index sheets briefly describing the contents of the ensuing portion. Fly sheets or index tabs may be in color.
f. Binding: Use heavy-duty plastic covers with binding mechanism concealed inside the manual; 3-ring binders are required. All binding is subject to the Engineer's approval.

2. Electronic
a. A single PDF file shall be provided for the entirety of Division 23. Individual PDF files of each section are not acceptable and will not be reviewed.
b. All submissions must be provided with a digital table of contents with linked bookmarks to allow for quick access to each section. Table of Contents shall be ordered by specification section. Bookmarks shall be linked to the fly sheets of the corresponding section.
c. All PDF's must be searchable utilizing the standard search function of a PDF viewer.
d. Where native PDF files are available from a vendor, those shall be used. Scanned versions of these documents are not acceptable.
e. Fly Sheets: Separate each portion of the manual with neatly prepared digital Fly Sheets briefly describing the contents of the ensuing portion. Fly sheets shall include the equipment type, applicable specification section, and address and telephone number of equipment supplier or nearest representative. Table of contents bookmarks shall point to the related fly sheet.

C. Provide front and back covers for each manual, using durable plastic material approved by the A.E, and clearly identified on the front cover with at least the following information:

OPERATING AND MAINTENANCE INSTRUCTIONS

FOR

(Item/system name and description)

(Name and address of Contractor and sub-contractor)

(General subject of this manual)

(Name and address of Engineer)

(Engineer's approval and date approved)

D. Contents:
Neatly prepared and typewritten detailed table of contents.
Complete instructions regarding operation and maintenance of all equipment involved including lubrication, disassembly, and reassembly.
Complete nomenclature of all parts of all equipment.
Complete nomenclature and part number of all replaceable parts, name and address of nearest vendor, and all other data pertinent to procurement procedures.
Copy of all guarantees and warranties issued.
Manufacturer's bulletin, cuts, and descriptive data, where pertinent, clearly indicating the precise items included in this installation and deleting, or otherwise clearly indicating, all manufacturers' data with which this installation is not concerned.
Such other data as required in pertinent sections of these specifications.

PART 3 - EXECUTION

3.1 INSTRUCTION MANUALS

A. Revisions:

1. Following the indoctrination and instruction of operation and maintenance personnel, review all proposed revisions of the Manual with the Engineer.

END OF SECTION 23 01 00

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SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
1. Common Motor Requirements for HVAC Equipment
2. Variable Frequency Drives
3. Expansion Fittings for HVAC Piping
4. Meters and Gages for HVAC Piping
5. General-Duty Valves for HVAC Piping
6. Hangers and Supports for HVAC Piping and Equipment

C. Related Sections:
1. Division 01 -- Commissioning
2. Section 23 00 10 – HVAC General Requirements
3. Section 23 05 48 – Vibration and Seismic Controls for HVAC Systems
4. Section 23 05 53 – Identification for HVAC Piping and Equipment
5. Section 23 05 93 – Testing, Adjusting and Balancing for HVAC
6. Section 23 09 00 – Instrumentation and Control for HVAC
7. Section 23 20 00 – HVAC Piping
8. Section 23 30 00 – HVAC Air Distribution
9. Section 23 70 00 – Central HVAC Equipment
10. Section 23 80 00 – Decentralized HVAC Equipment

1.2 REFERENCES

A. General: The following standards or codes form a part of this specification to the extent indicated by the reference thereto.

B. American Society of Mechanical Engineers (ASME):

C. ASME 95 Boiler and Pressure Vessel Code

D. B16.3 Malleable Iron Threaded Fittings

E. B16.4 Cast Iron Threaded Fittings

F. B31.9 Building Services Piping

G. National Electrical Manufacturers Association (NEMA)

H. Underwriters Laboratories, Inc. (UL)

1.3 COMMISSIONING OF HVAC SYSTEMS:

A. The Contractor shall provide contact information to the Commissioning Agent indicated in Division 1 for all major items of Equipment.

B. Provide additional submittal copy of major equipment for Commissioning Agent specified in Division 1.

1.4 SUBMITTALS

A. Submit shop drawings and product data in accordance with Division 1 and Section 23 00 10.

B. Shop drawings, diagrams, catalog data and such other data necessary to fully describe and substantiate compliance with these specifications shall be submitted for all equipment and materials marked with notation set forth in Section 23 00 10.

C. Operation and maintenance data shall be submitted in accordance with Division 1, for all items of equipment and materials marked with notation set forth in Section 23 01 00.

PART 2 - PRODUCTS

2.1 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

A. Motors shall be provided in place as an integral part of the driven equipment, ready for electrical connections. Motors shall be in accordance with NEMA Standards and of design suitable for the starting and running characteristics of the driven equipment. Motors over 5 HP shall be “premium” efficiency as defined by NEMA MG-1, latest edition.

B. All three phase motors over 5 HP shall be provided with minimum power factor of 90%. Power factor correction capacitors shall be provided if required and shall be furnished to the electrical subcontractor for installation. Shop Drawing submittals for motors over 5 HP shall list efficiency and power factor. Unless specified otherwise, all motors shall have continuous duty classification, 40° Centigrade ambient temperature, shall have enclosure suitable for indicated application and shall be wound for 120 volt, single phase, 60 cycle current, except motors above 1/2 horsepower (unless indicated otherwise) shall be wound for 200V or 230V/460V as required by the secondary voltage specified for main service in Division 26. Each motor shall be selected and rated at the voltage indicated so that the driven load does not exceed the nameplate rating and service factor of the motor. All motors 460V/480V 20 HP and above and 208V/230V 10 HP and above shall be wound for wye-delta (6 or 12 lead) starting with capabilities of being wired for across-the-line starting.

C. Motors for use with variable frequency drives (VFD) shall be wound for across-the-line type starting and shall be rated for “VFD-duty” or shall be Premium Efficiency type with Class F (1500 volt) insulation and thermal overload protection. Motors for VFD applications shall meet or exceed IEEE 519-1992. Motors for VFD applications shall have maximum 4:1 speed range corresponding to 60 Hz and 15 Hz. Power factor correction is not required when motor is used with VFD. Motors for VFD service shall be Inverter Duty Rated with internal shaft grounding to prevent common mode voltage (shaft current) bearing failures.

D. Where 2-speed motors are indicated for motors above 1/2 horsepower, motors shall have two separate windings.

E. Motor starters and motor protective switches shall be provided under Division 26 except where specified to be furnished specifically with the driven equipment. Accessories such as auxiliary contacts, hand-off-automatic switches, start-stop switches, pilot lights, control power transformers and other similar items shall be provided in or on the controllers as required by the control sequence indicated. Starting equipment, unless factory mounted on the equipment, shall be installed under Division 26.

2.2 VARIABLE FREQUENCY DRIVES [S] [O/M]:

A. Variable Frequency Drives (VFD) shall convert primary power to adjustable voltage/frequency three phase AC power for stepless motor control from 5% to 105% of motor base speed. Units shall be pulse-width-modulation (PWM) type. Units shall be UL listed and suitable for installation in return air plenums, complete with Hand/Off/Auto switch, Run or Stop switch and display to indicate unit status, frequency and fault diagnostics. Unit shall have automatic soft restart after power outage, soft start/stop, and interface provisions for start/stop and control from the DDC system specified in Section 23 09 00 interconnections. Unit shall have all motor protective devices as required by NEC. Unit shall have line circuit breaker,

bypass switch, motor thermal overload relay, phase-loss protection, ground-fault protection, harmonic compensated load side reactor and control transformer.

B. All drives provided for the project shall be supplied by the same manufacturer, including those installed with equipment at the factory. The VFD shop drawing shall be inclusive of all drives on the project.

C. Drives shall be suitable for operation without damage to the connected motor. Drives shall have multiple, adjustable deadbands across the entire speed range for operation of connected equipment without vibration. Units shall have display on each drive to indicate all faults and diagnostics.

D. Drives shall be matched to driven motors in accordance with motor and drive manufacturers' recommendations.

E. Drives shall be suitable for speed control by the DDC System specified in Section 23 09 00 using any of the following signals, 3-15 psi, 0-5 vdc, 0-10 vdc or 4-20 ma dc.

F. Drives shall be provided with current sensing device to indicate abnormal conditions such as broken belt.

G. Where wiring to the driven motor exceeds 150 feet or as otherwise recommended by the manufacturer, a load side drive filter shall be furnished and installed. Where drives have remote disconnects at the driven motor, a run contact shall be provided to stop the drive without harm if the remote disconnect is opened.

H. Drives shall be installed in NEMA classified cabinets suitable for the location in which installed. Units located outdoors shall be NEMA 3R or NEMA 4.

I. Harmonics: The drives provided shall not add significant voltage harmonic distortion to the electrical system. If voltage harmonic distortions exceed 5%, line reactors or isolation transformers shall be provided in a separate enclosure.

J. VFD shall be provided with communication interface to allow two-way communication with the DDC System specified in Section 23 09 00.

K. Warranty: Provide parts and labor warranty for a period of five (5) years.

L. Installation and Start-up:
   1. The services of a qualified manufacturer's technical representative shall supervise the contractor's installation, testing, and start-up of all the drives furnished under this specification. A maximum total of one (1) supervision day (8 hours) shall be provided by the manufacturer's representative.
   2. System start-up shall include a checkout of vibration at various frequencies through field observation and manufacturer's data on the driven equipment. Frequency deadbands shall be set-up for each point of equipment vibration.
   3. Upon acceptance of the drive equipment, training of the operators shall consist of one (1) training day (8 hours).

2.3 EXPANSION FITTINGS FOR HVAC PIPING

A. Expansion joints [S] shall be equal to Adsco RBJ Ram-Pak slip-type, single direction, 4" minimum traverse, 150 lb service, flanged ends, with base, suitable for steam or hot water service.

B. Expansion joints [S] shall be Flexonic internally guided, corrugated bellows, expansion compensator, type H or HB, 2" minimum stroke, suitable for steam or hot water service. Expansion joints may be used in lieu of pipe loops in hot or cold water recirculating systems.

C. Anchors and guides for pipe shall be provided as indicated or as required at the job site to localize expansion and contraction of pipe. Anchors shall consist of heavy steel or brass collars bolted or welded to the pipe and rigidly connected to the building structure unless indicated otherwise. Anchor braces shall not be attached in places where they will damage or injure the structure during installation or by the weight or expansion force of the pipe line after installation. Detail drawings of pipe anchors shall be approved before anchor installation.

D. Flexible pipe joints at air handling units or other pieces of equipment isolated from the structure by vibration isolators as specified elsewhere shall be pipe line size and shall be Flexonics standard 125 psi,

Series PCS, stainless steel or bronze, flanged, screw or sweat type connectors with longitudinally welded stainless steel bellows and braided jacket.

2.4 METERS AND GAGES FOR HVAC PIPING

A. Thermometers ([S]) shall be 5" diameter adjustable angle, industrial type complete with stainless steel case, bezel, union (or 360° swivel) and stem, shatterproof lens, brass well, aluminum scale plate with black numbers and accurate to ±1°F.

B. Pressure gauges ([S]) shall be equal to Ashcroft bourdon tube type suitable for 125 psi service. Gauges shall be not less than 4" dial type with aluminum case and bar stock needle type gauge cock. Siphon shall be provided on steam gauges. Gauges shall be graduated in feet of water and psi. Minimum range 1.5 times normal operating pressure.

2.5 GENERAL-DUTY VALVES FOR HVAC PIPING

A. General: Valves shall be Apollo, Bray, Center Line, Crane, Jenkins, Jamesbury, Nibco, Milwaukee, Stockham, or Weco. All valves shall be suitable for 300 psi working pressure. Class 125 is not acceptable. Valves shall have threaded connections; except where flanges are specified they shall have fully lugged flanged connections suitable for dead-end service connections, and where installed in hard drawn copper lines they may have sweat connections. All valves shall be line size for the piping section indicated.

1. Equipment Service Valves over 4" ([S]): Valves shall be carbon steel or iron body fully lugged flanged high performance butterfly (HPBV) double offset type with 316 stainless steel disc and reinforced PTFE or RTFM replaceable seats, pressure assisted for tight shutoff. Butterfly valves shall provide bi-directional service, with downstream flange removed, and API 609 blow-out proof stem retention. Valves shall have upper and lower stem bearings of 316 stainless steel with PTFE seals.
2. Equipment Service Valves up to and including 2" ([S]): Valves shall be full port ball valves with stainless steel ball, 2-piece or 3-piece, brass body, bronze body, LF bronze body, or iron body, or shall be HPBV.
3. Equipment Service Valves 2-1/2" to 4" ([S]): Valves shall be full port ball valves with chromium plated brass ball, 2-piece or 3-piece, brass body, bronze body, LF bronze body, or iron body, or shall be HPBV.
4. Piping Branch Line Service Valves over 4" ([S]): Valves shall be iron body fully lugged flanged butterfly disc type with aluminum-bronze disc and EPT Nordel seats.
5. Piping Branch Line Service Valves up to and including 4" ([S]): Valves shall be full port ball valves, as specified for equipment service valves.
6. All valves for chilled water service shall have integral insulated handle equal to Nibco Nibseal. All valves for hot water service shall have stem extension for lever handle operator to accommodate up to 2" thick insulation.
7. Valves 4" and larger for steam service ([S]): Valves shall be fully lugged flanged HPBV type with carbon steel body and disc and reinforced PTFE seal ring.
    a. Operators for butterfly valves 6" and smaller shall be locking type manual lever with memory stop. Operators for butterfly valves 8" (VCU 4") and over shall be gear operator type with hand wheel, or chain wheel type as required for location where installed above 7 feet. Gear head shall have indicator to show disc position.
    b. Butterfly valves shall meet ANSI B16.34, B16.10, and B16.5, MSS-SP68, and API 609 standards.
    c. Valves for steam and condensate return service up to and including 3" shall be forged steel, bolted bonnet.
8. Globe valves ([S]) shall be all brass or bronze, with brass disc except globe valves over 2" size may be butterfly valves as specified above, under service valves. Non-rising stems are not acceptable.

B. Check valves ([S]) shall be brass or iron body, swing type, regrinding seat and shall be suitable for 250 psi working pressure. Check valves for condensate return service shall be forged steel body, swing type, regrinding seat and shall be suitable for 125 psi working pressure.

C. Balancing cocks ([S]) shall be all brass or bronze, venturi type, plated ball valves with Teflon seats, Tee handles, memory stops, and temperature/pressure ports. All balancing cocks shall be suitable for positive shut-off at 125 psi working pressure.

D. Circuit setter [S] [O/M] shall be Bell & Gossett, Armstrong, or Taco. Those 2-1/2" and smaller shall be bronze, ball type or brass, globe type balancing valves. Valves 3" and larger shall be cast iron globe or ball type. All circuit setters shall have provisions for connecting a portable differential pressure meter. Meter connections shall have built-in check valves. An integral pointer shall register degree of valve opening. Each balance valve shall be constructed for 125 lbs. working pressure at 250°F. Furnish one differential meter model RO-2 complete with meter, cutoffs, piping, fitting and dual hoses. Circuit setters shall not be intended for use as shutoff valves. A circuit setter with memory stop is not a substitute for service valves.

E. Automatic Flow Control Valves [S] [O/M] shall be Griswold, Flow Design, or Bell & Gossett and shall be provided at all hot water heating coils. Valves shall be automatic pressure compensating type and factory set to provide specified flow rates within ten (10) percent regardless of system pressure. Valves shall be selected to provide specified flow rates with a minimum pressure differential of 2 psig. Where system differential exceeds 32 psig, valves shall be selected for a range of 4-57 psig. Valve body shall be suitable for use with piping system and internal working parts shall be stainless steel, nickel plated brass or elastomeric diaphragm. All valves shall be provided with strainer, union and pressure-temperature test ports suitable for connecting differential pressure measuring devices. All valves shall be wye configuration for removal of controlling element without removing valve from piping. Each valve shall be identified as to direction of flow and flow rate. Each valve shall be provided with strainer in piping upstream of the coil. One differential pressure meter shall be provided complete with dual hose kit, valves, flow conversion chart and carrying case. Meter and accessories shall be turned over to the Owner upon final acceptance of the project. Valves shall be suitable for use with glycol/water configuration specified.

F. Triple Duty Valves [S]: Units shall be equal to Bell & Gossett straight pattern type for installation in vertical piping as indicated. Units shall provide functions of check valve, throttling valve, shut-off valve and calibrated valve with differential pressure ports. Valves shall be suitable for 125 psig and 250°F service. Valves shall be fitted with brass or bronze seat, replaceable bronze disc, stainless steel stem and spring. Valve rating shall not exceed 5 feet of water pressure drop at 100% flow and shall not exceed manufacturer's recommendations.

G. Radiator valves ([S]) shall be Trane, Hoffman or Webster packless manual control valves, straight or angle pattern with union joint, renewable seat, phenolic wheel handle and valve seat position indicator.

H. Thermostatic Radiator Valves ([S]) shall be equal to Danfoss series RA 2000 specifically for use with low pressure steam baseboard radiators. Valve shall be brass or bronze, straight type for horizontal mounting. Valve shall be rated for maximum 250°F and 15 psig steam pressure. Operator shall be tamper-resistant, valve mounted type with sensor and graduated dial.

I. Safety Valves [S]:
   1. Steam pressure relief valves for reducing stations shall be equal to Spirex-Sarco, bronze or cast iron body, manual test lever, suitable for steam service of sufficient capacity to relieve the full discharge capacity of the connected reducing valve. Discharge port of relief valves shall be pipe full size to 6" above roof and shall be supported so that no strain is on the valve. Valve shall be set to relieve at 5 psi above indicated operating pressure.
   2. Safety relief valves for water heating and cooling systems shall be equal to Watts ASME rated, series 740 or 174A. Valves for heating systems shall be sized to relieve the full heating capacity of the heater installed in the heating system at set pressure of 5 psi over operation pressure. Valves for cooling systems shall be 125 psi set pressure, 3/4" x 1" size. Pipe discharge port full size to floor and support so that no strain is on the valve body.

2.6 HANGERS AND SUPPORTS FOR HVAC DUCTWORK, PIPING AND EQUIPMENT

A. Suspended horizontal piping shall be supported by adjustable wrought steel clevis hangers except that straight runs of hot piping (>100°F) with 40 ft. or more between anchor and expansion device shall be supported on roller type hangers or supports. See Section 23 07 00 for calcium silicate hanger inserts at clevis hangers. All piping connected to motor driven reciprocating or rotating equipment shall have vibration isolation hangers as specified in Section 23 05 48. Protection saddle, welded to pipe, shall be provided at each roller support except on chilled water lines, saddle shall be external metal shield with calcium silicate preformed section as specified in Section 23 07 00, vapor sealed. Calcium silicate inserts may be omitted for pipe smaller than 2 inches. Where supports bear on copper pipe they shall be copper plated. Chain, strap or other makeshift devices will not be permitted as hangers of supports.

B. Maximum pipe support spacing for steel piping shall be ten feet on center, -copper and brass tubing 1-1/4" and smaller shall be supported six feet on center. Galvanized steel angles or channels shall be provided 10 feet on center across top of tunnels for support of pipes as indicated.

C. Vertical steel piping shall be guided or supported in the center of each riser and not over 15 feet on center, copper or brass tubing shall be supported at not over 10 feet on center; and supported at the base of each riser and/or at the top of each riser as required by the piping run. All vertical piping shall be guided or braced where required to prevent lateral movement. Bracing shall include auxiliary stanchions where piping is not in close proximity to suitable structure.

D. Refrigerant piping smaller than 3/4" shall be supported using B-Line Armafix clamps by Cooper Industries or equal.

E. Rigid support sway bracing shall be provided at changes in direction greater than 45 degrees for all pipe 4 inches and larger.

F. Pipe and suspended equipment hanger rods shall be attached to the top chord only on steel joists and beams by joist or beam clamps without welding. Welding of support rods and connection at any place other than the top chord will not be permitted unless written approval is granted by the Engineer and the Architect. C-clamp hangers shall be limited to 50 lb. or less when used at joists. Threaded rod shall be used through joist chords for loads greater than 50 lb.

G. Pipe and suspended equipment supported from concrete structure shall be high-strength screw anchor and threaded rod system. Anchor shall be zinc plated, heat treated, carbon steel with integral flanged head to accept threaded rod. Anchor shall be selected to provide a minimum safety factor of 2 for the load to be supported and shall be approved for use in cracked and uncracked concrete applications. Anchor shall be Simpson Strong-Tie Titen HD or equal.

H. Duct supports shall consist of not less than 1" by 1/16" galvanized strap iron hangers spaced not over 4 feet on center, except medium and high pressure flat-oval ducts wider than 48 inches shall be supported by trapeze angles. Straps shall be lapped across the bottom ducts a minimum of 1 inch. Ductwork shall be supported from the building structure. Ductwork shall not be supported from the ceiling system or any other building services. Heavy ductwork such as medium or high pressure duct supported by hanger rods, shall be attached to the top chord only on steel joists and beams by joist or beam clamps without welding. Welding of support rods and connection at any place other than the top chord will not be permitted unless written approval is granted by the Engineer and the Architect. All ductwork shall be braced as required to prevent lateral movement.

I. Roof mounted (piping and) duct supports shall be factory fabricated mounting pedestals as manufactured by Roof Products and Systems, Inc. (RPS) or equal. Pedestals shall be minimum 12 inches high, complete with equipment rail, slide channel "U" shaped mounting brackets, 18 gauge threaded galvanized rods, lateral spacer bracket and galvanized slide assembly. Supports shall be located to adequately support duct with no more than 4 feet of duct unsupported. Piping shall be secured to supports using accessories furnished by the support manufacturer.

J. Where piping is to be installed on an existing roof, pipe supports shall be pre-manufactured rubber pedestal supports, manufactured specifically for mounting on top of existing roofing systems. Pedestals shall be minimum 2.5 inches high complete with galvanized steel slide channel attached to the base. Two ½ inch diameter threaded rods 10 inches in length shall attach a galvanized steel slide channel to the base channel with the pipe being secured by a rigid steel pipe clamp. The support height shall be adjustable to accommodating a sloping pipe. Rooftop support shall be equal to RTSPUCES Rooftop Support Systems manufactured by Eberl Iron Works, Inc.

K. See Section 23 00 10 for special support requirements for Wooden Structure. Connection at any location other than those specified will not be permitted unless written approval is granted by the Engineer and the Architect. Drilling or cutting of wooden trusses shall not be permitted. See Section 23 00 10 for special support requirements for Pre-manufactured Light Gauge Metal Structure. Welding and connection at any location other than those specified will not be permitted unless written approval is granted by the Engineer and the Architect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's recommendations.

B. Support riser piping independently from the connected horizontal piping.

C. Hangers shall be spaced so that the supported load does not exceed the load recommended by the manufacturer. The supported load shall not overstress the building structural members. Where required hangers for the suspension of heavy items do not correspond with the building structural members, provide supplemental steel members fastened to the building structural members.

D. Valves in horizontal lines shall be installed with stems horizontal or above. Flanged butterfly valves shall be provided with spacer or spool piece between valve and adjacent appurtenance. Isolation service valves shall be installed on each side of each major piece of equipment such as a condenser, heating coil, cooling coil, and other similar items; and at any other points indicated or required for draining, isolation or sectionalizing purposes. Control valves shall be installed in accordance with control manufacturer's recommendations.

E. Install all thermometers and gages such that they can be easily readable standing on floor. Gages subject to vibration or physical damage shall be adequately supported and protected.

F. Where pressure/temperature ports are indicated on the drawings, they shall be provided with full port gauge cocks that allow penetration of instrument probes.

G. All outdoor water piping that does not contain glycol shall be provided with heat trace under insulation. All accessories shall be provided as necessary for a complete operating system.

H. Butterfly valves in horizontal lines shall be installed with the stem horizontal.

END OF SECTION 23 05 00

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SECTION 23 05 48 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
   1. Vibration Isolators
   2. Inertia Bases

C. Related Sections:
   1. Section 23 00 10 – HVAC General Requirements
   2. Section 23 20 00 – HVAC Piping
   3. Section 23 30 00 – HVAC Air Distribution
   4. Section 23 70 00 – Central HVAC Equipment
   5. Section 23 80 00 – Decentralized HVAC Equipment
   6. Division 26 - Electrical

1.2 QUALITY ASSURANCE

A. All vibration control apparatus shall be supplied by a single recognized manufacturer. The supplier of noise and vibration control equipment shall supervise, inspect and approve the installation of their equipment. The supplier shall submit a letter to the Engineer at the conclusion of the project stating that all items have been installed properly and that all equipment is adequately isolated.

1.3 SHOP DRAWINGS

A. Submit shop drawings and product data in accordance with Division 1.

B. Shop drawings, cuts, diagrams, catalog data sheets or such other data necessary to fully describe and substantiate compliance with the specifications shall be submitted for all vibration isolation equipment and materials. The Contractor shall submit drawings for review stating the static deflection, load capacity and location of the isolators, inertia slab dimensions and installation instructions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Kinetics Noise Control, Vibration Mountings and Control, Inc., Vibration Eliminator Co., Mason Industries, Vibro-Acoustics or Amber/Booth Company.

B. Model numbers used in this specification are those of Kinetics Noise Control and are included to establish a standard of quality.

2.2 ISOLATOR TYPES

A. Floor Mounted Equipment:

1. Type S spring vibration isolators shall be free-standing, unhoused, laterally stabile, steel springs, wound using high strength heat treated spring alloy steel, and shall have a horizontal spring stiffness equal to or greater than 1.0 times the rated vertical spring stiffness. Springs shall be selected to provide the tabulated minimum operating static deflections and shall provide a 50% overload capacity before reaching a solid state. Springs shall be designed to reach a solid state before exceeding the spring steel fatigue point. Springs used to isolate floor mounted equipment shall include a drilled and tapped steel top load plate, and a steel bottom load plate bonded to a 1/4" thick ribbed neoprene noise stop pad. Each spring mount shall include a steel leveling bolt, locknuts, and washers for attachment to supported equipment. Type S units shall be Kinetics Model FDS. Springs shall have the following minimum outside diameters:

Spring Deflection,	Rated Capacities, Lbs.		
Inches	Up to 370	371 to 1600	1601 to 11000
Up to 1.5	1.75" dia.	3.00" dia.	3.00" dia.
1.51 to 2.25	3.50"	5.0"	5.0"

2. Type 3, vertically restrained, spring mounts shall incorporate a single spring vibration isolator having all of the characteristics of Type S spring isolators as previously specified in a steel mount assembly designed to limit vertical movement of isolated equipment. If equipment loads are reduced or equipment is subject to external loads, vertical movement shall be limited without degrading the vibration isolation of the spring element during normal equipment operating conditions. The mounts shall have a flat steel top load plate, for welding to supporting equipment, vertically restrained by noise isolated bolts, connected to steel channel and drilled plated assemblies welded to a steel base plate. The base plate shall be bonded to a 1/4" thick ribbed neoprene noise stop pad and drilled for bolting to supporting structures. Type 3 units shall be Kinetics FLS.
3. Type 1 fiberglass isolators shall be precompressed molded fiberglass noise and vibration isolation pads, individually coated with a flexible moisture impervious elastomeric membrane. The fiberglass pads shall have been stabilized by ten (10) compression cycles to three (3) times the maximum published load. Load range and natural frequency shall be as recommended by the isolator manufacturer for each specific application. But, in no case shall a natural frequency higher than 12 Hz be provided for applications intended to isolate sound, nor higher than 15Hz for applications intended to isolate impact noise and shock. Type 1 units shall be Kinetics Model KIP.
4. Type N neoprene isolation mounts shall incorporate a cast-in tapped steel load plate, to permit bolting to supported equipment. The neoprene pad shall be molded using 2500 psi tensile strength, oil resistant compounds, and shall have no color additives in the compound. The neoprene isolator shall be selected to achieve the minimum operating static deflection tabulated, while not exceeding the published load capacity for the isolator used. Each neoprene isolation mount shall be externally color coded to identify load capacity, and shall incorporate a cast-in drilled steel anchor/base plate. Type N units shall be Kinetics Model RD.
5. Type NIP neoprene isolation pads shall be single rib or crossed, double rib neoprene in shear pads in combination with steel shims. Neoprene pads shall be molded using 2500 psi tensile strength, oil resistant compounds. Type NIP units shall be Kinetics Model NPS, NPD, NGS, or NGD.

B. Suspended Equipment:

1. Type 2 hangers shall consist of a steel spring and a elastomer-in-shear isolator placed in series and encased in a welded steel bracket. The spring element of the hangers shall meet all specified characteristics of a "Type S" spring as previously specified. Springs shall be color coded for ease of load capacity identification and removable for field correction of overloaded hangers. The elastomer noise stop pad shall be selected to operate within the published load range for the pad for each spring capacity when placed in the bracket used. The hanger bracket shall be designed to carry five (5) times overload without failure, and shall allow up to 15° rod misalignment without metal to metal contact. Type 2 units shall be Kinetics Model SRH.
2. Type F hangers shall consist of an elastomer-in-shear isolator encased in a welded steel bracket. The elastomer shall be bonded to the hanger bracket and shall be selected to support the load within its published load rating. The hanger bracket shall be designed to carry a five (5) times overload without failure and allow up to 15° rod misalignment without short circuiting. Type F hanger shall be Kinetics Model RH.

2.3 BASE TYPES

A. Type 7 inertia bases shall consist of a concrete slab, cast into a prefabricated inertia base frame assembly designed and supplied by the isolation materials manufacturer. Frames shall be welded steel channel with a depth greater than 8% of the longest dimension, a minimum of 6" thick, and shall include welded-in 1/2" steel reinforcing rods on 8" centers each way. Prelocated equipment anchor bolts shall be fixed into position, and housed in steel bolt sleeves allowing minor bolt location adjustment. Isolator support brackets, when required, shall be welded into the corners of perimeter channel frames with 1/2" reinforcing rods 1-1/2" above bottom of brackets running continuous in two directions between isolator brackets. Where bases are used under pumps, the base shall be large enough to support riser elbows. Type 7 bases shall be Kinetics Model CIB-L or CIB-H.

B. Type B equipment bases shall consist of structural support members, with welded on isolator support brackets, and prelocated and drilled anchor bolt holes, designed and supplied by the isolation materials manufacturer. The structural steel bases shall have beams of minimum section depth equal to 8% of the longest span between support isolators, a minimum of 6", and shall be of sizes and shapes required for equipment to be supported. Isolator support brackets shall be welded to the structural beam base as required to provide the lowest possible mounting height of supported equipment. Anchor bolt holes shall be prelocated and drilled into all equipment bases to bolt down equipment. The structural steel bases shall provide a rigid, distortion free mounting base for supporting equipment, which allows no excessive differential motion between driven equipment components. Type B bases shall be Kinetics Model SFB or SBB.

C. Type 8 bases shall be prefabricated extruded aluminum rail system using 1" deflection Type S free standing stabile springs and a continuous elastomeric air and water seal. All metal parts shall be non-corrosive or zinc plated. Each rail system shall be designed and sized specifically to fit the roof curb and the equipment proposed to receive the isolation rails. The upper portion of the equipment rail shall be designed to continuously support the weight of the equipment provided. Springs shall be spaced to provide a uniform 1" static deflection when equipment is mounted on the isolation rails. All rail sections shall be designed and arranged to shed water outward and shall be watertight. Type 8 bases shall be Kinetics Model KSR.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment: All equipment listed hereinafter shall be isolated from the structure and fixed parts by means of resilient vibration and noise isolators. Isolators for floor and roof mounted equipment shall be solidly anchored to the support base or floor and to the supported equipment unless indicated otherwise.

B. Piping and Conduit: All piping and electrical conduit connected to the chillers (including refrigerant piping), pumps, air handling units, or other pieces of moving equipment which are isolated from the structure by spring type vibration isolators shall be isolated from these units by flexible pipe connectors and shall be suspended on isolation hangers to a point 10 feet away. Use Type 2 hangers for suspended piping, Type S mounts for floor mounted piping. Flexible pipe connectors are specified as part of the piping work.

C. Ductwork: Flexible connections shall be incorporated in the ductwork adjacent to all air moving units as part of the sheet metal work. Ductwork shall be suspended on Type F hangers for a distance of 10 feet from these units.

3.2 MINIMUM VIBRATION ISOLATOR STATIC DEFLECTION

Type of Equipment	Base Type	Isolator Type	Deflection, In.
Unit Ventilators	N/A	NIP	.25
Rooftop Air Conditioning Units	8	S	1

3.3 EQUIPMENT WITH INTERNAL ISOLATION

A. Where air handling units have fan and motor assembly internally isolated from the unit casing, using both spring isolators and flexible fan discharge connections, external isolators for the air handling unit shall not be provided.

END OF SECTION 23 05 48

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
1. Prepare and paint Division 23 equipment, accessories, ductwork, piping and miscellaneous materials located in Equipment Rooms, Boiler Rooms, pipe trenches and other utility areas housing mechanical equipment and materials.
2. Identification of piping in exposed and accessible locations.
3. Marking and designation of equipment.

C. Work Not Included:
1. Painting of ductwork, piping or equipment located on the building exterior.
2. Painting of ductwork, piping or equipment exposed in finished areas other than those listed under WORK INCLUDED above.
3. Painting of existing equipment, piping or ductwork.

D. Related Sections:
1. Section 09 90 00 – Painting and Coating
2. Section 23 00 10 – HVAC General Requirements
3. Section 23 05 00 – Common Work Results for HVAC
4. Section 23 07 00 – HVAC Insulation
5. Section 23 09 00 – Instrumentation and Control for HVAC
6. Section 23 20 00 – HVAC Piping
7. Section 23 30 00 – HVAC Air Distribution
8. Section 23 70 00 – Central HVAC Equipment
9. Section 23 80 00 – Decentralized HVAC Equipment
10. Division 26 - Electrical

1.2 REFERENCED STANDARDS:

A. General: The following standards or codes (latest edition) form a part of this specification to the extent indicated by the reference thereto.

B. American National Standards Institute (ANSI):
1. ANSI A13.1 Scheme for Identification of Piping Systems

C. American Society for Testing and Materials (ASTM):
1. ASTM E 84 Standard Test Method for Surface Burning Characteristics of Building Materials
2. ASTM C 411 Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation

D. National Fire Protection Association (NFPA):
1. Standard 255 Method of Test of Surface Burning Characteristics of Building Materials

E. Underwriters Laboratories, Inc. (UL)
1. Standard 723 Tests for Surface Burning Characteristics of Building Materials

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Except as otherwise specified, materials shall be the products of the following manufacturers:
   1. Sherwin-Williams
   2. Pratt and Lambert
   3. Pittsburgh Paints (PPG)
   4. Benjamin Moore
   5. Porter Paints
   6. Seton Identification Products

2.2 MATERIALS:

A. Deliver all paints and materials to the project site in their unopened original containers with all labels intact and legible at the time of use.

B. All coatings exposed to supply and return airstreams and where applied to exposed surfaces in a return air plenum, shall have a composite flame spread rating not exceeding 25, and a smoke developed rating not exceeding 50 as tested under procedure ASTM E-84-75, NFPA 255 and UL 723. Coatings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411, latest edition.

C. Sherwin-Williams Industrial Maintenance Coatings System 4000 products are listed below to establish color and a standard of quality.
   1. All Hangers and Supports: One coat Series 54 Gloss Black Alkyd Enamel.
   2. All major items of equipment and equipment supports including air handling units, condensers, fans and all other similar items shall be painted as follows:
      a. Uninsulated hot surfaces on equipment, operating at or above 150°F, shall be painted with two coats of No. B59S8 Heat Resistant Aluminum.
      b. Other equipment surfaces of aluminum, iron and steel shall be primed with one coat of No. B50Y1 Zinc Chromate Primer. Galvanized surfaces shall be chemically prepared and primed with one coat of Galvite B50W3 Primer. Field insulated surfaces shall be primed with No. B28W200 Wall Primer. Where equipment is furnished with factory prime or finish coat, only patch priming is required at any damaged areas before finish coats are applied. Finish all equipment with two coats of Series 54 Alkyd Gloss Enamel, No. SW4063 Robotic Blue. Exterior of belt guards and other protective guards shall be finished with two coats of Series 54 Alkyd Gloss Enamel, No. SW4084 safety yellow color. Interior of and all items covered by belt guards and other protective guards shall be finished with two coats of No. SW4083 safety orange color.
      c. Nameplates and Testing Agency Labels on equipment or machinery shall not be painted.
   3. Ducts:
      a. Interior duct behind all grilles, registers and diffusers shall be painted with one coat of flat black prime or flat black finish paint.
      b. Exposed in equipment rooms and other unfinished areas such as storage areas and utility type spaces; uninsulated galvanized steel ducts shall be chemically prepared and primed with one coat of Galvite B50W3 Primer. Aluminum ducts and insulated ducts with aluminum jacket shall be primed with one coat of No. B50Y1 Zinc Chromate Primer. Canvas or paper insulation jacket shall be primed with one coat of No. B28W200 Wall Primer. Finish with Series 54 Alkyd Gloss Enamel, gray No. SW4028 Gypsum applied in sufficient number of coats to effectively cover the prime coat.
   4. Piping: Exposed in equipment rooms and where connections are made to equipment located in storage rooms and other utility type areas.
      a. Priming:
         1) Insulation Canvas or Paper Jacket: One coat No. B28W200 Wall Primer.
         2) Insulation Aluminum Jacket: One coat No. B50Y1 Zinc Chromate Primer.
         3) Bare Iron or Steel or Copper: One coat No. B50Y1 Zinc Chromate Primer.
         4) Galvanized Steel: Pipes and ductwork shall be chemically prepared and primed with one coat of Galvite B50W3 Primer.
         5) Asphalt Coated Pipe: One coat No. B28W200 Wall Primer.
      b. Finish: All pipe lines and the supports or hangers therefore, shall be finished with Series 54 Alkyd Gloss Enamel, gray No. SW4028 Gypsum applied in sufficient number of coats to effectively cover the prime coat. Painting of pipe hangers is specified hereinbefore.
      c. Materials shall be as recommended by the manufacturer for the surface to be finished.

d. Unless otherwise specified, primer shall be by the same manufacturer as the finish coat.
e. Materials shall not be thinned or cut except as recommended by the coating manufacturer. Thinners shall be by the same manufacturer as the primer and finish coat.

D. Valve tags ([S]) shall be neat circular brass with designations stamped thereon, attached with solid brass jack chain to each valve stem or handle.

E. Each item of equipment such as pumps, air handlers, etc., and equipment control devices such as motor starters, disconnect switches, etc. shall be properly marked with laminated engraved plastic nameplates ([S]) fastened with sheet metal screws, bolts or permanent adhesive. Pressure sensitive tape is not acceptable.

F. All piping, insulated and uninsulated, shall be identified ([S]) with Seton Setmark or equal wrap around piping system markers and arrow flow directional marker. Markers shall be pre-coiled, semi-rigid plenum-rated plastic or polyester with sealed color graphics. Markers shall be minimum 12 inches long with 1-¼ inch high letters, formed to cover entire circumference of the pipe. Markers shall be attached to piping using plenum-rated plastic tie wraps. Pipe identification shall use the same designations or abbreviations used on the drawings. Marker colors shall be in accordance with ANSI.

PART 3 - EXECUTION

3.1 WORKMANSHIP:

A. The work shall be accomplished by qualified mechanics skilled in the painting trade. Painting of equipment, piping, ductwork and other materials shall not commence until all testing is complete and systems are ready for operation. Materials shall be applied according to manufacturer's directions. All containers shall be securely closed when not in use. Flammable materials shall not be stored on premises. Flammable waste shall be disposed of daily in devices approved for such purposes. Materials shall be evenly spread, and smoothly flowed on without runs or sags. Each coat shall be thoroughly dry before application of succeeding coats.

3.2 PROTECTION OF WORK:

A. The painters shall protect all adjacent surfaces with drop covers during the process of painting. Upon completion, paint spots, if any, shall be removed from all surfaces.

3.3 PREPARATION OF SURFACE:

A. Surfaces to be painted shall be completely dry before applying paint. Metal surfaces shall be cleaned with mineral spirits before applying materials. Rust and scale shall be removed by wire brushing or sanding. Galvanized surfaces shall be chemically pretreated with crystalline (zinc phosphate) phosphate in strict accordance with the manufacturer's recommendations. Surfaces shall not be painted when the temperature is, or is likely to be, near the freezing point, nor when they are exposed to hot sun.

3.4 IDENTIFICATION OF PIPES AND EQUIPMENT:

A. Equipment: After <u>all</u> other painting is completed, each piece of equipment shall be properly identified with nameplates. Identification symbols and designations shall be the same as shown on the Contract Documents. Where equipment is installed above lay-in ceilings (dampers, or similar), an additional plastic nameplate shall be adhered to the face of the T-bar support so that it can be identified from within the space.

B. Apply piping system markers after completion of required insulation and finishes on piping systems. Markers shall be applied in the following locations and where identified by the Engineer:
1. At each valve and at connection to equipment.
2. At every tee and branch connection.
3. At each riser including branch risers from mains.
4. At each side of a pipe passage through floors, walls and partitions.

5. Every 15 feet on straight runs of piping mains and branches.
6. Within 6 feet of elbows (each side).
7. At access doors or similar points that permit view of concealed piping.
8. Markers shall be provided on all piping above lay-in ceilings.
9. Provide arrow markers showing direction of flow incorporated into, or adjacent to, each piping system marker.
10. Apply all piping system markers where view is unobstructed, and legends can be read and easily identified.
11. Apply all tags and piping system markers in accordance with the supplier's instructions.

END OF SECTION 23 05 53

SECTION 23 05 93 - TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
1. Cleaning
2. Adjusting and Balancing

C. Related Sections:
1. Division 01 -- Commissioning
2. Section 23 00 10 – HVAC General Requirements
3. Section 23 05 00 – Common Work Results for HVAC
4. Section 23 07 00 – HVAC Insulation
5. Section 23 09 00 – Instrumentation and Control for HVAC
6. Section 23 20 00 – HVAC Piping
7. Section 23 30 00 – HVAC Air Distribution
8. Section 23 70 00 – Central HVAC Equipment
9. Section 23 80 00 – Decentralized HVAC Equipment

1.2 REFERENCES

A. General: The following publications listed below, form a part of this specification to the extent indicated by the reference thereto.

B. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA):

Balancing and Adjustment Manual

C. Associated Air Balancing Council (AABC):

National Standards for Total System Balance

D. National Environmental Balancing Bureau (NEBB):

Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

E. American Petroleum Institute:

Publication 1615 Installation of Underground Petroleum Storage System

1.3 QUALIFICATIONS

A. For the air conditioning, heating and ventilation systems the Contractor shall obtain the services of a qualified, independent testing organization specializing in total system air and water testing and balancing. The Contractor shall be responsible for making changes in pulleys, belts and dampers where necessary to obtain the required air volume as determined by the Testing and Balancing Contractor. The Testing and Balancing Contractor shall provide all labor, engineering and test equipment required to adjust, test and balance all heating, ventilating, air conditioning and exhaust systems as hereinafter specified. All

personnel involved in the execution of the work under the balancing contract shall be experienced and factory trained specifically in the total balancing of mechanical systems, as well as being regular employees of the Balancing Contractor. The Test and Balance Contractor shall work in close coordination with the Controls Contractor to ensure that the system is operating as designed and to aid in adjusting setpoints as necessary for proper system operation.

1.4 TAB COORDINATION AND RESPONSIBILITIES

A. The TAB Agent shall provide the following:
   1. All instrumentation used in the course of testing and balancing shall be accurate and shall have been calibrated within the six months prior to commencing test and balance work for this project.
   2. Where existing air or hydronic systems are to be renovated, the TAB Contractor shall provide a complete measurement of air and water flow for systems indicated to remain prior to any construction or demolition of existing systems. For air systems, the data shall be taken and recorded for each piece of air handling equipment serving the area of renovation and those indicated on the drawings for ductwork or other mechanical renovations. Data shall be provided as outlined for balancing data hereinafter. For hydronic systems, pump flow data for each system shall be provided as well as flow to each terminal device being modified, replaced, or removed. Any discrepancies in the data shall be reported to the Architect/Engineer prior to commencing any mechanical work.
   3. The TAB Agent shall conduct a pre-TAB inspection two weeks prior to commencing the test and balance. The TAB Agent shall notify the Contractor in writing of any deficiencies that would affect the ability to successfully complete the test and balance or result in an incomplete or unacceptable report.
   4. During the course of the test and balance, the TAB Agent shall immediately notify the Contractor of any equipment or system discrepancies discovered that need to be corrected prior to the satisfactory completion of the test and balance procedures.
   5. Equipment settings, including damper positions, valve positions, fan speed controls, and similar devices shall be marked to show final settings.

B. The Contractor shall provide the following:
   1. Prior to the commencement of testing and balancing, the installation of building systems shall be fully complete. Building controls systems shall be complete, operational, and verified by the Contractor.
   2. The Contractor shall resolve any discrepancies noted by the TAB Agent in the Pre-TAB Inspection prior to commencing the test and balance. The Contractor shall provide written confirmation of the corrective action that was taken to correct each deficiency.
   3. The Contractor shall make available qualified personnel during the period in which the test and balance is being conducted for the purpose of problem resolution and controls support.
   4. The Contractor shall resolve any deficiencies noted by the TAB Agent prior to the submission of the report and prior to any subsequent visits required by the TAB Agent.

1.5 SUBMITTALS

A. Prior to commencing work under this section, the Contractor shall submit the name of the testing organization, a proof of certification by the Associated Air Balance Council or National Environmental Balancing Bureau, and a list of five local projects on which testing and balancing has been completed for two years, for approval by the Architect/Engineer. The submittal shall include TAB procedures proposed for the systems specific to this project.

B. As part of the submittal, the Contractor shall provide a list of any conditions where balancing or testing cannot be accomplished due to access or other project conditions.

C. Heating, Air Conditioning and Ventilation Systems Balance and Performance Data: At a time no later than the Substantial Completion Inspection, the Contractor shall provide the Architect/Engineer with two (2) typewritten copies of schedules containing air and water system balance and performance data.

D. Equipment and System Verification: Letters, signed by representatives of boiler, chiller, cooling tower, heat pump, air conditioning unit, and temperature control manufacturers, shall attest that their respective equipment installed on this project has been started, tested and set to operate safely and at the control points required as an integral part of the systems specified herein. The Contractor shall attest by letter that all equipment has been wired and tested to see that the indicated sequence of motor control is

established, that all safety controls function properly, that all motor protective devices are sized correctly and that the systems are operating at the points set on the controls. The Engineers will not conduct a site visit for the purpose of determining the status of final payment until these letters are received.

E. Test data shall be submitted for all equipment and systems where specifically required by this specification and all items identified with [TD] behind the product data.

1.6 COMMISSIONING OF HVAC SYSTEMS

A. Participate in Commissioning Meetings designated by the Commissioning Agent.

B. Participate in resolving controls issues identified by the Commissioning Agent.

C. Notify Commissioning Agent a minimum of 2 weeks in advance of start-up of Testing, Adjusting and Balancing (TAB) work. Arrange and attend meeting between Commissioning Agent and TAB agency for review of TAB procedures, TAB work plan, and TAB schedule. Refer to Division 1 for complete scope of Commissioning work.

D. Provide Commissioning Agent with a copy of preliminary and final balance reports.

1.7 CONDITIONS

A. Partial Testing: As much as practical, systems shall be tested as complete systems. Tests on portions of a system will be permitted to facilitate proper progress scheduling. When systems are tested in segments, a system diagram indicating portion tested and a separate and complete report including the date of test is required for each segment.

B. Concealed Work:
1. All concealed work shall be tested and approved by the Architect/Engineer prior to the application of insulation or construction of chase walls.
2. Covering shall not be applied to any piping nor shall any piping be concealed or covered until pipes have been tested, all leaks stopped, retested and approved.
3. Where ductwork is inside a shaft or chase, TAB agent shall coordinate with Contractor to make the required traverses before shaft walls are closed in, or shall make provisions to allow for traverse to be done at a later date through fire rated (where required) access door of adequate size for full traverse.

C. Work in Existing Buildings: Where new piping systems are connected to existing systems, test the new system prior to making connections to existing system. Connections to existing systems are not to be tested unless required by local authorities.

PART 2 - PRODUCTS

2.1 GENERAL

A. All equipment, instruments, materials and utilities required for cleaning, testing and balancing of the air and hydronic systems shall be provided by the Contractor.

2.2 INSTRUMENTATION

A. All instruments used by this Contractor shall be accurately calibrated and maintained in good working condition.

2.3 TESTS OF MATERIALS

A. Manufacturers' certificates will be accepted in lieu of tests of materials. If individual laboratory tests are desired by the Architect-Engineer, they will be secured by this Contractor and paid for by the Owner.

PART 3 - EXECUTION

3.1 CLEANING

A. Equipment shall be wiped clean to remove all dust, oil, dirt or paint spots. Trash, plaster, mortar or paint shall be removed from all coils, plenums and end pockets.

B. Heating Piping, Cooling Piping and Ductwork shall be thoroughly blown out or flushed and cleaned of all foreign matter before connections are made to equipment. Temporary bypasses shall be provided around coils, control valves, ice tanks, heat exchangers and other similar items to prevent trash from being flushed into these items. Care shall be taken at time of installation to prevent pipe compound, scale or other objectionable matter from entering the piping systems. Strainers shall be cleaned. After all construction dirt has been removed from the building, new filters shall be installed in all air units.

3.2 ADJUSTING AND BALANCING:

A. Equipment: Before attempting to adjust and balance the air and water systems, the Contractor shall verify that the following items have been completed and are correct.
1. Motor and bearings are properly lubricated.
2. Direction of rotation of motors.
3. Belt tension.
4. Electric current flow in each phase of motors and electric heating elements.
5. Motor protective devices are sized to properly protect installed motors.
6. Thermostats, controls, accessories and other items requiring setting or adjustment shall be set as indicated.

B. Air System Balancing Procedure:
1. Place all related supply, exhaust and return air systems in operation with the fans running at design RPM.
2. Establish system conditions for the maximum demand in airflow; generally, a cooling application. Variable volume systems shall be set and balanced such that the systems are operating at minimum static pressure necessary to maintain proper airflow at the terminal devices.
3. Measure supply air volumes by means of the duct traverse method, making a minimum of sixteen (16) readings. Test holes shall be in straight duct as far as possible downstream from elbows, takeoffs, dampers, etc. Seal duct access holes with metal snap-in plugs. The use of duct tape to seal access holes will not be permitted.
4. Adjust balancing dampers for required branch duct air quantities. Ducts with multiple branches shall have at least one branch with volume damper(s) completely open.
5. Adjust grilles and diffusers to within deviations listed below of individual requirements specified, and also adjust so as to minimize drafts and sound in all areas. Restriction imposed by flow regulating devices in or at terminals shall be minimal. Final measurement of air quantity shall be made after optimum air pattern has been achieved.

System Type	CFM Range	Allowable Deviation
Supply\Return	0-50	+ or –5 CFM
	50-1,000	+ or – 10%
	>1,000	+ or – 5%
Exhaust	0-50	+ 5 CFM
	50-1,000	+ 10%
	>1,000	+ 5%

6. The total air delivery in any particular fan system shall be obtained by adjustment of the particular fan speed. The drive motor of each fan shall not be loaded over the corrected full load amperage rating of the motor involved. Where belt drive fans are used in conjunction with VFD's, the fan speed shall be adjusted by changing pulleys such that fan speed to achieve design airflow occurs at 60 Hz. These sheave and pulley changes shall be included in the Contractors scope of work.

7. Adjust quantity of air on each zone to the values given in the specifications and/or plans.
8. If the supply fan volume, return fan volume, and outdoor air volume are not within plus or minus 5% of the design capacity at design RPM, determine the reason by reviewing all system conditions, procedures and recorded data. Check and record the air pressure drop across filters, coils, eliminators, sound traps, etc., to see if excessive loss is occurring. Particularly study duct and casing conditions at the fan inlet and outlet.
9. Any changes that are required for the final balancing results will be provided for by the respective Contractors who supplied and installed such equipment under their contractual obligations. Such changes may encompass, but are not necessarily restricted to, the changing of pulleys, belts, dampers or adding dampers or access holes.

C. Water Systems Balancing Procedure.
1. Prior to commencing water balancing, the TAB Agent shall confirm that all systems have been properly filled and bled of air; strainers have been cleaned, and balancing valves (except bypass valves) are fully open.
2. All heating, cooling and condensing water systems shall be adjusted to provide required quantity to or through each component as indicated on drawings.
3. Venturi tubes, orifices or other metering fittings and pressure gauges shall be used to measure water flow rates and balance systems.
4. Systems shall be adjusted to provide the approved pressure drops through the heat transfer equipment (coils, converters, etc.) prior to the capacity testing.
5. Where flow metering fittings are not installed, flow balance shall be determined by measuring temperature differential across the heat transfer equipment.
6. Automatic control valves shall be positioned for full flow through the heat transfer equipment of the system during tests. Flow through by-pass circuits at three-way valves shall be adjusted to balance that through the supply circuit.
7. Adjustment of distribution shall be effected by means of balancing devices (cocks, valves and fittings) and automatic flow control valves as provided; service valves shall not be used.
8. Where automatic flow control valves are utilized only pressure differential need be recorded, provided that the pressure is at least the minimum applicable to the tag rating.
9. Where available pump capacity (as designed) is less than total flow requirements of individual heat transfer units of system served, full flow may be simulated by the temporary restriction of flow to portions of the system; specific procedures shall be delineated in the agenda.
10. Steam condensate pump discharge balancing cock shall be set for the discharge pressure indicated in the equipment notes.
11. If the pump flow is not within plus or minus 5% of the design capacity at design RPM, determine the reason by reviewing all system conditions, procedures and recorded data.
12. Any changes that are required for the final balancing results will be provided for by the respective Contractors who supplied and installed such equipment under their contractual obligations. Such changes may encompass, but are not necessarily restricted to, the changing or trimming of impellers.
13. Pump speed shall be modulated prior to closing the triple duty valve when balancing, however, the maximum VFD speed shall not be so low that the minimum flow is not achievable when the VFD is at minimum. The full range of flow shall be available at all times. The intent is to have the triple duty valve as open as possible

D. Compensating for Diversity.
1. When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

3.3 BALANCE AND PERFORMANCE DATA REPORT [TD]:

A. General: Each heating, ventilating and air conditioning system shall be operated and tested continuously for at least two consecutive days to verify that the system is operating satisfactorily and safely and that all equipment is producing the required capacity. To be successful, this test must be conducted with all controls in automatic position and all lights on or off to simulate day time or night time use of the building. Submit two typewritten copies of reports covering air and water system balance and performance. Reports must be received by the Architect-Engineer at least one week prior to the Contractor's request for a substantial completion inspection. Reports that contain deficiencies related to incomplete or improper system installation will be rejected by the Engineer without further review.

B. Calibration Data: The report shall include a list of all instrumentation used and the date of the most recent calibration for each instrument.

C. Balance Data: The following balance data shall be provided. Design and actual water and air flows shall be provided in tabular form.
   1. All Air Handling and Air Conditioning Equipment Used for Heating, Cooling and Ventilating:
      a. System nomenclature and identification.
      b. Nameplate information: Manufacturer, model and serial number, horsepower, rpm, voltage, phase, maximum amperage.
      c. Fan speed.
      d. Static pressure profile – reading between all components and total external static pressure.
      e. Outside, return, and supply air quantities.
      f. Actual running motor amperage.
      g. For all VAV units, provide location of downstream static pressure sensor, set point (if applicable), and reading.
      h. For all VAV units, provide VFD speed setting (Hz) at both minimum and maximum flow (at final balanced condition).
      i. Final fan operating point plotted on appropriate fan curve.
   2. Fans:
      a. System nomenclature and identification.
      b. Nameplate information: Manufacturer, model and serial number, horsepower, rpm, voltage, phase, maximum amperage.
      c. Fan speed.
      d. Total external static pressure.
      e. Air quantity.
      f. Actual running motor amperage.
      g. Final fan operating point plotted on appropriate fan curve.
   3. Air Outlet and Inlet:
      a. Room identification.
      b. Manufacturer.
      c. Size.
      d. Free area factor.
      e. Air quantity.
      f. Velocity.
   4. All Hydronic Coils and heat exchangers:
      a. Coil nomenclature and identification.
      b. Flow control valve nameplate information: Manufacturer, model and serial number.
      c. Differential pressure across flow control valve.
      d. Differential water pressure across the coil or heat exchanger.
      e. Design and actual GPM.
   5. Boilers:
      a. Nameplate information: Manufacturer, model and serial number.
      b. Water flow through each boiler (hot water).
      c. Check for proper, steady water level (steam).
   6. Glycol Feed Unit:
      a. Nameplate information: Manufacturer, model and serial number
      b. Pressure switch setting for each system.

D. Performance Data: The following information shall be recorded twice each day and twice each night during the performance test. Reading shall be taken for each item at a different time each succeeding day at least two hours later than the time the reading was taken on the preceding day.
   1. Water Boiler:
      a. Nameplate information: Manufacturer, model and serial number.
      b. Boiler identification number.
      c. Boiler water flow.
      d. Water supply and return temperature.
      e. Boiler stack temperature and CO_2.
   2. Steam Boiler:
      a. Nameplate information: Manufacturer, model and serial number.
      b. Boiler identification number.
      c. Steam pressure.
      d. Boiler stack temperature and CO_2.
   3. Heat Exchanger:
      a. Nameplate information: Manufacturer, model and serial number.
      b. (Steam pressure) Water supply and return temperature through each side.
      c. Water flow.

d. Entering and leaving water temperature (through each side).

4. Hot Water Reset Valve:
   a. Heating water system supply and return temperature.
   b. Outside air temperature.
5. All Air Handling and Air Conditioning Equipment Used for Heating, Cooling and Ventilating (except for unit heaters, VAV boxes, and cabinet unit heaters):
   a. System nomenclature and identification.
   b. Dry bulb and wet bulb temperatures entering and leaving all coils.
   c. Water flow through all coils.
   d. Water temperatures entering and leaving all coils.
   e. Water pressure drop through all coils.
6. Space Pressurization:
   a. Measure and record space pressurization in corridor served by each major air handling unit.
   b. Coordinate with Controls Contactor for fan speed adjustments to achieve space pressurization setpoint of 0.05" w.c. (adjustable).
7. Temperature: Each Room in Building. Temperature measurements shall be taken with the Contractor's calibrated equipment. Trended data from the temperature control system is not acceptable.

E. Control Setting: During the performance and balance tests, control settings may require adjustment, and if so, shall be adjusted to produce the best balanced system operation. The final setting of each operating and safety control shall be recorded. This shall include, but not be limited to, thermostats, limit controls, damper position switches, firestats, freezestats, humidistats, aquastats and other similar items.

3.4 HVAC SYSTEMS FINAL TESTS:

A. Upon completion of the work, in accordance with these drawings and specifications, the Contractor shall make a final test in the presence of the Architect-Engineer. With all equipment energized and all controls in automatic position, the systems and equipment specified herein shall be proven to operate safely and to heat and cool the structure uniformly. If not, adjustments and corrections shall be made until satisfactory operation is achieved.

B. At the time of final inspection, the Contractor shall recheck, in the presence of the Engineer and Owner, random selections of water and air quantities, and air motion recorded in the certified report. In general, selections for recheck will not exceed 25 percent of the total number tabulated in the report.

3.5 HVAC SYSTEM POST ACCEPTANCE TESTS:

A. Should completion of the building occur at such time that the required performance test must be conducted and test data recorded and submitted during a season when both heating and cooling system performance cannot be checked, the Contractor shall perform the tests and record all such data as is available with system operating automatically under the prevailing weather conditions. That part of the system portion which cannot be recorded because of the prevailing weather shall be delayed until the weather is appropriate at which time the remaining part of the required tests shall be conducted and data recorded accordingly. Portions of the tests may not be delayed without written consent of the Engineer.

END OF SECTION 23 05 93

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SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
1. Piping Insulation
2. Ductwork Insulation
3. Equipment Insulation

C. Related Sections:
1. Section 23 00 10 – HVAC General Requirements
2. Section 23 05 00 – Common Work Results for HVAC
3. Section 23 20 00 – HVAC Piping
4. Section 23 30 00 – HVAC Air Distribution
5. Section 23 70 00 – Central HVAC Equipment
6. Section 23 80 00 – Decentralized HVAC Equipment

1.2 SUBMITTALS:

A. Submit shop drawings in accordance with Division 1 and Section 23 00 10.

B. Submit shop drawings and catalog data for each type of material proposed for this project. Indicate thickness of material for individual services, and installation methods.

1.3 REFERENCES:

A. General: The following standards or codes (latest edition) form a part of this specification to the extent indicated by the reference thereto.

B. American Society for Testing and Materials (ASTM):

ASTM E 84 Standard Test Method for Surface Burning Characteristics of Building materials.

ASTM C 411 Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation

C. National Fire Protection Association (NFPA):

Standard 255 Method of Test of Surface Burning Characteristics of Building Materials

D. Underwriters Laboratories, Inc. (UL)

Standard 723 Tests for Surface Burning Characteristics of Building Materials

PART 2 - PRODUCTS:

2.1 GENERAL

A. Acceptable Manufacturers:
1. Manville, Owens Corning, Armstrong, IMCOA, Knauff or Certain-Teed except where specific manufacturer is named.

B. All insulation materials, jackets and fitting covers shall have a composite flame spread rating not exceeding 25, and a smoke developed rating not exceeding 50 as tested under procedure ASTM E-84-75, NFPA 255 and UL 723. Duct coverings and linings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411.

2.2 MATERIALS

A. Piping:
1. Hot Water (100°-225°F): Fine heavy density fibrous glass, rigid phenolic foam or calcium silicate insulation with general purpose jacket, molded to conform to piping, 0.25 btu•in./sq.ft./°F/hr. maximum “K” value at 75°F.
2. Hot Water (100°-225°F), Steam and Steam Condensate: Fine heavy density fibrous glass or calcium silicate insulation with general purpose jacket molded to conform to piping, 0.30 btu•in./sq.ft./°F/hr. maximum “K” value at 200°F (mean).
3. Refrigerant and Interior Condensate Drain Piping: Closed cell flexible elastomeric insulation, 0.28 btu•in./sq.ft./°F/hr. maximum “K” value at 75°F., maximum water vapor transmission rating of 0.1 perms-inch. Insulation located outside the building shall have a selective finish to protect insulation from ultra violet (UV) solar radiation, unless specifically designed to withstand UV radiation. Insulation on underground and underfloor piping shall be closed cell polyolefin, 1” thick, with water vapor transmission rating of 0 perms-inch.

B. Ductwork:
1. Exposed Rectangular Ducts: Rigid fibrous glass insulation, 3.0 lb. density, 0.24 btu•in./sq.ft./°F/hr. maximum “K” value at 75°F, with factory applied reinforced aluminum foil vapor barrier.
2. Round Ducts, Flat Oval Ducts and Concealed Rectangular Ducts: Flexible fibrous glass insulation, 1.0 lb. density, 0.27 btu•in./sq.ft./°F/hr. maximum “K” value at 75°F, with factory applied reinforced aluminum foil vapor barrier.
3. Acoustic Lining (where indicated and/or noted on Drawings): Fiberglass insulation, 0.26 btu•in./sq.ft./°F/hr. maximum “K” value at 75°F, absolute roughness of exposed surface shall not exceed 0.005 ft., coated to prevent erosion at air velocities up to 2000 fpm, 1.5 lbs/cu.ft. minimum density. Noise reduction co-efficient shall average not less than 0.60 when tested by Acoustical Material Association procedure mounting 6. Liner shall be provided with EPA approved biocide in the erosion coating to protect against microbial growth. Liner shall meet or exceed requirements of ASTM G21 (fungi resistance) and ASTM G22 (bacterial resistance). Acoustic lining shall be one inch thick unless specifically noted otherwise.

C. Duct and Equipment lagging [S] shall by Kinetics KNM mass-loaded. Limp, vinyl barrier material and shall consist of a single layer of loaded vinyl noise barrier. The loaded vinyl noise barrier shall have a density of 1.0 PSF or 2.0 PSF, as noted on the Drawings, and a thickness of .10 inches for 1 PSF type and .20 inches for 2 PSF type. STC rating shall be 26 or greater for 1 PSF type and 31 for 2 PSF type. All materials shall be suitable for installation in a plenum.

D. Hot and Cold Equipment: Rigid fibrous glass insulation molded or fitted to conform to equipment, 0.24 btu•in./sq.ft./°F/hr. maximum “K” value at 75°F.

E. Sealants, Mastics and Adhesives: Products either manufactured by or recommended by the insulation material manufacturer.

PART 3 - EXECUTION:

3.1 PREPARATION

A. Do not install insulation before piping, medium/high pressure ductwork and equipment have been tested and approved.

B. Ensure surface is clean and dry prior to installation. Ensure insulation material is undamaged and dry before application. Finish with system at operating conditions and temperature.

3.2 INSTALLATION

A. General: Ensure insulation is continuous through inside walls and partitions. Insulated piping passing through (smoke barriers,) smoke partitions, fire walls, fire partitions, and fire rated floors shall have insulation of type, thickness and density to match U.L. Through-Penetration Firestop Systems as specified in Section 23 00 10 under Sleeves and Inserts. Insulated piping passing through nonfireresistance rated floors shall be fireblocked as specified in Section 23 00 10 under Sleeves and Inserts. Insulated ducts passing through smoke partitions and fire rated assemblies where a fire damper is not required shall be insulated with calcium silicate for a length equal to twice the thickness of the wall with all voids between the sleeve and duct insulation tightly packed with mineral-wool insulation or U.L. approved packing with sealant. All penetrations through equipment room walls and other areas of noise or heat generation shall be tightly sealed with mineral fiber rope. Finish insulation neatly at hangers, supports and other protrusions.

B. Piping:
   1. General:
      a. All pipe insulation (except refrigerant piping) shall be secured with outward clinching stainless steel staples and sealer.
      b. Fittings and valves shall be insulated and jacketed with the same material as the adjacent piping or it may be finished with a smooth coat of approved insulating cement and jacketed with an approved recovering cloth and vapor sealed. Where PVC fitting covers are used, insulation shall be wrapped tightly using sufficient quantities to prevent deformation of covers.

         OR

         Use mitered segments of insulation on elbows and oversized insulation on valves and tees coated with two coats of vapor barrier mastic, reinforced with glass fabric extending two inches onto adjacent pipes, and same diameter as adjoining covering. No plastic materials on fittings will be allowed.
      c. Mitering of straight pipe insulation to form elbows will not be acceptable or allowed.
      d. All jacket joints and seams shall be lapped not less than 2".
      e. Insulation exposed to weather (and insulation exposed to abuse in finished spaces) shall be covered with minimum 0.016 aluminum jacket with all joints sealed weather-tight.
      f. Insulation at pipe hangers (except for rain conductors and domestic water piping 2" size and smaller) shall be calcium silicate in preformed sections 12" long enclosing pipe around entire circumference. Insulation at pipe hangers for domestic water piping 2" size and smaller shall be as specified for piping. Pipe hangers shall be oversized to enclose pipe and insulation. Provide sheet metal saddle between hanger and insulated pipe. Pipe hanger insulation shall be as manufactured by Pipe Shields, Inc., Bergen-Power Pipe Supports, Inc., Rilco Mfg. Co., Inc. or Valued Engineered Products, Inc.
      g. Elastomeric and other foam insulations shall be installed without stretching or compressing individual lengths.
      h. (Jacket all exposed insulated piping, fittings and equipment with 8 oz. Canvas jacket pasted on smoothly with Foster 95-90 adhesive and the entire outer surface shall receive one flooding brush coat of Foster 81-42 fire retardant white coating.)
   2. Hot Piping:
      a. Insulation shall be terminated neatly at unions, flanges, and valves. All exposed edges of insulation materials shall be sealed.
      b. Where heating coils are located downstream from cooling coils and at variable air volume units, piping shall be insulated continuously up to the coil. Insulation shall be vapor sealed and installed as specified for cold piping for a distance of 5 feet from the coil.

3. Refrigerant Piping: Cover all valves and fittings with equivalent thickness of insulating material. All edges shall be tightly butted. Seal all joints vapor tight.

C. Ductwork:
1. External:
   a. Rigid duct insulation shall be secured to rectangular ducts with mechanical fasteners such as metal stick clips or cupped head weld pins located a maximum of 3" from each edge and spaced a maximum of 12" on center each way. All insulation joints shall be tightly butted. All joints, voids and punctures in facing shall be sealed vapor tight with pressure sensitive foil tape and mastic.
   b. Flexible duct insulation shall be provided with a minimum 2" facing flap overlapping adjacent and connecting insulation. Seams shall be stapled approximately 6" on center with ½" outward clinching staples. Where rectangular ducts are 24" in width or greater, insulation shall be secured to the bottom of the duct with mechanical fasteners to prevent sagging. All insulation joints shall be tightly butted. All joints, voids and punctures in facing shall be sealed vapor tight with mastic.
2. Internal: The lining shall be applied to cut-to-size pieces fastened to the entire interior of the duct with mastic, stick clips and speed washers. Edges and joints shall be coated with fire resistant mastic. External duct insulation is not required on ducts with internal lining unless noted otherwise. External duct insulation shall be provided on all ducts with, or without internal lining in unheated attic spaces and where exposed to outside conditions.
3. Ductwork exposed to outside conditions shall be insulated as specified herein and covered with minimum .025 inch thick aluminum jacket with seams lapped a minimum 3", sealed with silicon caulk. Covers shall be neatly finished and completely watertight.
4. Where duct mounted heating coils are located downstream from cooling coils and at variable air volume terminal units the coil shall be provided with vapor-sealed external duct insulation on sides, top and bottom.
5. Where ductwork is indicated to have internal acoustic lining, sheet metal drops to diffuser and register necks shall be unlined and shall be externally insulated.
6. The top of all diffusers shall be insulated to cover the entire top surface area, including flex duct transitions, and vapor sealed

D. Hot Equipment: Apply insulation with edges tightly butted, joints staggered and secured in place by steel bands not over 12" on center. Provide sufficient clearance around openings for normal operation of equipment. Finish with two 1/2" thick coats of insulating cement over chicken wire. Second coat shall be mixed 2 to 1 by weight with Portland cement and troweled smooth.

E. Damaged Insulation: All existing thermal coverings that are removed or damaged during construction shall be replaced or repaired to not less than original condition. Repaired sections shall provide equal or better thermal performance and vapor protection.

F. Patching: Where existing control, monitoring or other penetrating devices are removed from ductwork or piping, the insulation shall be patched to match thickness, type and finish of existing insulation.

G. Where existing insulation has been removed under the scope of asbestos removal, insulation shall be replaced as indicated for new work. Refer to the drawings for the extent of the existing piping to be reinsulated.

3.3 INSULATION THICKNESS SCHEDULE

A. Piping:

Type	Size, Inches	Insulation Thickness, Inches
Heating Water	1-1/4" and Under	1-1/2
	1-1/2" and Over	2
	*Runouts 1" and Under	1
Steam & Condensate Return	1-1/4" and Under	2-1/2
	1-1/2"	3
	2" and Over	4
Refrigerant Suction	All	1
Waste Lines Carrying Condensate from A/C Units, Ice Makers, etc.	All	1/2

*Runouts to individual terminal units less than 4 feet in length (between the control valve and coil for HVAC piping).

B. Ductwork:

Type	Insulation Thickness Inches, External
Outside Air Intake and Untempered Supply	2
Supply (Heating and Cooling)	1-1/2
Return (Equip. Room Only)	1-1/2
Plenums	1-1/2
Exhaust (Between MOD & Louver)	2
Supply & Return Exposed to Outside Air Conditions (& in Attic Space)	2

END OF SECTION 23 07 00

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SECTION 23 08 00 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
1. Coordination and Cooperation with Commissioning Agent and participation in the commissioning process indicated in Section 019113.
2. Providing for commissioning work in the project construction schedule.
3. Commissioning work shall be a team effort to ensure that all mechanical equipment and systems have been completely and properly installed, function together correctly to meet the design intent, and document system performance parameters for fine-tuning of control sequences and operational procedures. Commissioning shall coordinate system documentation, equipment start-up, control system calibration, testing and balancing and performance testing.
4. The commissioning team shall be made, up of representatives from the owner, design professionals, major equipment suppliers, and construction trades. The trades represented on the commissioning team shall include, but not be limited to, sheet metal, piping and fitting, controls, test and balance, and electrical. The lead person for each trade who will actually perform or supervise the work is to be designated as the representative to the commissioning team.

C. Related Sections:
1. Section 23 00 10 – HVAC General Requirements
2. Section 23 05 00 – Common Work Results for HVAC
3. Section 23 05 53 – Identification for HVAC Piping and Equipment
4. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC
5. Section 23 09 00 – Instrumentation and Control for HVAC
6. Section 23 20 00 – HVAC Piping
7. Section 23 30 00 – HVAC Air Distribution
8. Section 23 70 00 – Central HVAC Equipment
9. Section 23 80 00 – Decentralized HVAC Equipment
10. Section 24 00 10 – Commissioning Requirements of HVAC Systems

1.2 SUBMITTAL DATA:

A. Require all equipment suppliers to provide data required by the Commissioning Agent of type and in quantities as indicated in Section 24 00 10.

1.3 CONTRACTOR RESPONSIBILITIES:

A. General: Division 23 contractor responsibilities shall include active participation in the commissioning process as defined in Section 24 00 10 to facilitate successful completion of the contract. Ensuring all subcontractors and equipment suppliers cooperate in the Commissioning process. The Contractor shall coordinate with the Commissioning Agent to produce complete, operating systems, properly adjusted and tuned for comfortable operation and optimum efficiency.

B. Commissioning is primarily the responsibility of the Commissioning Agent indicated in Section 24 00 10, with support for start-up, testing, and support for commissioning, the responsibility of Division 23 contractor. The commissioning process does not relieve Division 23 contractor from participation in

the process or diminish the role and obligations of Division 23 contractor to complete all portions of the work in a satisfactory and fully operational manner. In general, Division 23 is to perform all check-outs, start-ups, testing, adjusting and balancing with the Commissioning Agent witnessing all tests and performing verification tests as follow-up. The Commissioning Agent will also serve as an additional reviewer of all equipment and material installations for compliance with the Contract.

C. Division 23 contractor shall be an active member of the Commissioning Team composed of representatives from the Owner, Architect/Engineer, Contractor, contractor's trades and major equipment suppliers.

D. See Section 24 00 10 for additional Division 23 responsibilities.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 DIVISION 23 COMMISSIONING RESPONSIBILITIES:

A. Identify a Division 23 Contractor's representative to the Commissioning team within one month after award of Contract. The representative shall have authority to make decisions on behalf of the Contractor.

B. Participate in Commissioning Meetings designated by the Commissioning Agent.

C. Performance verification tests shall be conducted as appropriate during cooling season and during heating season. Provide qualified personnel for participation in commissioning tests including seasonal testing required after initial commissioning.

D. Provide qualified personnel from each trade for participation in commissioning meetings as designated by the meeting agenda.

E. Participate in resolving issues identified by the Commissioning Agent.

F. Correct identified deficiencies to fulfill contract and warranty requirements.

G. Provide copies of all Contract documentation to the Commissioning Agent.

H. Participate in Owner Training as set up by the Commissioning Agent.

I. Inspect, check and confirm the correct and complete installation of all equipment in accordance with verification checklists as provided by, or as approved by the Commissioning Agent. Contractor's standard quality control verification checklists may be used, however minimum requirements shall be as indicated under Section 24 00 10, system Verification Checklists. Copies of all Contractor's completed, signed verification checklists shall be furnished to the Commissioning Agent.

J. Notify Commissioning Agent a minimum of 2 weeks in advance of scheduled equipment and system verifications and start-ups. See Section 24 00 10 for listing of systems and subsystems to be evaluated by the Commissioning Agent in the commissioning process.

K. Notify Commissioning Agent a minimum of 2 weeks in advance of start-up of Testing, Adjusting and Balancing (TAB) work. Arrange and attend meeting between Commissioning Agent and TAB agency for review of TAB procedures, TAB work plan and TAB schedule.

L. Notify Commissioning Agent a minimum of 2 weeks in advance of controls work of Section 23 09 00 for the following procedures:
   1. Point-to-point wiring check-out,
   2. Owner verification of controls graphics, setpoints and alarms,
   3. System start-up and check-out,
   4. Initial system tuning,
   5. Owner training.

M. Correct all construction and equipment deficiencies found during the commissioning process where in accordance with the Contract. Where any correction, improvement or change is outside of the Contract, as agreed by the Commissioning Team, prepare and submit a contract change proposal for the work in a timely manner. The Owner may elect to accept, reject or negotiate such contract change proposals.

END OF SECTION 23 08 00

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SECTION 23 09 00 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections apply to this Section.

B. Work Included:
1. Complete System of Automatic Controls
2. Electric Appurtenances
3. Direct Digital Controls (DDC)
4. Pneumatic Actuation

C. Related Sections:
1. Division 01 -- Commissioning
2. Section 23 00 10 – HVAC General Requirements
3. Section 23 05 00 – Common Work Results for HVAC
4. Section 23 05 53 – Identification for HVAC Piping and Equipment
5. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC
6. Section 23 09 93 – Sequence of Operations for HVAC Controls
7. Section 23 20 00 – HVAC Piping
8. Section 23 30 00 – HVAC Air Distribution
9. Section 23 70 00 – Central HVAC Equipment
10. Section 23 80 00 – Decentralized HVAC Equipment
11. Division 26 – Electrical
12. Division 27 – Electrical

1.2 SUBMITTALS:

A. Submit shop drawings and product data in accordance with Division 1 and Section 23 00 10.

B. Provide complete shop drawings, catalog data sheets and such other data necessary to fully describe and substantiate compliance with these specifications for all control items and systems included in this section.

C. Shop drawings shall indicate the exact location(s) of the outdoor temperature sensor(s).

D. Operation and maintenance data shall be submitted in accordance with Division 1, for all items of equipment and materials indicated in this Section.

E. Application Software Documentation: Contractor shall provide a blueprint documentation of the software application program for each stand-alone digital controller. Documentation shall include block software flowchart showing the interconnection between each of the control algorithms and sequences. A program listing shall be printed on the same blueprint, along with the program flowchart, and description of the sequence of operation. This blueprint shall be stored and maintained in each stand-alone digital controller. System acceptance shall not be completed until this documentation is provided and located in each panel.

1.3 QUALITY ASSURANCE:

A. When all temperature controls have been installed, the temperature control contractor shall completely commission the system to verify that all systems and components are operating in accordance with the specifications. Where corrections or adjustments to the controlled equipment are required, the

temperature control contractor shall document such changes to the Contractor, and recheck the control system once the changes have been made.

1. All equipment and subsystems shall be operated through all specified modes of control and sequences of operation, including full load and part load conditions.
2. All physical valve and damper positions shall be visually verified to correspond with the positions indicated by the controls software.
3. All instrumentation shall be properly calibrated.

B. Final point-to-point check-out and commissioning of the Temperature Control System shall be by the temperature control manufacturer or its exclusive authorized representative.

C. At the completion of this project, the Contractor shall submit a letter to the Engineer stating that all controls have been installed as specified, that each system has been calibrated and that each system is operating in a safe and efficient manner. Included with the letter, the Contractor shall provide a printout of all status control and monitoring points for a 48-hour period at 4-hour intervals, one printout of each type report available, and a copy of the completed start-up checklist used by the technician during system verification.

1.4 SCOPE OF WORK:

A. All new mechanical equipment in the scope of work shall be tied into the owner's existing Alerton controls system, any existing pneumatic controls on equipment included in the scope of work shall be converted to new electronic automatic controls. The direct digital control system shall be comprised of a network of various independent, stand-alone digital controllers, together with Centralized Control Stations, and Centralized Host Stations as specified to provide centralized access and facility wide control functions. The stand-alone digital controllers shall be interconnected in a communicating network to provide facility wide access and sharing of information. A Local Area Network (LAN) shall be provided to interconnect the stand-alone digital controllers for high-speed data transmission within each building. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers may utilize BACnet/Zigbee communications.

1. The Temperature Controls Subcontractor shall provide technical support for the Testing and Balancing Subcontractor. The technicians shall be fully qualified in all aspects of the system and shall have extensive knowledge of the project. Support shall include, but not be limited to the following:
2. Assistance in determining hydronic and air systems pressure setpoints.
3. Assistance in determining proper automatic damper positions for all air handling units, air conditioning units, and VAV units.
4. Simulating conditions as necessary for proper and optimized testing and balancing of the air and hydronic systems.
5. Where Wireless communications are used:
    a. IEEE 802.15.4 radios shall be used to minimize risk of interference and maximize battery life, reliability, and range.
    b. Communication between equipment controllers shall conform to ZigBee Building Automation (ZBA) standard as BACnet tunneling devices to ensure future integration of other ZBA certified devices.

B. Programming shall be provided in accordance with commonly accepted industry standards and practices to ensure proper and efficient control of all equipment and systems. Where ASDC's with factory programming are not capable of operating systems in the sequence described herein, the Contractor shall provide a digital controller with custom programming.

C. Programming shall be provided to accomplish the sequence of operations as described in Section 23 09 93. Changes to the operational sequences shall be made only with written approval from the Engineer.

D. Electrical Coordination:

1. BAS Contractor shall coordinate the location of all control panels with Division 26 and 27. All power circuits and communication network/devices necessary for the control panels shall be provided within the Contract.
2. Power wiring indicated (device and circuit designation indicated) on the drawings shall be provided under Division 26.
3. The BAS manufacturer shall be responsible for coordinating the required voltage for all motor operated dampers associated with fans. The damper actuator shall match the voltage of the associated fan for all fans.
4. The BAS manufacturer shall be responsible for power wiring not indicated (device or circuit designation not indicated) on the Drawings. It shall be the BAS contractor's responsibility to review

the Contract Documents to determine the extent of power wiring included in Division 26 and to provide additional power wiring as required. Work shall be in accordance with Division 26 specifications and all local, state and national codes and ordinances.

5. The BAS manufacturer shall be responsible for data cabling not indicated (device not indicated) on the Drawings. It shall be the BAS contractor's responsibility to review the Contract Documents to determine the extent of data cabling included in Division 27 and to provide additional data cabling as required. Work shall be in accordance with Division 27 specifications and all local, state and national codes and ordinances.
6. Where the contractor performing work under this section requires an additional circuit for power wiring to a device or panel under section above, an RFI shall be issued requesting approval to use an available circuit in the nearest panel. Once approval is granted, all wiring and conduit from the breaker to the device or panel shall be provided under this section of the specifications.
7. Where the contractor performing work under this section requires an additional communication network\device under section above, an RFI shall be issued requesting approval to use an available opening in the nearest switch. Once approval is granted, all cabling and conduit from the switch to the device shall be provided under this section of the specifications.

1.5 COMMISSIONING OF HVAC SYSTEMS:

A. Refer to Division 1 for work of Commissioning Agent and coordination with work of Division 23.

B. Notify Commissioning Agent a minimum of two weeks in advance of controls work for the following procedures:
1. Point-to-point wiring check-out,
2. Owner verification of controls graphics, setpoints, and alarms,
3. System start-up and check-out,
4. Initial system tuning,
5. Owner training.

1.6 SPARE PARTS:

A. Provide spare controllers of the following types and quantities:
1. Air Handlers – one (1) of each type controller
2. Unit Ventilator Units – one (1)
3. Damper Actuators – one (1) of each size/type
4. Valve Actuators – one (1) of each size/type)

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Component parts of this system shall be manufactured by Trane or Alerton. Trane is used as basis of design.

B. Installation shall be by qualified employees or authorized representative of the temperature control manufacturer. Temperature control work by independent contractors performing work without direct supervision from the authorized representative will not be accepted.

2.2 SYSTEM REQUIREMENTS:

A. The system shall be a complete system of automatic temperature regulation of the DDC type with electric and electronic accessories and components as indicated. The system shall be backwards-compatible with the Owner's existing operating and control systems.

B. The software shall not require any licensing fees or annual fees. The host must be able to support a minimum of 50 simultaneous users with the ability to expand the system to accommodate an unlimited number of users.

C. All control items except thermostats, sensors and transmitters located in rooms shall be properly identified with engraved plastic nameplates permanently attached.

D. Room thermostat, sensor and transmitter locations shall be coordinated to align vertically or horizontally with adjacent light switches or control instruments. Room thermostats and sensors shall be mounted with bottom 5'-4" above the floor.

E. All components and materials shall be UL or ASTM rated for use in air plenums.

2.3 MATERIALS:

A. Sensors, Transmitters and Thermostats:

1. Temperature sensors for the Direct Digital Control (DDC) System shall be precision RTD's or thermistor. Accuracy shall be plus or minus 1 degree F over the entire control range. Sensors for pipe applications shall be immersion type, provided with pipe well. Sensors for duct application shall be of the averaging type, with a 5 foot or a 22 foot length element. Duct element length shall be adequate to serpentine across the entire duct area. Where sensors are located downstream of fans or at least 10 duct diameters downstream of coils, elbows, junctions, or dampers, single point sensors may be used. Outdoor temperature sensors shall be provided with sunshield of copper or painted aluminum on a northern exposure. Space temperature sensors shall be compatible with unit controller and shall be provided in a decorative metal or plastic enclosure. Sensors located in gymnasiums or multi-purpose rooms shall be provided with heavy-duty wire guards. (Sensors located in public spaces such as corridors and public toilets shall be recessed type with flush mounted stainless steel blanking cover.) (Space sensors shall be provided with set-point adjustment) (and override switch/button.) (Where wireless space sensors are used, battery life shall be 7.5 years or greater with lithium batteries. Sensors shall be provided with lithium batteries.)
2. Differential pressure transmitters for measuring duct system pressures, shall have an approximate range of no greater than two times the maximum operating pressures of the duct system.
3. Differential pressure sensors for measuring space static pressure relative to outside static pressure shall have a range of -0.1 to 0.1" w.c. and an accuracy of $\pm$1%. The low port shall be connected to an outside air static sensing probe, such as a Dwyer A-306, designed to mitigate the effects of wind. The high port shall be connected to a tube terminating through the ceiling into the occupied space.
4. Differential pressure transmitters for measuring hydronic system differential pressure shall be two-wire type with true differential pressure sensing, ceramic sensor technology, stainless steel housing, NEMA 4 rated, and shall have an approximate range of no greater than two times the maximum differential pressure of the piping system. Unit shall be equal to Kele DPW-692.
5. Humidity sensors shall provide a range of 0-100% relative humidity and an accuracy of plus or minus 2% RH from 0 to 93.8% RH at 25 degrees Celsius. Accuracy shall be plus or minus 1% RH within 10% RH of the user setpoint. Operating temperatures shall be from -40 degrees Fahrenheit to +176 degrees Fahrenheit. The unit shall not be damaged when exposed to 100% relative humidity.
6. High temperature thermostat for detection of excessive temperature in the duct shall be U.L. listed, manual reset type with an adjustable temperature setting. Set at 136°F.
7. Low temperature thermostat for detection of low temperature in the duct shall be manual reset type with 20' temperature sensitive element, located downstream from the coil. If any portion of the element senses a temperature below its setting, the contacts shall break. Set at 35°F. Units shall be double pole for connection to the fan starter circuit and for monitoring by the DDC.
8. Electric thermostats shall be line voltage type complete with auto-off switch. The thermostat shall be rated for 6 amps at 120 volts.
9. Remote bulb electric thermostats shall be equipped with a liquid-filled capillary tube 8' long. The electrical rating shall be 10 amps at 120 volts.
10. Surface-mounted aquastats shall have adjustable set point and 10° differential. Contacts shall be rated 10 amps at 120 volts.
11. Sensors mounted in walk-in freezers and coolers shall be BAPI thermobuffer type, model BA/*-TB. Sensors shall be installed in a fluid filled chamber to eliminate temperature spikes. Sensor shall be stainless steel type, 0.4°F accuracy, with a 4" long glycol filled chamber. Glycol shall be the same as specified hereinafter.
12. Flow switches for water shall be McDonnell Miller.
13. Carbon dioxide sensors shall be auto-calibration type with LCD display. Units shall utilize non-dispersive infrared (NDIR) and shall have a range of 0-2000 ppm CO2. Units shall have accuracy of ±3%. Operating range shall be 32°F to 122°F. Outputs shall be 0-10 VDC or 4-20 mA. Unit housings shall be suitable for installation in return air plenums (where applicable) and shall have a standard one (1) year element warranty with lifetime warranty on calibration.

14. Space mounted combination carbon dioxide/relative humidity/temperature sensors. Where the drawings indicate multiple space sensors at a single location, a combination sensor shall be used. The combination sensor shall provide the functions matching the sensor annotations on the drawings. Operating range shall be 32°F to 122°F. Outputs shall be 0-10 VDC or 4-20 mA. Unit shall be provided with a one (1) year warranty.
    a. Temperature accuracy shall be ± 1 degree. Sensors shall be provided with set-point adjustment and override switch/button.
    b. Carbon dioxide sensing (where indicated) shall be auto-calibration type with utilizing non-dispersive infrared (NDIR) with gold-plated optical chamber. Range shall be 0-2000 ppm CO2. Units shall have accuracy of ±3%. Field replaceable carbon dioxide element shall be provided with a lifetime warranty on calibration.
    c. Humidity sensors (where indicated) shall provide a range of 10-90% relative humidity and an accuracy of plus or minus 2% RH with an operating range of 0 to 100% RH at 25 degrees Celsius. Field replaceable relative humidity element shall be provided with a one (1) year warranty.
    d. (Where wireless space sensors are used, battery life shall be 7.5 years or greater with lithium batteries. Sensors shall be provided with lithium batteries.)
15. Current relays shall be Hawkeye 700 Series or approved equal. Units shall be self-induced powered, solid state electronic with status and power LED's and binary output. Units shall be automatically self adjusting to detect loss-of-load and under current conditions (broken belt, etc.) with a range of 3 to 135 amps. Units shall be suitable for use with variable frequency drives, automatically compensating for changes in frequency and voltage. Operating range shall be 5°F to 185°F. Units shall have a limited five (5) year warranty.
16. Airflow Measuring Stations shall be constructed of aluminum or stainless steel. Units shall be ASHRAE Traversing design with shrouded impact sensors, accuracy of ± 2% and repeatability of ± 0.25% at minimum airflow of 400 FPM and maximum airflow of 10,000 FPM. Units shall have 1/4 inch NPT pressure connections and shall be suitable for maximum 200°F airstream.
17. Fan Inlet Airflow Measuring Probes shall be of the multiple averaging pitot/static sensor type with sensors distributed for equal-area averaging of flows. Internal pitot/static sensors shall be constructed of aluminum with hard anodized finish. Sensors shall be accurate to within 2.0% of actual airflow rate, from 400 to 12,000 fpm. Sensors shall be immune to the effects of changing temperature, humidity or static pressure. Primary sensor output shall be linear and shall not drift over time. Sensors shall not be affected by the presence of dirt or dust in the air stream. Fan flow measuring stations shall consist of multi-sensor probes which are installed in the inlet(s) of the fan, with companion transmitter field-mounted as indicated.
18. Water Flow Sensor/Transmitter
    a. The flow sensor shall be an insertion type with a non-magnetic, spinning impeller (paddle wheel) as the only moving part. The sensor sleeve will be brass with the sensor housing being glass-filled PPS. The impeller shall be glass-filled nylon or Tefzel® with a UHMWPE or Tefzel® sleeve bearing. The shaft material shall be tungsten carbide. The flow sensor shall be supplied with a 2" full bore gate valve in brass and a nipple threaded for a 2" NPT connection. A bleed valve and three ethylene-polypropylene O-Rings shall be supplied with the 2" NPT adapter portion of the sensor. A removable installation tool shall be attachable to the sensor for insertion or removal of the flow sensor from the pipe. The sensor will have all electronics epoxy-sealed with a 2-conductor, shielded cable extending out through a ½" conduit connection on the top of the sensor. Insertion of the sensor into any pipe size shall be a fixed 1 ½" depth from the inside wall to the end of the sensor housing. The sensor shall operate in line pressures up to 200 psi and liquid temperatures up to 220° F, and operate in flows of 1 foot per second to 30 feet per second in pipes of 3" diameter up to 40" diameter with linearity of ± 1% and repeatability of ± 1%. This sensor shall be equal to Data Industrial Model 225. The detachable installation tool shall be Model HTT.
    b. The analog flow transmitter shall be a loop powered device capable of transmitting a linear 4 - 20 mA signal proportional to frequency. The unit shall be microprocessor controlled with no switches or potentiometers to set. The transmitter shall meet ISA Class L, H and U non-isolated requirements. All circuitry shall be encapsulated in a 3.65" by 1.50" low profile epoxy body to meet MIL spec M.1-146058C type AR, for humidity, moisture and fungus resistance. Operating range shall be 32° F to 158°F. All programming, including flow sensor selection, pipe size, flow range setting, response time and filtering shall be set digitally via a computer using Windows based software with a programming kit (disk and cable). The transmitter shall be easily programmed in the field using a lap top computer. The transmitter shall have a ground lug to maximize EMI protection when necessary. The transmitter may be mounted directly on any Data Industrial 200 Series insertion flow sensor or up to 500 feet remotely from the sensor, on a DIN Rail, as a panel mount or in a weather proof or NEMA 4X enclosure. The analog transmitter shall be equal to Data Industrial Model 310-00.
    c. Flow meters for the measurement of water associated with the HVAC system (including domestic water makeup to HVAC) shall be Onicon F-1000 series or equal. Provide inline style (F-1134 or F-1101) for all pipes 1" and less, Single Turbine insertion style for pipe

1.25” to 2” (F-1100), and Dual Turbine (F-1200) shall be provided for all pipes 2.5” and greater. Unit shall come complete with D-100 Flow display, or equal, to allow local indication of flow. Provide all accessories required for tie-in to BAS system specified, including any required transmitters, data acquisition devices, and programming.

d. Flow meters for the measurement of domestic water shall be Sensus Omni C2 Series or Badger Meter Recordall Compound Series Meter. Meters shall consist of a combination of an AWWA Class II turbine meter for measuring high rates of flow and a nutating disc type positive displacement by-pass meter for measuring low rates of flow. An automatic valve shall direct flows through the disc meter at low flow rates and through the turbine meter at high flow rates. At high flow rates, the automatic valve shall also serve to restrict the flow through the disc meter to minimize wear. Meters shall comply with the lead-free requirements as defined by the 2014 provisions of the Safe Drinking Water Act which changes the definition of lead-free from the current 8.0% to not more than a weighted average of 0.25% lead when used with respect to the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixtures. A strainer shall be provided for the disc meter. It shall be easily removable and have an effective straining area of at least double the disc meter inlet. Provide all accessories required for tie-in to BAS system specified, including any required AMI/AMR encoders, transmitters, data acquisition devices, and programming.

e.

B. Valves shall be sized by the control manufacturer and shall have threaded connections except valves over 2” which shall have flanged connections. Valve packing shall be U-cup silicone or reinforced Teflon except where indicated. Maximum allowable pressure drop shall be 5 psi for water valves and 60% of inlet steam pressure for steam valves. All valves shall be equipped with positive positioners where indicated.

1. DDC valve actuators shall be electronic, low voltage modulating type, hydraulic or gear train, with spring return. Actuators shall be sized to provide smooth and positive operation and tight shutoff against full design system pressure. Valves for VAV boxes shall be drive-open, drive-closed type.
2. Valves for steam or heating water service shall be normally open type. Valves for cooling water service shall be normally closed type. Valve bodies 2” and smaller shall be bronze or high grade red brass in sizes 1/2” through 2”. Valve bodies 2-1/2” and larger shall be iron.
3. All modulating valves shall have a minimum rangeability of 25 to 1. Steam control valves shall have linear flow characteristics and water valves shall be equal percentage type. All modulating valves 4” and below shall be globe type. Modulating valves larger than 4” shall be butterfly type. Modulating valves 2” and smaller may be ball type.
4. All valves shall have stainless steel stems with replaceable packing, stem, seats and disk (,ball) or plug.
5. The pressure characteristics of all valves shall be the same or better than the piping in which installed and shall be suitable for the design system pressures indicated. Valve bodies shall have minimum ratings of 125 psig water service and 30 psig steam service unless noted otherwise.

C. Dampers and Damper Motors:

1. Control dampers shall be Ruskin Model CD36 low leakage type manufactured specifically to control the air flow in heating, ventilating and air conditioning systems. Frames shall be made of galvanized sheet steel, formed into channels and riveted. In addition to the rigid frame construction, corner brackets shall be used to maintain alignment of the damper. Blades shall consist of formed galvanized sheets, formed for extra strength to withstand high velocities and static pressures. Square or hex blade pins shall be furnished to assure non-slip pivoting of the blades when a damper is used as a single module or is interconnected with others. Motor operated dampers shall be Class 1A with maximum leakage rate of 4 cfm/ft2 at 1.0 inch water gauge when tested in accordance with AMCA 500D. Maximum blade width shall be 8”.
2. Damper actuators shall be provided for all automatic dampers. Damper actuators controlled from the DDC shall be electronic (pneumatic) modulating type, low voltage, spring return and shall be of sufficient capacity to operate the connected damper. Outside air and relief air damper actuators shall be spring return normally closed. Line voltage motors shall be two-position type.

D. Transformers are required for low voltage control items. Control manufacturer shall provide transformers with adequate capacity to operate connected equipment.

E. Panels: Control cabinets shall be furnished for each a.c. unit, major equipment components and elsewhere as indicated. Control cabinets shall be fabricated of extruded aluminum or steel. The cabinets shall have a face panel for flush mounting gauges, switches, pilot lights, etc. and sub-panel for mounting controllers, relays, etc. Controls which require manual positioning or visual indication shall be flush mounted and identified with engraved nameplates on the face panel. Controls which are required to be accessible only for maintenance and calibration are to be mounted on the sub-panel in the cabinet. Each item shall be identified by engraved nameplates.

F. Miscellaneous relays, transformers, switches and other devices shall be provided as required for the sequence of control indicated. Relays shall be located adjacent to the controlled device such as motor or motor starter. Relays may be located within starters and equipment control panels where space is available and where approved by NEC. Relays outside of the controlled device shall be provided with NEMA enclosure suitable for location where installed.

G. Disconnect Switches shall be provided for each 120V power connection to Stand-Alone Digital Controllers, Application-Specific Digital Controllers and all other electronic devices provided under this Section.

H. Uninterruptible power supply (UPS) with power conditioning shall be provided for each Building Network Controller and Stand-Alone Digital Controller. UPS power shall be capable of providing a minimum of 15 minutes backup power.

I. Direct Digital Control System:
   1. Building Network Controllers:
      a. Central Building Controllers shall be provided as required by the system architecture for network communication with, and supervision over the control system. The controller shall provide for custom programming, global management, and overriding control of the all components of the control system via a LAN or communications link. Controller shall provide seamless communication with all Stand-Alone Digital Controllers, Application Specific Digital Controllers, unitary controllers, and third party controllers where indicated. Controllers shall be provided with Ethernet card capable of 10/100/1000 megabits for connection to Owner's LAN/WAN.
   2. Stand-Alone Digital Controllers:
      a. Stand-Alone Digital Controllers shall be programmable controllers capable of custom programming provided for air handling units, heating water systems, chilled water systems, and other similar equipment/systems.
      b. Stand-Alone Digital Controllers shall be 16-bit microcomputer based, providing a multi-tasking operating system for control functions simultaneous with all other facility management, operator interface, and system communications functions. Stand-alone digital controllers shall provide true floating point arithmetic calculations, to accommodate accumulation of large totalized valves, and shall support calculation and accumulation of values up to 10 to the thirty-eighth power. Controllers connected to the local area network shall provide communications to all connected stand-alone digital controllers. Controllers shall be tested and certified to operate in ambient temperature of -40°F to + 140°F. Stand-alone digital controllers shall provide interface for portable operator access to password controlled access to all levels of operational capability, from simple information access, to full programmability of all functions.
      c. (Stand-Alone Digital Controllers shall be provided with operator display and touch pad to allow for viewing of system operation and modification of operating setpoints.)
      d. All programming defining the functions to be performed by the stand-alone digital controller, including but not limited to application programs and point database, shall be protected from loss due to power failure for a minimum of thirty days. Systems providing non-volatile memory for these functions are preferred. Systems not providing non-volatile memory shall provide battery backup sufficient to provide protection for the specified period.
      e. Each Stand-Alone Digital Controller shall be provided with a minimum of 8 spare inputs and outputs. These spare points shall be allocated as follows: 2 spare binary outputs, 2 spare binary inputs, 2 spare analog outputs, and 2 spare analog inputs.
      f. Stand-Alone Digital Controller operating system software shall be multi-tasking. Multi-tasking capability shall be provided to simultaneously perform at least, but not limited to, the following functions:
         1) Downloading of application program changes to the stand-alone digital controller without affecting the simultaneous operation of existing operating application programming.
         2) Printing of scheduled or on-demand reports without pre-empting operator functions.
   3. Application Specific Digital Controllers:
      a. Application Specific Digital Controllers (ASDC) with factory programming and no time clock may be provided for equipment such as VAV units, fan coil units, unit heaters, exhaust fans, small unitary equipment, etc. provided they are capable of controlling the equipment in accordance with the Drawings and the specified sequence of operations. ASDC's shall be capable of receiving program changes and time functions via the LAN or communications link. ASDC's shall be capable of making monitored point available to the DDC.
      b. DDC control, monitoring and alarm functions may be extended to remote equipment by the use of ASDC's. Use of ASDC's shall be transparent to the central DDC without effect on DDC functions or color graphic displays.

c. Each ASDC shall be microprocessor based DDC and shall perform all sequences as indicated and shall communicate with all other DDC controllers via the LAN or communications link. Each ASDC shall also be capable of stand-alone operation and as directed by the central DDC system.
d. Each ASDC shall provide for portable operator interface either through connection to the space sensor or connection directly to the ASDC.
e. Programmable ASDC's shall be provided with 72 hour battery back-up or non-volatile EEPROM memory and self-contained clock. The clock shall be capable of time synchronization from the DDC.

4. Unitary Control Interfaces:
   a. Where unitary controls of packaged equipment are capable of communicating with the specified control system, they may be integrated into the network in lieu of Stand-Alone Digital Controllers. All specified functions and monitoring points shall be provided as specified in the Drawings and/or sequence of operations. Where required control and monitoring points are not provided as part of the unitary controls, DDC control and monitoring shall be provided.
5. Portable Operator Interface (Laptop or Notebook Computer): Provide one portable operator interface for the Owner's use in on-site analysis and control of stand-alone units and network. Unit shall operate on batteries as well as AC line voltage, and shall provide minimum 14-inch WLED display with 1366 x 768 resolution. Unit shall be provided with the latest version of Windows 7 Professional™ operating system, Intel Core iX or AMD processor at 2.2 GHZ or higher, 16X DVD+/-RW optical drive, minimum 320 GB hard drive, 2 GB of DDR3 memory, Ethernet card capable of 10/100/1000 megabits, and an 802.11 b/g/n compatible wireless LAN card. Unit shall provide a full size typewriter-style keyboard, with a minimum of eight programmable function keys and thumb pad. Unit shall be provided with a data communications cable for direct connection to the stand-alone control unit or network. Interface ports shall support RJ-11, RJ-45, RS-232, RS-485, or all types as required to interface with specified controllers.
6. Centralized Host Stations:
   a. The digital control system shall have capacity to support a Centralized Host Station. Centralized Host Stations shall, in conjunction with the network of stand-alone digital controllers, and additional computers or components, provide the performance requirements within this specification. The centralized host station shall include all hardware and software components to serve as a centralized facility operator station providing color graphics, facility wide access and coordination of global control strategies, and centralized documentation. The centralized host station is existing shall include:
      1) Five thousand point host software with dynamic color-graphics, ICON Driven.
      2) Minimum 19-inch LCD high-resolution color-graphics flat panel monitor.
      3) Two (2) auto answer auto dial modems, minimum 56.0 KB.
      4) One (1) serial or USB printer (minimum 160 cps).
      5) One (1) external USB hard drive, sized to match the size of the hard drive provided in the computer serving the Centralized Host Stations, minimum 500 GB.
      6) Simultaneous support of local and remote dial up communications.
      7) All require cabling.
   b. The computer serving the Centralized Host Stations shall be a 32 or 64 bit computer, which shall operate under the latest version of Windows 7 Professional™. The computer shall include as a minimum, an Intel Core i5 or AMD dual or quad core 2.6 GHZ processor, 4000 megabytes of DDR3 RAM, 128 megabyte PCI-E video card, Ethernet card capable of 10/100/1000 megabits, 16X DVD+/-RW SATA optical drive, and shall operate from a minimum 500 gigabyte SATA hard disk drive. The computer shall include an optical mouse in conjunction with the color graphic terminal and a standard 101/102 keyboard. The computer shall support all peripherals as specified. In addition, the computer supplied shall be provided with all components installed as required to support peripherals including serial or USB printers, auto answer/auto dial modems (RJ-11), and Ethernet (RJ-45).

7. Web Browser Access Interface/Controller: Provide a Web Browser Access Interface/Controller to allow real time access to the DDC system from a remote location via the Internet. Device shall be capable of supporting Microsoft Edge, Google Chrome, and Mozilla Firefox web browsers and provided with a minimum of two Ethernet (RJ-45) ports for connection to the Owner's LAN/WAN and the dedicated DDC network. Secure Sockets Layer (SSL) security protocol shall be provided with a minimum of two levels of security. Privileges allowed at each level of security shall be adjustable and programmed by the Temperature Controls Subcontractor as defined by the Owner. The following functions shall be available through the web browser:
   a. View operation of all systems controlled by the DDC.
   b. Modify system setpoints and schedules.
   c. View and acknowledge alarms.

d. Define, save, plot, and print trend data.

J. Centralized Host Station Performance Requirements:

1. Color Graphic Operator Interface: The color graphic terminal shall be driven by software allowing the operator to access any system information via a “system penetration” method. “System penetration” shall allow the operator to begin at an entire site plan color graphic display and progressively select portions of the site plan to be chosen for closer inspection or selection of a more detailed color graphic display of a desired portion of the facility. The operator shall be able in this manner to “penetrate” to any desired system information without being required to enter any commands via the keyboard.
2. Dynamic Color Graphic Displays: Color graphic floor plan displays and system schematics for each piece of mechanical equipment including air handling units, and hot water systems shall be provided to optimize system performance analysis and speed alarm recognition. All mark numbers for equipment, controller and sensor designations shall exactly match those indicated on the Contract Drawings unless otherwise directed by the Owner. All software and hardware upgrades shall be provided as required to integrate color graphics of this Contract with the Owner’s existing color graphics. All Campus, Building and Floor Plan graphic conceptuals shall be approved by the Owner prior to creation of screen graphics. Names and numbers for rooms, wings, and buildings shall be in accordance with the Owner’s final numbering systems. Color graphic display shall include, but not be limited to:
   a. The real-time value dynamic display of any connected point in the network of stand-alone digital controllers.
   b. The alarm status condition of any desired system alarm point.
   c. Any software parameter such as setpoints for control sequences, minimum position adjustments, or throttling ranges.
   d. All systems having air-side economizer shall display calculated or measured return air and outside air enthalpies.
3. Appearance of color graphics shall follow the below-listed order of penetration progression:
   a. Campus plan (where more than 1 building, new and existing, is controlled or monitored).
   b. Plan color view of each building showing each floor and penthouse.
   c. Entire color floor plan of the building on one screen without scrolling, and showing all equipment rooms with tags of all equipment located therein, and locations of all major system space sensors.
   d. Large scale color floor plan view of each equipment room showing actual locations of controlled or monitored equipment.
   e. Each item of equipment with dynamic color graphic system schematic display.
   f. Each system schematic display shall be “linked” to the previous graphic, and to the system parameters of each monitored and controlled point.
   g. All screen graphics for systems with economizers shall show calculated values of enthalpy for outdoor air and return air.
   h. All graphics shall have user definable background, line and text colors for all screens.
4. Centralized Scheduling and Modification: The color graphic terminal shall support operator access to the global scheduling screens which allow the operator to review and modify any or all controlled schedules as desired. The centralized scheduling function shall allow modification of equipment and lighting operating schedules, modification of facility holiday schedules, and when desired allow assignment of temporary schedules for designated portions of the facility or specific equipment.
5. Global Electrical Demand Limiting Control shall have the capability to allow the operator to review and modify the parameters affecting global demand control strategies. Demand control shall utilize sliding window control algorithm with provision for multiple load shed facility wide as appropriate to owner’s requirements. Time of day demand limits shall be assignable to appropriate billing period time slots.
6. Energy Management Reporting shall have the capability to provide daily, weekly, monthly, and/or yearly formatted reports of facility, metered electrical consumption. Reports shall provide detail information for hourly KWH consumption, daily peak hour of consumption, daily time of peak demand, demand setpoint in use at time of peak, daily degree days, and outside air temperature and relative humidity at time of peak. Reports shall be created to provide individual reporting as desired by the owner for multiple facility meters, multiple sites, or aggregate facility metering combining multiple meters. The centralized host station shall retain daily summary energy data for up to five years. Reports can be designated as automatically printed, or called-up for report printout demand. The centralized host station shall support auto dial polling for remote sites for individual energy reporting and histories of multiple sites and have sufficient capacity to accommodate auto polling and report accumulation of a minimum of 100 sites. Reporting parameters, formatting, and frequency shall be in accordance with the Owners preferences.
7. Optimum Start Control programs shall be self-learning and shall adapt the algorithm parameters to the optimum values for each applied zone. Optimum start/stop shall provide separate control outputs for heating, cooling, fan and ventilation control sub-systems to maximize energy efficiency. The Centralized Host Station shall provide operator access to all optimum start parameters for

designated items, equipment, or scheduled systems. Trend Reports: The Centralized Host System shall support logging and historical accumulation of trended data from the entire facility, or multiple sites with capacity for acquiring trend data from a minimum of 100 sites. The system shall be capable of utilizing dedicated logging printers and provide the capacity to document printed trend data accumulated from any or all of the stand-alone digital controllers in connected on-site network, or from any number of remote sites which connect to the centralized host system dedicated logging printer via dial-up modem or Ethernet connection. The centralized host system shall provide capacity to store to disk a directory of at least 150 trend logs. Such trend logs can be accessed from the directory by the operator at any time for analysis of selected sets of the trended data, display onto the screen, or hard copy documentation.

8. Third Party Software Packages: The Centralized Host System shall provide the capacity to run specific third party software packages for word processing, spreadsheets, or database management programs.
9. Database Archiving: The Centralized Host System shall provide capability to up-load or download global control functions and programs being performed by the network of stand-alone digital controllers, and the individual database and application programming resident in each controller in the facility, or on remote sites. The up-load programs shall be retained on the centralized host system's hard disk for system backup. Programs may be modified using editor functions, and downloaded to individual units as desired.
10. Database Maintenance Reports: The centralized host system shall provide a daily report of all modifications made to any software function in the system. Report shall include the specific setpoints, schedules, sequence parameters, or limits that were modified and the time and location of the modification, and the identification of the operator making the modification.
11. Override Report: The centralized host system shall provide a daily report of all overrides issued, and/or in force on the system. Override reports shall allow tracking of operator functions and maintenance of desired operational conditions.
12. System Maintenance Report: The centralized host system shall provide a report of maintenance items on an automatic printout basis. Maintenance events shall be settable by the user based on event, elapsed run time, number of cycles or calendar day/date.
13. All operator access shall have multiple-level password protection. All setpoints for safeties shall be protected by the highest level password.
14. All help files imbedded in the software as well as all auxiliary software necessary for full access and to allow programming and other functions shall be provided and made accessible to the operator.

K. Control Panels shall be a fully electronic analog control or digital control system, providing all control functions for the equipment specified to be controlled from that panel. Each control panel shall serve one or more equipment systems. Multiple control panels serving a single piece of equipment are prohibited. Each control point shall serve a single, distinct input or output. Control functions to be performed by control panels are as described hereinafter in the sequences of operation and on the drawings. Each panel shall service one or more equipment systems.

L. All signals between the DDC control panel and the monitored or controlled devices shall be low voltage (less than 100 volts).

M. Sensing of temperature, humidity, differential pressure, and all other inputs shall be industry standard signals by one of the following types:

1. 0-20 mA
2. 4-20 mA
3. 0-5 VDC
4. 0-12 VDC
5. Resistance Signals

All inputs shall be compatible with the controllers used, and with the requirements for readout of variables.

N. On/Off Outputs: The control panel shall internally provide test points for the circuit driving the equipment contactor, for troubleshooting the low voltage circuit to the contactor. All relays or digital output modules shall provide a pilot light or LED display of this same status.

O. Modulating Outputs shall be industry standard 0-5 VDC, 0-12 VDC or Milliamp outputs of 0-20 mA or 4-20 mA, or drive open/drive closed type modulating outputs. Drive open/drive closed type controllers shall include sufficient components and control algorithms.

P. Standard Software Function Libraries: Complete libraries of control algorithms for DDC, Energy Management, and Facilities Management functions shall be resident for all stand-alone digital controllers and shall be drawn from for the creation of the application programming.

Q. Energy Management Control: The network of stand-alone controllers shall individually perform Time of Day Scheduling, Optimum Start/Stop, Enthalpy Optimization, and all Control Optimization strategies, such as Supply Air Reset, and Soft Start Ramp-up, for their connected systems of equipment. Coordination of strategies involving multiple systems of equipment shall be performed by sharing of necessary data between the stand-alone controllers on the communicating network.

R. Electric Demand Limiting Control: The stand-alone controllers shall have the capability to communicate and provide coordination for global electric demand limiting control. Demand limiting algorithm shall be resident within a selected stand-alone digital controller and shall issue load shed commands to the network for control of specific items of equipment. Demand limiting shall be sliding window demand control with a minimum of three user definable time of day demand limit setpoints. Multiple load shed tables shall be definable, and be shed for rotational or sequential restoration as appropriate for the loads within each designated shed table. The stand-alone digital controller to which electrical consumption meters may be installed shall provide for daily, and monthly formatted reports of metered electrical consumption. Reports shall be individually named and identified with a title line definable for each report, and shall provide information as detailed as hourly KWH consumption, daily peak hour of consumption, daily time of peak demand, demand setpoint in use at time of peak, daily degree days, and outside air temperature and relative humidity at time of peak. Reports shall be created to provide individual reporting as desired by the Owner for multiple facility meters, multiple sites, or aggregate facility metering combining multiple meters. System shall have capability to designate reports for automatic print, or call-up for report printout on demand, as well as upload to selected centralized host system for historically archiving.

S. Alarm Occurrence Status: Alarm condition reports shall provide a printout listing the status of specific items associated with the equipment generating the alarm. Report shall be routed to a specific printer or combination of printers at the Centralized Host Station or the on-site programming unit. Report shall record time and status information and allow operational personnel to use this information to diagnose the alarm situation.

T. Telecommunications Support: Each building network shall be provided with the necessary equipment, programming, and connections to communicate with remote host computers through one auto dial/auto answer modem and through an Ethernet connection to the Owner's LAN/WAN.

U. Remote Access and Notification: The system shall be installed such that access to the entire facility can be accomplished through both the modem and the Owner's LAN/WAN. The modem and Ethernet connection shall each be capable of providing the following functions:
   1. Access to the entire facility control system by the Contractor to provide service and diagnostic support.
   2. Access by the Owner from off-site for similar purposes, and for remote operation, monitoring, and adjustment of facility functions.
   3. Notification of desired exceptions and alarms to multiple remote sites scheduled as necessary for business hours, or off-hours reporting.

V. Off Hours Exception Reporting shall provide the Owner a means of specifying up to two remote sites for which off hours exceptions shall be reported. Selection of the site to be connected shall be programmed by the Temperature Controls Subcontractor as directed by the Owner, and set to change automatically per time of day and day of week.

W. Generally, the stand-alone digital controller and control panel shall be located on or near the unit, which they control as indicated on the Drawings.

X. Lightning arrestors shall be provided on all wiring, which exists or enters the building. Arrestors shall be located adjacent to the protected equipment.

Y. As a part of this contract the Temperature Control Subcontractor shall provide eight hours of classroom instruction in operation, programming and maintenance of the system to owners operating and maintenance personnel. Instructors shall be fully qualified in all aspects of the system. Training shall be scheduled as required by the owner and shall take place at an owner-designated location. Training shall be video recorded and provided to the Owner in DVD format.

PART 3 - EXECUTION

3.1 WORK BY OTHERS:

A. All line voltage wiring (101 volts or more) shall be furnished and installed as a part of Divisions 26 and 27.

B. All low voltage wiring (100 volts or below) shall be furnished and installed as an integral part of this section of the specification in strict accordance with Divisions 26 and 27. Refer to Divisions 26 and 27 for special requirements of separation between Control and Instrumentation wiring from Communications/Data Cabling.

C. All dampers, valves, immersion wells and pipe pressure tappings will be installed by the Mechanical Contractor.

D. All relays, firestats, sensors, annunciators, alarms, or other electrical devices not indicated to be installed by Divisions 26 and 27, shall be installed under Division 23. Coordinate with Divisions 26 and 27 for locations as necessary.

E. BAS Contractor shall coordinate the location of all control panels with Divisions 26 and 27. All power circuits and communication network/devices necessary for the control panels shall be provided within the Contract.

3.2 GENERAL SEQUENCE REQUIREMENTS:

A. Refer to Section 23 09 93 for Sequence of Operation for HVAC Controls.

B. Sequences of operation, flow diagrams, and points list are complementary. All control strategies shall be satisfied even if some of the required control points, alarm, or software have been inadvertently left off of the points list or flow diagram. Similarly, control points, alarm, and software strategies indicated on the points list shall be provided even if a written sequence or flow diagram device has been inadvertently omitted.

3.3 INTERFACE WITH PACKAGED UNITARY EQUIPMENT CONTROLLERS:

A. Where packaged equipment is indicated elsewhere within the Contract Documents to provide unitary control with BACNET or similar interface, the DDC shall communicate with and monitor the packaged controllers. Coordinate with available equipment protocols, BACNET MS/TP (or BACNET IP if approved by Owner). At a minimum, the DDC system shall:
   1. Provide signals to the packaged controllers for occupancy and all setpoints necessary. Setpoints adjustment shall be available through the graphics interface. Occupancy scheduling shall be as indicated for equipment with DDC control.
   2. Monitor all unit alarms and provide an alarm within the BAS of any alarm conditions within the unit. Alarm indications shall be specific to the type alarm occurring with the unit.
   3. Monitor all points indicated within this section, all points indicated within the respective equipment specifications and all points shown on the controls schematic Drawings. Additional points shall include monitoring of actual unit percent capacity or stages of capacity where available. Where any control or data point is not provided within the equipment controls, the DDC shall provide the necessary input/output, sensor, etc. necessary for control or monitoring of that point.
   4. Provide graphics displays for all packaged equipment to include: all points indicated within this section, all points indicated within the respective packaged equipment specifications, and all points shown on the controls schematic Drawings. The main graphics display for the respective unit shall include all points shown on the controls schematic Drawings. Any data available in excess of that indicated above shall be available outside the main graphics screen.

3.4 INTERFACE WITH VARIABLE FREQUENCY DRIVES

A. Where variable frequency drives are provided, the DDC shall communicate with and monitor the drive. Coordinate with available equipment protocols, BACNET MS/TP or BACNET IP if approved by Owner. At a minimum, the DDC system shall:
   1. Provide speed and start stop signals to the drive.

2. Monitor all unit alarms and provide an alarm within the BAS of any alarm conditions within the unit. Alarm indications shall be specific to the type alarm occurring with the unit.
3. Monitor all points indicated within this section, all points indicated within the respective equipment specifications and all points shown on the controls schematic Drawings.
4. Provide graphics displays for all drives to include: all points indicated within this section, all points indicated within the respective equipment specifications, and all points shown on the controls schematic Drawings. The main graphics display for the respective unit shall include all points shown on the controls schematic Drawings. Any data available in excess of that indicated above shall be available outside the main graphics screen.

3.5 SYSTEM MONITORING AND ALARM

A. The DDC shall provide an alarm for the following points as applicable to each unit, system, or piece of equipment. Where points occur in more than one unit or system, an alarm shall be provided for each system in which it occurs. The alarm indication shall be specific as to the parameter that has either exceeded or fallen below limits or provides indication that the system is not operating as commanded. The alarm indication shall identify the system in which the alarm occurs. Limits for alarm indication shall be coordinated with the Owner's representative and shall not be so tight as to cause nuisance alarms.
   1. Economizer Fault Detection and Diagnostic (FDD) alarms
   2. High/low discharge air temperature for all VAV units (adj.)
      Low: Setpoint minus 5°F for a period of greater than 10 min.
      High: Setpoint plus 5°F for a period of greater than 10 min.
   3. Return air humidity (adj.)
      Greater than 60% for a period greater than 10 min.
   4. Discharge static pressure for all units (exceeds high limit) (setpoint + 0.5") adj.
   5. Differential static pressure across filters (0.75") adj.
   6. Minimum outside airflow on VAV units
      Below setpoint for a period of greater than 10 min.
   7. High return or space CO2 (adj.)
      Greater than 1,200 ppm for a period greater than 10 min.
   8. VFD alarm indication
   9. Current relays
   10. High/low space temperature
      High: 85° adj.
      Low: 45° adj.
   11. Duct smoke detectors
   12. Differential pressure across fans or pumps (adj.)
      High: Setpoint + 5 psi
      Low: Setpoint – 5 psi
   13. Boiler alarm(s)
   14. Heating water system supply temperature
      High: Setpoint + 5°F
      Low: Setpoint – 5°F
   15. Server Room Temperature Alarm (adj.)
      Greater than 80°F
   16. Air Handler Freeze Protection (Mixed air temperature < 34°F) adj.
   17. Glycol low level
   18. Float switch alarms
   19. Activation of generator

3.6 PLACING IN SERVICE AND ACCEPTANCE

A. Prior to final acceptance and authorization for final payment by the Owner, Control System "punch list" inspections shall be made by representatives of the Owner's construction, maintenance, and energy management departments. This is not to preclude that punch lists shall be made by the Contractor to check the completion of his work prior to final "punch lists" inspection. The punch lists inspections shall be in three parts. An inspection shall be performed and punch list (Installation Punch List) prepared regarding the physical installation of the BAS equipment, wiring, etc., and separate punch list shall be prepared regarding the graphics interface (Graphics Punch List); and a third punch list shall be prepared regarding the software programming and systems performance verification at the site (Site Performance Verification Punch List).
   1. Graphics Acceptance:
      a. Contractor shall perform self-review of graphics prior to requesting graphics review by Engineer. At a minimum, prior to requesting a Graphics/Programming Punch List inspection,

all required "head end" software and graphics at the server shall be installed and functioning; graphics shall be accessible and demonstrated at the school. This work shall be performed prior to building occupancy.

b. Graphics checklist, provided by Engineer to Contractor shall be completed by Contractor and returned to Engineer indicating that the Graphics are ready for review by Engineer. Engineer will provide review comments to Contractor. Contractor shall acknowledge that any corrective work cited in the review comments has been completed. Engineer will validate Contractor's response and acknowledge acceptance of Graphics when appropriate.

3.7 MINIMUM DDC GRAPHICS:

A. At a minimum, the following DDC graphics shall be provided.
   1. Floor Pans
      a. Overview of entire building.
      b. Floor plan for each floor.
      c. Zone plan for each zone.
   2. All screens
      a. Outside air temperature & humidity
      b. Animations for all active equipment (feedback status, not command)
      c. Add an "Active Alarm" button. This button should access a report that displays all current active alarm messages.
      d. All setpoint adjustments and alarming as defined in the individual equipment sequence of operation specifications shall be incorporated into the graphics package.
      e. All static and dynamic values of all inputs, outputs and setpoints for the area or equipment being displayed.
   3. Air Handler Summary Screen with:
      a. Fan Status
      b. Fan Speed
      c. CHW, HW Valve % Command and Position
      d. Electric Heat % Command and Output
      e. OA Damper Position
      f. Discharge Air Temperature
      g. Down-Duct Static Pressure (VAV Units)
      h. Hyperlink to each Air handler full screen
   4. Floor Plan Screens
      a. All VAV boxes Color coded by air handler
      b. Hyperlinks to the individual air handlers serving each floor area
      c. Small floor plan of entire building in upper left corner with hyperlink to each individual floor section
   5. Each Air Handler Screen
      a. Occupancy Status
      b. Heat/Cool Status
      c. Economizer Status
      d. Dehumidification Status
      e. Outside air Enthalpy
      f. Return air Enthalpy
      g. All Damper Positions
      h. Minimum OA Flow Setpoint
      i. Actual OA Flow
      j. Discharge air temperature setpoint, or Space temperature setpoint
      k. Down-duct pressure setpoint
      l. Fan discharge static reading and setpoint (unless binary switch in which case a tripped condition shall alarm the DDC with specific overpressure indication)
      m. CO2 setpoints
      n. Energy Wheel Animation (Where wheel is present)
      o. List of exhaust fans associated with each system with link to exhaust fan screen
      p. All monitored points
   6. All piping pressure setpoints
      a. Outside Air temperature enable setpoint with onscreen adjustment capability.
      b. All monitored points
      c. Link to full BACnet points
   7. Heating Water System
      a. Boiler Run Status with Animation
      b. System Heating Water Setpoint with Reset Schedule On Screen
      c. All Piping Pressure Setpoints

d. Outside Air temperature enable setpoint with onscreen adjustment capability.
e. All Monitored Points

B. Dynamic temperature values, humidity values, air or water flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention. Setpoints (heating, cooling, humidity, CO2, supply air temp, supply static, differential pressure, etc.), shall be shown in a data block adjacent to the actual displayed dynamic values.

C. All engineering units related to displayed data shall be configured to provide easily understood representations of the equipment operation.
1. Valves and dampers shall have Open % for modulating control and Open/Close for 2- position control
2. Temperatures shall be displayed in ºF
3. Humidity shall be displayed in %RH
4. CO2 levels shall be displayed in PPM
5. Fans, pumps and other motors shall be displayed as On/Off

D. A Menu button located on the overall floor plan graphic should access a Main Menu screen with individual buttons to access the: Special Activity schedules; Chiller; Pumps; AHUs, RTUs, ERUs, Air Terminal Units, Exhaust Fan; etc. Additionally, this main menu should have buttons to access sub-menus for, Reports, Histories, Graphs, etc.

E. From each detailed graphic the operator is to be able to return to the floor plan graphic and menu screen.

F. In addition to the floor plan and mechanical system flow schematics, provide tabular listings of all equipment statuses and space temperature sensors for quick access and review.
1. All temperature, humidity, CO2 values are to be dynamic and change colors for normal, hi or low alarm.
2. The mechanical room group is to list all pertinent chilled water and hot water system equipment statuses and water temperatures. The list is to have a button to access chiller plant and boiler plant schematic flow graphics.
3. Each zone group list shall include the room numbers in sequential order with the room temperature and humidity valves listed. All room numbers are to be hot buttons to directly access the unit or equipment graphic.

G. Graphics portrayed on a screen shall be scaled to fit the screen so that all diagrams and data are viewable without scrolling.

H. On-line notepad: Provide on-line notepad accessible from systems graphic screen. Notepad shall have two functions:
1. Sequence of operations as approved in “As-Built” documents shall be provided. Sequence shall be displayed when notepad is accessed from equipment graphic screen; e.g. when viewing the graphic screen for an air handling unit, clicking on the “Notepad” button will display a “pop-up” window with the text of the sequence of operation pertinent to that AHU. On-screen editing and saving of the sequence shall be possible.
2. Notes, in addition to sequences of operations, may be entered and saved

I. Overridden Points:
1. Overridden points should be highlighted against a yellow background when overridden and a neutral color when not overridden.
2. Provide a school/building specific record of currently overridden points retrievable by operator command.

3.8 INSTALLATION

A. The location of all control items on the exterior of the building shall be approved by the Architect prior to installation.

B. Where the condition occurs, provide insulated sub bases for all space temperature sensors located on exterior walls.

C. All sensors located in equipment, ductwork and piping shall be installed with appropriate fittings such that devices are securely attached to coils, duct, pipe, or similar and are not free to move, rotate, or become dislodged. The use of adhesives for attachment is not permitted.

3.9 SERVICE AND GUARANTEE

A. The entire control system shall be serviced and maintained in first class condition by the control manufacturer for a period of one year after acceptance at no extra cost to the Owner.

END OF SECTION 23 09 00

SECTION 23 09 93 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections apply to this Section.

B. Work Included:
   1. Sequence of Operations for HVAC Systems

C. Related Sections:
   1. Division 01 -- Commissioning
   2. Section 23 00 10 – HVAC General Requirements
   3. Section 23 05 00 – Common Work Results for HVAC
   4. Section 23 05 53 – Identification for HVAC Piping and Equipment
   5. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC
   6. Section 23 09 00 – Instrumentation and Control for HVAC
   7. Section 23 20 00 – HVAC Piping
   8. Section 23 30 00 – HVAC Air Distribution
   9. Section 23 70 00 – Central HVAC Equipment
   10. Section 23 80 00 – Decentralized HVAC Equipment

1.2 GENERAL REQUIREMENTS

A. Programming shall be provided in accordance with commonly accepted industry standards and practices to ensure proper and efficient control of all equipment and systems.

B. Control sequences shall be accomplished in accordance with control drawings and the sequences specified in this section and described on the drawings. It is the intent of this section to utilize sequences included in pre-programmed controllers when such sequences provide the intended operation. Where factory programming is incapable of providing the sequence specified in the Contract Documents, a custom controller with custom programming shall be provided.

1.3 SUBMITTALS

A. Refer to Section 23 09 00, Instrumentation and Control for HVAC.

1.4 WARRANTY

A. Refer to Section 23 09 00, Instrumentation and Control for HVAC.

1.5 COMMISSIONING OF HVAC SYSTEMS:

A. Refer to Section 23 09 00, Instrumentation and Control for HVAC.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 GENERAL SEQUENCE REQUIREMENTS:

A. Set points: All control setpoints shall be provided with appropriate deadbands where necessary to prevent the excessive cycling of equipment, valves, dampers, etc.

B. Failure of Digital Control System: The control system shall be installed to fail safe to the heating mode.
   1. All air handling and air conditioning units shall fail on with outside air damper closed, heating valves open to the coil and the reset valve open to the boilers.
   2. Night setback shall fail to day (occupied) mode.
   3. Heating water system shall fail with boiler energized to boiler control and heating water pump on.
   4. All interlocked exhaust fans shall be de-energized with the dampers closed.

C. Unoccupied Period Freeze Protection: When outdoor air temperature falls below 35°F during unoccupied periods, the following sequence shall occur.
   1. Heating (and chilled) water pumps shall be energized (pumps should be energized whenever any space requires heat).
   2. All air unit heating (and cooling) valves shall be fully open when the fan is off.
   3. All outdoor air dampers shall be closed and verified.
   4. All exhaust fans shall be de-energized with dampers closed (should already be de-energized during unoccupied periods).

D. Unoccupied Periods: At times when the building is unoccupied, the DDC shall control all systems to maintain an adjustable night setting for both heating and cooling. Unless otherwise specified, all outside air dampers shall be closed and all exhaust fans shall be de-energized. Where fan powered VAV boxes are utilized, night heating shall be performed as required by the individual terminal units without energizing the associated air handling units. Terminal units such as cabinet unit heaters and fan coil units shall cycle the fans as necessary to maintain unoccupied setpoints. The DDC shall stagger the occupied/unoccupied schedules for all air handling units to prevent large fluctuations in heating or cooling demand. Activation of the manual override on a space temperature sensor, where applicable, shall result in the following: the space temperature setpoint shall be indexed to the occupied setpoint for that space and the system serving that space shall be indexed to the occupied mode. All other spaces shall be maintained at unoccupied temperature setpoints.

E. Morning Warm-up: All air systems shall bring space up to occupied temperature before opening outside air dampers as part of the optimal start sequence.

F. System Start-up: Following any type of system shutdown, the DDC shall stagger the starting of all electrical loads to reduce electric peak demand.

G. System Shut-down: At any time air systems are de-energized, the DDC shall disable all ancillary systems dependent upon air movement such as electric heaters, humidifiers and direct expansion cooling. Ancillary systems required for freeze protection (except electric coils) shall remain operational.

H. Direct Expansion (DX) Cooling: Where the Sequence of Operation calls for DDC control of refrigeration compressors, condensing units or packaged compressor-cooling, the DDC shall provide “minimum-on” and “minimum-off” times in accordance with the equipment manufacturer’s recommendations.

I. Duty/Standby and Lead/Lag Control: All equipment indicated to be operated as duty/standby or lead/lag shall be sequenced based on run time and alternated bi-monthly or as otherwise required in accordance with the Owner’s preferred schedule. Sequencing shall occur as scheduled without the need for shutdown, if necessary. Sequencing for individual equipment shall occur so as not to impact the operation of the entire system. The DDC shall automatically energize the standby or lag device in the event of a failure in the duty or lead equipment.

J. Smoke Detection Control: Upon activation of an air handling unit duct smoke detector, all fan powered VAV boxes associated with that unit shall be deenergized.

K. Refer to the Electric Sequence Controls Schematics on the drawings for automatic control of fans, ancillary heating equipment, and other similar items. The following hard-wired interlocks shall be provided in addition to any others indicated on the Electric Sequence Controls Schematics:
   1. Boiler firing shall be inhibited unless combustion air dampers have been opened and verified open through actuator limit switches.
   2. Emergency boiler shutoff shall de-energize all boilers upon activation of the emergency break glass switch provided under Division 26.
   3. Activation of duct smoke detectors shall de-energize associated supply fans and return/relief fans (where applicable).
   4. Where refrigerant machines are installed in the same room as fuel fired devices, the detection of a refrigerant leak, as sensed by the refrigerant monitor, shall prevent and terminate the firing of all fuel fired appliances.
   5. Low air flow condition indicated by the air flow switch shall prevent the operation of electric heating coils.
   6. Cooling coil condensate drain pans shall be provided with safety switches to de-energize the unit and alarm the DDC upon accumulation of water.

L. All screen graphics for systems with economizers shall show calculated values of enthalpy for outdoor air and return air.

3.2 SEQUENCE OF OPERATION:

A. Refer to drawings for equipment sequences of operation.

END OF SECTION 23 09 93

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SECTION 23 20 00 - HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
1. Pipe and Pipe Fittings
2. Hydronic Pipe Specialties
3. Steam Specialties
4. Air Control Fittings
5. Miscellaneous Piping Specialties

C. Related Sections:
1. Division 01 -- Commissioning
2. Section 23 00 10 – HVAC General Requirements
3. Section 23 05 00 – Common Work Results for HVAC
4. Section 23 05 48 – Vibration and Seismic Controls for HVAC Equipment and Piping
5. Section 23 05 53 – Identification for HVAC Piping and Equipment
6. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC
7. Section 23 09 00 – Instrumentation and Control for HVAC
8. Section 23 70 00 – Central HVAC Equipment
9. Section 23 80 00 – Decentralized HVAC Equipment

1.2 REFERENCES:

A. General: The following standards or codes form a part of this specification to the extent indicated by the reference thereto.

B. American Society for Testing and Materials (ASTM):

A53-88a	Pipe, Steel, Black and Hot-dipped, Zinc-coated, Welded and Seamless
A106-88a	Seamless Carbon Steel Pipe for High Temperature Service
A120-88a	Pipe, Steel Black and Hot-dipped, Zinc-coated, Welded and Seamless for Ordinary Uses
A126-84	Gray Iron Castings for Valves, Flanges and Pipe Fittings
A254-88	Copper Brazed Steel Tubing
A420-88	Piping Fittings of Wrought Iron Carbon Steel and Alloy Steel for Low Temperature Service
A539-88	Electric-Resistance-Welded Coiled Steel Tubing for Gas and Fuel Oil Lines
B32-89	Solder Metal
B42-88	Seamless Copper Pipe, Standard Sizes
B75-86	Seamless Copper Tube

B88-95a Seamless Copper Water Tube

C. American Society of Mechanical Engineers (ASME):

ASME 95 Boiler and Pressure Vessel Code

B16.3 Malleable Iron Threaded Fittings

B16.4 Cast Iron Threaded Fittings

B31.9 Building Services Piping

D. International Ground Source Heat Pump Association (IGSHPA) Installation Manuals.

E. National Electrical Manufacturers Association (NEMA)

F. Underwriters Laboratories, Inc. (UL)

1.3 COMMISSIONING OF HVAC SYSTEMS:

A. The Contractor shall provide contact information to the Commissioning Agent indicated in Division 1 for all major items of Equipment.

B. Provide additional submittal copy of major equipment for Commissioning Agent specified in Division 1.

1.4 SUBMITTALS:

A. Submit shop drawings, product data and samples in accordance with Division 1 and Section 23 00 10.

B. Shop drawings, diagrams, catalog data and such other data necessary to fully describe and substantiate compliance with these specifications shall be submitted for all equipment and materials marked with notation set forth in Section 23 00 10.

C. Operation and maintenance data shall be submitted in accordance with Division 1, for all items of equipment and materials marked with notation set forth in Section 23 00 10.

D. IGSHPA Installation Manuals: Submit one copy of each manual to the Engineer.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS:

A. Material Standards:
1. Steel pipe shall be manufactured in accordance with ASTM A53 and shall be so labeled.
2. Copper pipe shall be manufactured in accordance with ASTM B88 and shall be so labeled.
3. HDPE pipe shall me manufactured in accordance with AWAA and shall be so labeled.

B. Steam Lines: Standard weight schedule 40 black steel. Fabrication shall be threaded up to 2” pipe size; lines over 2” may be threaded or welded. Threaded fittings shall be standard weight black malleable in accordance with ASME B16.3 or cast iron in accordance with ASME B16.4. Welding fittings shall be butt welding type or weld neck flanges. Pipe and fittings shall be suitable for 150 psi steam service. All nuts and bolts at bolted flanges shall be grade 8 for steam service.

C. Steam Condensate Return Lines: Extra heavy weight schedule 80 black steel. Fabrication shall be as specified hereinbefore for steam lines.

D. Heated Water Lines: Pipe 4” and smaller shall be type L hard drawn copper tubing or standard weight schedule 40 black steel pipe over 4” shall be standard weight black steel. Fittings for copper pipe shall be ASME B16.18 or ASME B16.22 solder type. Viega ProPress (no substitute) may be used for pipe 2” and

smaller. Fittings for steel pipe shall be standard weight, threaded, black, malleable in accordance with ASME B16.3 or cast iron in accordance with ASME B16.4 except fittings over 2" size may be welding type. Flanges shall be weld neck type. All fittings shall be suitable for 125 psi water service.

E. Underground Piping [S] shall be factory fabricated pipe conduit systems as manufactured by Rovanco Corp., Thermacor Process, Inc., Insul-Pipe systems, Perma-Pipe/Ricwill or Insul-Tek, Inc. Piping submittal shall include detailed drawings of proposed installation showing all required thrustblocks, anchors, wall entrances, expansion loops, etc., required for completed installation. Upon completion of piping installation, manufacturer's representative shall submit a letter verifying all components of this piping system have been properly installed and tested in accordance with manufacturer's recommendations.

1. Underground Heated Water piping shall include carrier pipe, insulation and outer casing to provide complete system with couplings, pipe guides, elbows, end seals and other accessories necessary for a complete installation. Installation shall be in accordance with manufacturer's recommendations. Outer casing shall be PVC with minimum thickness of .06 inches. Carrier pipe shall be standard weight black steel or type K hard drawn copper with pre-insulated fittings as specified hereinbefore for service indicated. Field insulation kits for fittings are not permitted. Insulation shall be 1-1/2 inch thick foamed in place polyurethane, minimum density of 1.9 lbs. per cu. ft. with a maximum K factor of 0.18 at 75°F. All joints and fittings shall be insulated and jacketed similar to the remainder of the piping system. Entire assembly shall be suitable for maximum operating temperature of +250°F and operating pressure of 150 psig water service.
2. All underground Steam and Condensate piping shall include carrier pipe, insulation and outer casing to provide a complete system with couplings, pipe guides, elbows, end seals and other accessories necessary for complete installation. Installation shall be in accordance with manufacturer's recommendations. Outer casing shall be suitable for 150 psig steam and condensate, dryable, testable, Class A, 10 gauge black steel type conduit piping with outer surface coated with a minimum thickness of 20 mils fusion bonded epoxy or a minimum thickness of 30 mils chemically bonded polyurethane. Carrier pipe shall be as specified hereinbefore for service indicated. Insulation for steam and condensate lines shall be 1-1/2 inch calcium silicate with a maximum K factor of 0.31 at 200°F. All joints and fittings shall be insulated and jacketed similar to the remainder of the piping system. Entire assembly shall be suitable for maximum operating temperature of +400°F and operating pressure of 125 psig steam.

F. Cooling coil condensate drain lines shall be type L hard drawn copper tubing (except where buried they shall be service weight cast iron). Fittings shall match the piping. Where cleanouts are indicated in buried piping, they shall be the same as cleanouts specified in Section 22 10 00 – PLUMBING PIPING AND PUMPS.

G. Refrigerant piping shall larger than ¾" shall be type "ACR" hard drawn copper tubing, pipe ¾" and smaller shall be soft copper refrigerant tube. Pipes shall be factory cleaned, dehydrated and capped with wrought copper fittings. Provide all accessories including, but not limited to, refrigerant duty ball type shutoff valves, solenoid valves, expansion valves, moisture indicating sight glass, replaceable core filter dryers, access ports with gasketed screw-on covers for charging and measuring subcooling, hot gas bypass valve (where indicated) and other accessories recommended by the refrigeration equipment manufacturer. Expansion valves shall be balanced port, externally equalized type. Provide heat exchangers for subcooling and suction line accumulator as recommended by the manufacturer. All components shall be selected and sized for the lowest pressure drop at the capacities indicated. Prior to offering the system for final acceptance, the Contractor shall submit a written certification from an authorized official of the equipment manufacturer stating the complete system, to include refrigerant piping, has been installed in accordance with the manufacturer's recommendations.

H. Provide utility location tape 12 inches to 24 inches above buried piping outside the building, consisting of polyethylene plastic and metallic core or metallic-faced, acid-and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inch minimum width, for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording.

1. Warning Tape for Metallic Piping: Acid and alkali-resistant polyethylene plastic tape. Minimum thickness of tape shall be 0.003 inch. Tape shall have a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.
2. Detectable Warning Tape for Non-Metallic Piping: Polyethylene plastic tape with minimum thickness of 0.004 inch. Tape shall have a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Tape shall be manufactured with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.2 HYDRONIC PIPE SPECIALTIES:

A. Fill valves ([S]) shall be Bell & Gossett or Watts complete with strainer and check valve. Valve shall be adjustable 25-60 psi and field set at 5 psi above pressure required to fill the system. Provide full size manual bypass with cutoffs around fill valve for fast fill and purging.

B. Manual air vents on 3/4" piping shall be chromium plated brass 1/8" NPT coin operated type. Provide extension tube if required to maintain access to vent operator. Manual air vents on 1" and larger branch piping and hydronic mains shall be a minimum 1/2" ball valve with hose thread adaptors. Extend vent piping as necessary to locate valves in accessible locations. Air vents and vent piping shall be suitable for 150 psi working pressure.

C. Automatic air vents ([S]) shall be Hoffman No. 79 or 78, suitable for 150 psi service and shall provide venting operation under all conditions. Exhaust port from each shall be extended with a concealed 1/4" copper tubing to floor of equipment rooms, to a drain, or to 6" above grade at building exterior.

2.3 STEAM SPECIALTIES:

A. Steam traps [S] shall be Sarco, Webster or Hoffman, thermostatic, inverted bucket, or float and thermostatic type as indicated. Traps shall be sized by the trap manufacturer to pass condensate at 2-1/2 times the condensation rate of the connected heating appliance at 1 psi drop on low pressure or 5 psi drop on medium pressure systems. Steam main drip traps shall be 3/4" bucket traps or Yarway series 130 impulse trap may be used in lieu of strainer and bucket trap. Traps shall be rated for 15 psi service on low pressure systems and 60 psi service on medium pressure systems and 125 psi service on high pressure systems.

B. Reducing valves [S] [O/M] for steam service shall be Leslie, Spence or Spirax Sarco self-contained, external pilot, piston or diaphragm operated cast iron or bronze body with single seated stainless steel valve for dead end service. Valves shall be adjustable over a 2 to 35 psi range and shall provide not less than 75% accuracy of regulation at 10% of the rated capacity. Inlet pressure 125 psi.

C. Bottom blow-off and drain valves for steam boilers shall be specifically designed for boiler blowdown services and shall be full size of boiler blow-off connection. Boilers shall have one slow and one quick opening valve in series. Slow opening valves shall have at least 5 - 360° rotations from fully closed to fully open. Valves shall be suitable for pressures indicated.

D. Surface blow-off valves for high pressure steam boilers shall be manual metering valve with position indicator and locking stem. Valves shall be suitable for pressures indicated.

E. Vacuum Breakers shall be vacuum relief valve by Sarco, Webster or Hoffman. Units shall have brass or stainless steel body suitable for pressures indicated.

2.4 AIR CONTROL FITTNGS [S] [O/M]:

A. All air control fittings shall be provided by the same manufacturer and are based on Bell & Gossett models.

2.5 MISCELLANEOUS PIPING SPECIALTIES:

A. Strainers shall be Y type with stainless steel basket suitable for 250 psi service. All strainers shall be provided with blowdown valves.

B. Dielectric fittings such as couplings or flanges shall be installed to isolate pipes of non-ferrous metal where connection is made to ferrous metal. Isolation shall be accomplished by use of a brass converter fitting of threaded brass or bronze couplings (not unions), or flanged joints with gaskets and bolt bushings. Materials shall withstand pressure and temperature as required. Valves of the same materials may also be used.

C. Drains shall be accessible and shall consist of 3/4" ball valves with hose thread adapters, cap and chain unless indicated otherwise.

D. Escutcheons shall be the split pattern chromium plated bronze or steel. Special height escutcheons shall be provided where extended sleeves are used. Escutcheons shall be sized to cover the entire opening.

E. Water seals (Trap) shall be provided on condensate drain from each air handling unit. Seal shall be of sufficient depth to prevent blowout or siphoning of water and shall be configured as indicated on the Drawings.

F. Pipe sleeves shall be installed as outlined in SECTION 23 00 10 HVAC GENERAL REQUIREMENTS.

G. Regulating relief valves [S] [O/M] shall be adjustable setting type, bronze body, modulating action relief valve as manufactured by Watson-McDaniel or equal. Size to relieve 50% of pump capacity. Set to relieve 5 ft. above specified system pump head.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION:

A. General: Sleeves and sealant shall be provided where pipes pass through floors, partitions or walls as outlined in Section 23 00 10, HVAC GENERAL REQUIREMENTS. Pipe shall be cut accurately to measurements established at the job site and worked into place without springing or forcing, properly clearing all windows, doors and other openings. Pipe in finished areas shall be concealed. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Each end of each piece of pipe shall be reamed. Pipe shall be installed to permit free expansion and contraction without damage to joints or hangers. Changes in direction shall be made with fittings, except that bending of pipe will be permitted provided a hydraulic or mechanical bender is used and wide sweep bends are formed. Bent pipe showing kinks, wrinkles, or other malformations will not be acceptable. Bushings and all thread nipples will not be allowed.

B. All piping shall be installed with sufficient pitch to ensure adequate drainage and all high points in water lines shall be provided with auto-air vents, all low points with drains. Steam and condensate lines shall slope a minimum of 1 inch in 40 feet in direction of flow unless indicated otherwise. Low points in steam lines and points at the end of a pipe run shall be provided with drip stations. Pipe size changes in steam lines shall be made with eccentric reducers with outlet on bottom. Branches from steam mains shall take off from the top of the main. Cooling coil condensate drain lines shall slope 1/8” per foot in direction of flow. Pipe extending through the roof shall be properly flashed.

C. Bull head tee piping connections shall not be used in supply or return arrangements.

D. Piping connections to equipment shall be provided with unions or flanges. Banked water coils shall be piped in reverse return arrangement with a balancing cock in the return leg of each coil. Steam coils shall be trapped individually. Vacuum breaker shall be provided at steam supply connection to each steam coil or steam bundle. Boilers shall not be connected into the piping systems until they have been thoroughly cleaned internally in accordance with the manufacturer’s instructions and not until they can be fired under a fairly continuous load. Connections shall not be made to any equipment until the piping systems have been cleaned completely and are free of all dirt.

E. Open ends of pipe lines or equipment shall be properly capped or plugged during installation to keep dirt or foreign material out of the system.

F. Escutcheons shall be provided where exposed pipes pass through finished walls or floors.

G. Steam condensate lines from a steam trap discharge may lift condensate where equipment served has two-position control and lift does not exceed one foot/psig steam. Where equipment served has modulating control, steam condensate lines shall be sloped for gravity drainage; lift will not be acceptable.

H. Miscellaneous piping terminating at floor drains or in the air shall be resiliently anchored to protect against fatigue or damage incurred as a result of vibration or abuse.

I. Provide P/T ports in the supply and return piping at all coils, heat exchangers, pumps, and where otherwise indicated on the drawings.

J. All piping to a coil or heat exchanger shall be the full size of the runout indicated with a reducer as necessary at the coil connection. This shall include all appurtenances except control valves.

K. All underground piping shall be installed minimum 3'-0" below grade and minimum 4'-0" below roadways unless otherwise indicated on the Drawings.

L. Underground Steam Piping Systems shall have conduit systems tested in addition to carrier piping, as indicated in Section 23 05 93.

M. Joints:

1. Copper tubing shall be cut square, ends reamed and all filings and dust wiped from interior of pipe. Joints shall be soldered with solder drawn through the full fitting length. Excess solder shall be wiped from joint before solder hardens. Solder shall be 95/5 composition – 50/50 will not be allowed. All solder joints shall have piping surfaces sanded or brushed. Self-cleaning solder flux as a substitute for sanding or brushing is not acceptable. In lieu of soldered fittings in hydronic piping, Viega ProPress (no substitute) fittings may be used for copper pipe 2" and smaller.
2. Threaded joints shall be made with tapered threads properly cut. Joints shall be made tight with a stiff mixture of litharge and glycerin or other approved thread joint compound applied with a brush to the male threads only. Not more than three threads shall show after the joint is made up. The use of thread protectors for pipe couplings is not acceptable. Expanding self-hardening pipe dope ("expando") shall not be used.
3. Welded Joints:
    a. Welded joints shall be fusion-welded by qualified welders in accordance with American National Standard B31.1.06, Chapter 5, unless otherwise required. Changes in direction of piping shall be made with welding fittings only. Mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. The contractor shall wire brush and paint welded pipe welds before insulation is applied. Saddle type welding outlets may be used for equipment take-off's from the mains.
    b. All pipe welding shall be done only by competent and experienced welders. High test welding rods suitable for the material to be welded are to be used throughout. All welds shall be built up to a thickness of 1 ½ times pipe wall thickness. All tees, branches, reducers or specialties that may be required in welded piping shall be carefully laid out by welders, using templates, and the joints shall have carefully matched intersections and shall be properly spaced. Finished pass on all welds shall be a smooth continuous weld cap. Multiple "stringers" on horizontal welds will not be acceptable.
    c. During welding, all piping shall be securely clamped in place so that true alignment is held throughout the welding process. Where there is apt to be distortion, proper allowance shall be made so that the sections to be joined will be in proper alignment after the weld is completed. Care shall be exercised to prevent the occurrence of protruded metal into the pipe. All welds shall be of sound metal, free from laps, cold shuts, gas pockets, oxide inclusions and similar defects.
    d. Adequate protection blankets, screens, etc. shall be provided during cutting and welding to protect existing adjacent surfaces.
4. Flanges and unions shall be faced true and made square and tight. Unions shall be 300 psi service, bronze seat type. Flanges shall be ASA Standard 125 psi service with red rubber gaskets or 150 psi service with high temperature gaskets. Unions or flange joints shall be provided on each side of each valve 2-1/2" or larger and in each line immediately preceding the connection to each major piece of equipment such as a heating coil and other similar items.

3.2 REFRIGERANT PIPING:

A. All refrigerant piping shall be sized, installed, and routed in accordance with the refrigeration equipment manufacturer's recommendations.

B. All piping joints and the inside of all piping shall be clean. Burnish all mating surfaces until all dirt, oxide, or other debris is removed. Using no flux, braze all joints using hard solder equal to Stay-Bright for pipe 2 inches and below or Stay-Silver for pipe larger than 2 inches. Remove all internal components from refrigerant accessories which may be subject to heat damage prior to brazing. Joints for copper tubing for ductless split systems smaller than ¾" may be flared fittings.

C. Before charging, refrigerant lines shall be thoroughly cleaned and purged. Refrigerant lines shall be pulled down to a vacuum of 500 microns and then pressure tested according to the manufacturer's instructions before charging with refrigerant.

D. All filters from filter dryers shall be replaced after 48 hours of system operation and prior to final acceptance.

E. Refrigerant circuit access ports located outdoors shall be fitted with locking-type tamper resistant caps or shall be otherwise secured to prevent unauthorized access.

3.3 RELIEF VENTS:

A. All natural gas vents and refrigerant relief devices shall be independently and directly piped to the outside in accordance with the local Building Code, the International Fuel Gas Code and ANSI/ASHRAE Standard 15a. Refrigerant relief devices shall include chiller rupture disks and purge piping.

3.4 CONTROL ACCESSORIES:

A. Control valves, pipe wells and pressure tappings shall be furnished under Section 23 09 00 and installed as work of this Section.

3.5 TESTING:

A. Chilled Water and Heating Water, Condenser Water and Steam Supply and Condensate Return Piping:
   1. Piping shall be tested and results approved by the Architect/Engineer prior to application of insulation.
   2. Piping system shall be capped and subjected to a static water pressure of 50 psig above operating pressure (minimum 125 psig), and pressure maintained for four (4) hours with no leaks or loss in pressure. Testing with air is prohibited.
   3. Test source of pressure shall be isolated from the system before conducting pressure tests.

B. Underground Piping System Outer Conduit:
   1. Outer conduit shall be tested with air at 15 psig for four (4) hours with no leaks or loss in pressure. Each joint shall be checked with soap suds. Inner carrier piping shall be tested as specified above for service indicated.

3.6 FLUSHING:

A. All hydronic systems shall be flushed.
   1. The piping system installation shall be complete & all pressure tests accepted.
   2. Temporary bypasses shall be provided around coils, control valves, heat exchangers and other similar items to prevent trash from being flushed into these items.
   3. In order to remove larger debris, the entire system to be filled with domestic water, vented, then drained to sanitary system.
   4. A temporary circulating (if necessary) pump will be sized by mechanical contractor to provide the correct flow for flushing the entire system. Minimum velocities shall be 3 ft/s minimum for flushing.
   5. System will be continuously circulated while periodically draining & adding water to maintain proper system pressure. This will continue until water clarity is acceptable as determined by the water treatment contractor. The length of time this step takes depends on the flow rate and quantity of water flushed in GPM.
   6. Once water clarity is confirmed by the water treatment Contractor, chemical cleaning agents shall be introduced into the system and circulated as detailed in the chemical treatment submittal.
   7. The water treatment Contractor shall provide water samples from different system locations to confirm total dissolved solids and turbidity levels are within acceptable levels.
   8. All strainers shall be cleaned.

3.7 SYSTEM STARTUP:

A. When heating water system has been tested and made tight, flush all dirt, trash, and extraneous material with cleaner as recommended by equipment, and glycol manufacturers and in accordance with this Section, Section 23 80 00, and Section 23 05 93. Prior to the balance and operating tests, the system shall be charged and completely filled with water or a glycol/water solution, as is currently utilized by the existing hydronic system, as confirmed by the Owner's representative.

B. Hot water systems shall be tested, flushed and cleaned as indicated for chilled water, completely filled with clean water and charged with chemical treatment.

C. Where specifications are unclear as to what treatment is required, the Contractor shall provide minimum treatment as recommended by the equipment manufacturer.

3.8 SYSTEM STARTUP:

A. When heating water systems have been tested and made tight, flush all dirt, trash, and extraneous material with cleaner as recommended by equipment manufacturers, the Owners Water Treatment Consultant, and in accordance with this Section, Section 23 80 00, and Section 23 05 93. The cleaning chemicals used shall be provided by the Contractor. The Contractor shall notify the Owner's Water Treatment Consultant 30 days prior to the boil-out/cleaning of the system.

B. The chemicals to be used by the Contractor for the specified initial treatment shall be furnished by Contractor. The Owner's Water Treatment Consultant shall be provided the opportunity to supervise the cleaning of equipment and the initial chemical fill for placing the equipment in normal service.

C. Chemical formulation shall be compatible with system materials, shall conform to DEQ regulations and shall not exceed DEQ or local effluent limits.

D. After cleaning and chemically treating the HVAC systems, the Contractor shall furnish the Owner, in writing, the following information:
   1. Date of initial treatment.
   2. Type of chemicals used for treatment.
   3. Estimated date that further treatment or testing will be required.

END OF SECTION 23 20 00

SECTION 23 30 00 - HVAC AIR DISTRIBUTION

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
1. HVAC Ductwork
2. Air Duct Accessories
3. Air Outlets and Inlets
4. Wall Louvers
5. Brick Vents
6. Roof Vents
7. Ventilation Hoods

C. Related Sections:
1. Section 01 91 13 -- General Commissioning Requirements
2. Section 23 00 10 – HVAC General Requirements
3. Section 23 05 00 – Common Work Results for HVAC
4. Section 23 05 48 – Vibration and Seismic Controls for HVAC Equipment and Piping
5. Section 23 05 53 – Identification for HVAC Piping and Equipment
6. Section 23 07 00 – HVAC Insulation
7. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC
8. Section 23 09 00 – Instrumentation and Control for HVAC
9. Section 23 70 00 – Central HVAC Equipment
10. Section 23 80 00 – Decentralized HVAC Equipment

1.2 REFERENCES:

A. General: The following standards or codes form a part of this specification to the extent indicated by the reference thereto.

B. Air Movement and Comfort Association (AMCA):

Bulletin 210, Standard Test Code for Air Moving Devices

Standard 511, Air Performance and Water Penetration

C. American Society for Testing and Materials (ASTM):

ASTM A 525 General Requirements for Steel Sheet, Zinc Coated (Galvanized) By the Hot-Dip Process

ASTM A 527 Steel Sheet, Zinc Coated (Galvanized) By the Hot-Dip Process, Lock-Forming Quality

ASTM E 84 Standard Test Method for Surface Burning Characteristics of Building Materials

ASTM C 411 Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation

D. Underwriters Laboratories, Inc. (UL)

Standard 723 Tests for Surface Burning Characteristics of Building Materials

E. Sheet Metal and Air Conditioning Contractors' Association (SMACNA)

Duct Construction Standards (Latest Edition)

HVAC Air Duct Leakage Test Manual (Latest Edition)

F. National Fire Protection Association (NFPA):
1. Standard 90A – Standard for the Installation of Air Conditioning and Ventilating Systems
2. Standard 90B – Standard for the installation of Warm Air Heating and Air Conditioning Systems
3. Standard 96 – Standard for the Installation of Equipment for the Removal of Smoke and Grease – Laden Vapors from Commercial Cooking Equipment
4. Standard 255 – Method of Test of Surface Burning Characteristics of Building Materials

1.3 DEFINITIONS:

A. Duct Sizes: Sizes shown on Drawings are actual sheet metal dimensions. For acoustically lined ducts, sizes indicated are actual sheet metal sizes allowing for 1" thick acoustic lining. For double wall ductwork, sizes indicated are inside dimensions.

B. Low Pressure Ductwork: Static pressure rating less than 2" w.g. and velocities less than 2000 fpm.

C. Medium Pressure Ductwork: Static pressure rating less than 6" w.g. and velocities greater than 2000 fpm and all ductwork upstream of VAV boxes.

D. High Pressure Ductwork: Static pressure rating over 6" w.g. and velocities greater than 2000 fpm.

1.4 COMMISSIONING OF HVAC SYSTEMS:

A. The Contractor shall provide contact information to the Commissioning Agent indicated in Division 1 for all major items of Equipment.

B. Provide additional submittal copy of major equipment for Commissioning Agent specified in Division 1.

1.5 SUBMITTALS:

A. Submit shop drawings, product data and samples in accordance with Division 1 and Section 23 00 10.

B. Shop drawings, diagrams, catalog data and such other data necessary to fully describe and substantiate compliance with these specifications shall be submitted for all equipment and materials marked with notation set forth in Section 23 00 10.

C. Operation and maintenance data shall be submitted in accordance with Division1, for all items of equipment and materials marked with notation set forth in Section 23 01 00.

D. All fans for use with Variable Frequency Drives (VFD) shall have critical speed and multiples of critical speed indicated on each submittal.

1.6 SPARE PARTS

A. Each fan powered terminal box and make-up air fan shall be provided with 3 sets of filters. At end of construction each unit shall be provided with a clean filter and one set shall be turned over to the Owner as spares.

B. Each filter grille shall be provided with 3 sets of filters. At end of construction each unit shall be provided with a clean filter and one set shall be turned over to the Owner as spares.

C. Each belt driven piece of equipment shall be provided with one spare set of belts to be turned over to the Owner at the end of construction.

PART 2 - PRODUCTS

2.1 HVAC DUCTWORK

A. Materials:
1. Sheet Metal Ducts: Trademarked galvanized steel, lock forming quality, having zinc coating of 0.90 ounces per square foot for each side (G90, ASTM A653 and A653M).
2. All ductwork without external insulation, exposed to view in finished, non-utility spaces shall have paint-grip or galvaneal coating to accept field painting.
3. Fasteners: Use rivets and bolts throughout; sheet metal screws may be used on low pressure ducts.
4. Sealants: United McGill “United Duct Sealer” or equal. Water and fire resistant when dry, compatible with mating materials. Where sealants are used on exposed ductwork, composition shall be designed to prevent bleed-through of finish paint, or sealant shall be pre-painted with a coating impervious to bleed-through.
5. All duct and accessory materials shall have a composite flame spread rating not exceeding 25, and a smoke developed rating not exceeding 50 as tested under procedure ASTM E-84-75, NFPA 255 and UL 723. Duct coverings and linings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411.
6. (Fibrous Glass Ducts: 1 inch thick rigid fibrous glass with aluminum foil, glass scrim and kraft paper jacket vapor barrier, 0.23 btu/in./sq.ft./°F./hr. maximum “K” value at 75°F.)

B. Fabrication:
1. All ductwork shall conform accurately to the dimensions indicated on plans and shall be fabricated and installed in accordance with ASHRAE Guide and Data Books and SMACNA Duct Construction Standards, except that sheet metal gauges and zinc coating shall not be lighter than specified under this Section.
2. All rectangular sheet metal ducts over 18” wide shall be cross-broken for rigidity.
3. Reinforcing angles, stiffeners and tie-rods for all sheet metal ducts shall be provided where required to prevent sagging, buckling, and vibration in accordance with the latest SMACNA Duct Construction Standards Publication. Reinforcing for flat oval duct shall be provided as specified for rectangular duct in accordance with the latest SMACNA Duct Construction Standards Publication.
4. Lap metal ducts in direction of air flow. Hammer down edges and slips to leave smooth interior surface.
5. Where square elbows are indicated on the Drawings, curved elbows may be used provided the centerline radius is not less than 1-1/2 times the width of duct and as space allows.
6. Provide turning vanes in all square elbows. Provide air foil type turning vanes on all ducts more than 24” wide. Mitered round elbows (2-piece) shall not be used unless specifically indicated. Mitered round elbows shall have airfoil turning vanes.
7. Transitions shall be made with a slope ratio of 4:1, except at equipment divergence and convergence shall not exceed a slope ratio of 3:1.
8. All duct joints and seams shall be mechanically tight, and sealed with sealant or gaskets to provide a substantially airtight system.
9. All duct liners shall be installed using fasteners in strict accordance with SMACNA Duct Construction Standards. Fastener pins shall be clinched pin type or welded pin type. The use of adhesive type pins is not acceptable. All liners shall have transverse edges coated with adhesive, all corners lapped and butted or folded.
10. Duct liners at fan discharges shall be lapped on outside of fan discharge flange or shall have metal nosing on leading edge. Fastening pin length shall be equal to liner thickness.
11. Provide easements where low pressure ductwork conflicts with piping and structure. Where easement exceeds 10% duct area, split into two ducts maintaining original duct area.
12. Plenums and Casings (Site Fabricated Units) [S]: Construct of galvanized steel panels joined by standing seams on outside of casing. Rivet or bolt all seams and joints on approximately 6” centers and seal with sealant. Reinforce with steel angles and provide diagonal bracing. Access doors shall be 36” x 18” with frame welded to plenum, three brass hinges and three brass tension fasteners operable from either side of door.
13. (Fibrous glass ductwork may be substituted for internally or externally insulated or uninsulated low pressure sheet metal ductwork when approved by Engineer.)
14. Ductwork associated with clothes dryer exhaust shall have smooth interior finish with joints running in the direction of airflow. (Ductwork associated with commercial clothes dryer shall be installed with a minimum 6 inches to combustible materials.)
15. All radiused elbows shall have centerline radius (R = 1.5 D), and shall be stamped or pressed smooth radius or minimum five gore type. Adjustable gore type fittings are not acceptable.

C. Low Pressure Ducts:

1. Sheet Metal Gauges:

a. Rectangular Ducts:

Max. Dimen., In.	Min. Gauge
Up to 30	24
31 to 54	22
55 to 84	20
85 and Over	18

b. Round Ducts:

Duct Diameter, In.	Min. Gauge
Up to 22	24
23 to 36	22
37 to 50	20
51 to 60	18
61 to 84	16

D. Medium and High Pressure Ducts:

1. Sheet Metal Gauges:

a. Rectangular Ducts:

Max. Dimen., In.	Min. Gauge
Up to 18	22
19 to 48	20
49 to 72	18
73 to 96	16
97 to 144	14

b. Round Ducts (Factory Made With Spiral Lock Seams equal to United McGill):

Duct Diameter, In.	Min. Gauge
Up to 26	24
28 to 36	22
38 to 50	20
51 to 60	18
61 and Over	16

c. Flat-Oval Ducts (Factory Made With Spiral Lock Seams equal to United McGill):

Max. Width, In.	Min. Gauge
9 to 24	24
25 to 48	22
49 to 70	20
71 and Over	18

2. Fittings shall be minimum 20 gauge on flat oval, but not less than 2 gauges heavier than ductwork in which it is installed on round and flat oval. Fittings for duct sizes 5" round and below may be minimum 24 gauge.
3. All take-offs shall be full body pre-manufactured 45° conical lateral type or alternate pre-manufactured fitting with equivalent loss coefficient. The use of field-installed or factory lateral taps or manifolds is not acceptable.
4. All elbows shall have centerline radius (R = 1.5 D), and shall be stamped or pressed smooth radius or minimum five gore type. Adjustable gore type fittings are not acceptable.

E. Flexible Ducts [S]: Flexible Ducts shall be Flexmaster Type 1M or Thermaflex type M-KE. Duct shall incorporate acoustic rated CPE or PE inner liner, 1" thick fiberglass insulation, and reinforced metalized vapor barrier. Maximum C factor shall be 0.24 btu/hr/sq.ft./°F at 75°F mean temperature. Duct shall have a working pressure of not less than 6 inches w.g. for positive pressure and 1 inch w.g. for negative pressure and suitable for velocities up to 4000 fpm. Vapor transmission shall be less than 0.05 Perm when tested in accordance with ASTM E96, Procedure A. The entire assembly shall be rated and marked as UL 181 Class 1. Flame Spread Rating shall not exceed 25 and Smoke Developed Rating shall not exceed 50 when tested in accordance with ASTM E-84-75, NFPA 255, and UL 723. Minimum duct insertion loss at 2500 fpm for a 10-foot length of straight duct shall be as listed below when tested in accordance with ADC FD-72 R1:

Duct Insertion Loss, dB

Octave Band	2	3	4	5	6
Frequency, Hz	125	250	500	1000	2000
6 inch duct	7	19	34	37	38
8 inch duct	8	13	29	35	36
12 inch duct	20	26	27	33	26

2.2 AIR DUCT ACCESSORIES

A. Access Doors:
   1. Doors for low pressure rectangular ductwork shall be galvanized steel, 20 gauge rigid type, 12" X 16" minimum size unless noted otherwise, except where size of duct will not accommodate this size, they shall be as large as possible. Door shall have gasket, two hinges, and two compression latches with outside and inside handles. Provide insulated doors where installed in insulated ductwork.
   2. Doors for round or flat-oval low, medium or high pressure ductwork shall be a complete factory mounted, duct section/access door assembly constructed of minimum 20 gauge galvanized steel. Access door shall match within two inches the diameter of duct and shall be complete with gasket, insulated door with handle, compression clips and chain retainer.

B. Fire dampers [S] shall be provided in accordance with the National Fire Protection Association Standard No. 90A. Dampers shall be UL 555 approved (for dynamic air systems), factory fabricated and assembled, and shall consist of 24 gauge, or heavier, interlocking curtain or rotating damper blades, fusible link and linkage, and 22 gauge, or heavier, galvanized steel frame. Dampers shall be tested for closure under airflow conditions and shall be labeled for maximum airflow and direction of flow. Where fire dampers are located in walls behind sidewall grilles, the fire damper shall be designed and UL listed for flush installation of the grille. Where fire dampers are located in watertight ductwork, fire dampers shall be constructed of 304 stainless steel; all duct/sleeve connections shall be sealed watertight with sealant in accordance with the terms of the UL Listing. Entire unit shall be securely anchored in structure where opening is made. Free area of fire damper for medium/high velocity ducts shall equal the cross section area of duct in which installed. Free area of fire damper for conventional velocity ducts shall be not less than 75% of the cross section area of duct in which installed. Dynamic fire dampers shall be rated for velocities up to 2000 fpm and pressures up to 4.0 in. wg. Fire dampers shall be furnished to the job site with instructions detailing UL approved installation method.

C. Smoke dampers [S] [O/M] shall be provided in accordance with the National Fire Protection Standard No. 90A, and as indicated on Drawings. The damper unit consisting of a 16 gauge galvanized steel frame, parallel blade dampers, motor, fusible link (212°F) and control linkage, shall be factory fabricated, and shall be UL 555S labeled for 1-1/2 hour service. Damper motor shall be 120V electric type of sufficient capacity to operate the connected damper. Damper shall be suitable to automatically reset itself when activated by a smoke detector. End enclosures shall be the same size and shape as connecting ductwork. Smoke dampers shall be Leakage Class I and rated for velocities up to 3000 fpm and pressures up to 4.0 in. wg.

D. Gravity dampers shall be Airline type CBD counter balanced back draft damper constructed of felt edged aluminum blades. Set to open at .10" H2O. Maximum leakage rate shall be 20 cfm/ft2 at 1.0 inch water gauge when tested in accordance with AMCA 500D.

E. Dampers:
   1. General:
      a. Fabricate of galvanized steel.
      b. Where manual dampers occur behind or above finished portions of hard ceilings or walls, a remote cable operated damper by Young Regulator Co. shall be provided.
      c. Where dampers are located in accessible spaces, operators shall be locking type quadrant operators. Quadrant operators shall be installed on 1-1/2" high 4 bend galvanized steel bracket so that duct insulation may be extended and sealed under the quadrant operator.
      d. End of damper rod on each damper shall be grooved to show damper position.

F. Manual Volume Dampers shall be Ruskin model MD35, opposed blade multi-louver (single blade for dampers under 11" nominal) construction 16 gauge minimum with molded synthetic or stainless steel bearings, galvanized channel iron frame and maximum blade width of 8 inches. Axles shall be positively locked into blades to prevent slippage or loosening. Damper blades shall be interlocking type with linkage, control shaft, and standoff locking regulator (Rossi Everlock or equal).

G. Rectangular branch take-off connections from mains shall be made using 45 degree entry fittings per SMACNA 1995 figure 2-6. Grille and register connections to mains shall be made using 45 degree entry fittings where space allows. Where diffuser, register or grille is located too close to the main, air deflectors shall be used. Air deflectors shall be factory fabricated. Adjustable deflectors shall be complete with worm gear operator when behind grilles, an extension rod and concealed regulator when above plaster ceilings, or self-locking lever type regulator when accessible.

H. Instrument Test Holes: Holes, with patches, in ducts and plenums shall be provided where directed or necessary for using pitot tubes for taking air measurements for balancing the air systems. At locations where ducts or plenums are insulated and on all medium and high pressure ductwork die cast collars with threaded neoprene caps shall be provided.

I. Apparatus Connections: At points where sheet metal connections are made to fans or where ducts of dissimilar metal are connected, provide a flexible connection of neoprene coated canvas of sufficient length to eliminate transmission of vibration. Flexible connections shall be securely fastened and air tight.

J. Duct Sleeves: All ducts shall have sleeved openings 1" larger than the overall duct dimensions framed in place when the wall is constructed and 1/4" larger when floors are poured. Space between duct or duct insulation and sleeve shall be tightly filled with mineral fiber rope insulation and sealed. All duct penetrations through corridor walls, floors not requiring fire dampers and walls indicated to be smoke partitions shall be sealed with U.L. approved firestopping sealant. In fire partitions or floors requiring fire dampers, the duct sleeve shall be sized to match the fire damper frame with all voids packed tight with mineral fiber rope. All penetrations through draftstop partitions shall be sealed to maintain the integrity of the partition. Flanges, constructed of 20 gauge galvanized sheet metal, not less than 3" wide, shall be installed at each opening in finished areas.

K. Prefabricated curbs shall be provided where ductwork above roof penetrates roof surface, sized to match ductwork and duct supports. Curbs shall be insulated type, 12 inches high complete with mounting flange and integral cant strip where acceptable to roofing manufacturer. Outer shell shall be mitered and welded continuously to form a rigid leakproof shell; inner shell shall be solid metal similarly constructed. Wood nailing strips shall be bolted to top of curb shell to provide means for securing flashing material to the curb. Curb shall be constructed of galvanized steel. Ductwork and insulation cover shall be counterflashed to the curb. Curb sidewalls shall be fully insulated to minimum R-5. Top of curb shall be gasketed for airtight fit of rooftop unit.

L. Spin-in collar [S] shall be 20 gauge galvanized steel, welded and riveted construction. Each fitting shall have conical bell-mouth duct fitting, locking groove, insulation guard, adjustable damper with 3/8" square shaft, u-bolt, nylon bushings, and standoff locking regulator (Rossi Everlock or equal).

M. All wire mesh, woven metal fabric, bird screens, and similar items shall be constructed from corrosion resistant, galvanized steel or aluminum.

N. Acoustic Lining [S]: Fiberglass insulation, 0.26 btu/in./sq.ft./°F./hr. maximum "K" value at 75°F, absolute roughness of exposed surface shall not exceed 0.005 ft., coated to prevent erosion at air velocities up to 2000 fpm, 1.5 lbs/cu. ft. minimum density. Noise reduction co-efficient shall average not less than 0.60 when tested by Acoustical Material Association procedure mounting 6. Liner shall be provided with EPA approved biocide in the erosion coating to protect against microbial growth. Liner shall meet or exceed requirements of ASTM G21 (fungi resistance) and ASTM G22 (bacterial resistance). Acoustic lining shall be one inch thick unless specifically noted otherwise.

O. Barred Ductwork shall be constructed using tool resistant steel and shall be 1/2 inch or 3/4 inch diameter solid steel bars on 6 inch centers. Ducts exceeding 12 inch size shall have 2-1/2 inch x 3/8 inch intermediate framing in addition to the round bars. Bars shall be enclosed in a 3/16 inch thick welded steel sleeve of length to suit thickness of wall where installed. Two 3/16 inch x 1 inch x 1 inch angle steel frames, one welded to unit and one shipped loose for field welding shall be provided for each unit.

P. Duct Smoke Detectors: The air duct smoke detector shall be of the photoelectronic type, with sampling and exhaust tubes of the proper dimensions, insect screen, and shall incorporate an air-tight smoke chamber in compliance with UL 268A standard for smoke detectors for duct applications. The detector enclosures shall be equipped with an integral mounting base capable of accommodating either photoelectronic or ionization detector heads and shall be capable of local testing via a magnetic switch. Detector housing cover shall be clear polycarbonate. The detector shall operate at air velocities of 300 feet per minute to 4000 feet per minute. The unit shall operate on 120 volts AC and be complete with one (1) Form A (NO) and two (2) Form C (DPDT) 2 amp rated contacts. Standby current shall be 15 milliamps. Alarm current shall be 20 milliamps. A remote trouble/alarm lamp, piezo horn (85dB) and keyed switch reset test station shall be provided with each air unit.

2.3 AIR OUTLETS AND INLETS [S]:

A. Acceptable Manufacturers:
1. Standard Products: Price, Metal Industries, Krueger, Tuttle and Bailey, and Titus.

2. Stainless Steel Products: Price, Keyes, and Anemostat.
3. Security Products: Price, Metal Industries, Krueger, Keyes and Titus.

B. General:
1. All devices shall be commercial grade and shall be constructed of steel or aluminum as indicated on the drawings.
2. Manufacturer shall certify cataloged performance and ensure correct application of each air device to provide air pattern, velocity, pressure drop and sound characteristics NC suitable for space installed. Shop drawings shall include air quantity, size, pressure drop, throw ft, and sound level NC.
3. All devices located in ceilings shall have white baked enamel finish. Devices at other locations shall have prime finish suitable for painting or anodized aluminum unless noted otherwise.
4. Maximum air outlet noise level shall not exceed NC35.
5. Provide sponge rubber seal around edges of all supply registers and grilles.

C. Diffusers:
1. Square ceiling diffusers shall be welded steel or aluminum as indicated on the drawings, removable core, louver face, complete with equalizing grid, volume control unit and adjustable vanes for down-discharge pattern.

D. Registers and Grilles:
1. Return and exhaust registers shall be aluminum, unless noted otherwise, complete with 45 degree fixed airfoil vanes at not more than 1/2 inch centers. Provide 1 or 1-1/4 inch margin, 1/8 inch beveled frame with concealed screw holes. Damper shall be opposed blade face operated type with removable key. Units on watertight ducts shall be all polished stainless steel or aluminum with baked enamel finish, including damper, linkage, core and frame.

2.4 WALL LOUVERS [S]:

A. Louvers shall be stationary, stormproof units constructed of (16 gauge galvanized steel) (0.081” extruded aluminum) complete with 1/2” mesh matching bird screen in removable frame and extended sill. Blades shall be “S” or “K” shape spaced 3 1/4” - 4” O.C. Finish shall be (prime coat for field finish coat) (baked enamel) (mill finish) (anodized), color as selected by Architect. Pressure drop shall not exceed 0.10 inch H_2O at 700 fpm and water penetration shall not exceed 0.01 oz./sq. ft. at 500 fpm when tested in accordance with AMCA Standard 511, and shall be licensed to bear the AMCA seal. (All project louvers shall be provided under this Section. See Architectural Drawings for louvers not shown on Mechanical Drawings, at gables, elevator vents, smoke vents and similar areas.)

2.5 BRICK VENTS [S]:

A. Brick vents shall be of No. 356 cast aluminum frame and blades, four inches deep, and of sizes indicated on the Drawings. Units shall have minimum 39% free area, and shall be coated with asphaltum paint coating on all mortared surfaces. Units shall be provided with 7 x 7 mesh insect screen and shall have a factory furnished sheet metal duct extension equal to or greater than the thickness of the wall to enable field duct connection. Units shall have rear water-stop, front top drip and front bottom sill to prevent water-staining of surrounding masonry. Finish shall be (mill grade) (baked enamel, color as selected by Architect).

2.6 ROOF VENTS [S]:

A. Roof vents shall be provided by same manufacturer as roof fans and have same finish for matching appearance. Roof vents shall be louvered penthouse constructed of (16 gauge galvanized steel) (18 gauge extruded aluminum) suitably braced to prevent twisting and complete with 1/2” mesh matching bird screen and curb cap flashing. Finish shall be (prime coat) (baked enamel) (mill finish) (anodized) color as selected by Architect. (Provide motor-operated dampers with actuator where indicated.) Prefabricated curbs shall be insulated minimum R-5, minimum 12” high, provided complete with mounting flange, integral cant strip and rack or flange to support dampers. Outer shell shall be mitered and welded continuously to form a rigid leakproof shell, inner shell shall be solid metal similarly constructed. Wood nailing strips shall be bolted to top of curb shell to provide means for securing flashing material to the curb. Curb shall be constructed of same material as roof vent.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Duct clearance and lengths shall be established from measurements taken at the job site before any ducts are fabricated.

B. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing and balancing of system. Where exhaust ducts are installed within a chase or shaft, pitot tube shall extend to the outside of the chase or shaft and be capped.

C. Locate ducts with sufficient space around equipment to allow normal passage, and operating and maintenance activity.

D. Locate all ductwork to align with the ceiling grid where connections are to be made to Diffusers, Registers and Grilles. Field verify exact grid location before installing ductwork.

E. Locate all Diffusers, Registers and Grilles as indicated on plans and in accordance with the Reflected Ceiling Plans, if provided.

F. Provide low loss factory fabricated fittings for all round take-off connections to low velocity rectangular ducts.

G. All Flex duct shall be properly supported to prevent any short radius bends or kinks. Connections to diffusers shall be made using long radius bends or elbows with turning vanes to ensure that airflow is distributed evenly across the neck of the diffuser. Conditions that create higher airflows in one quadrant of diffuser throw are not acceptable. Maximum flex duct runout length shall be 5 feet. Flex duct shall not penetrate wall construction of any type.
   1. Flex duct clamps shall be Thermaflex Snaplock Clamp or equal using minimum ½" wide stainless-steel band with cadmium plated hex bolt to tighten band with worm-gear action.

H. Install duct accessory items in accordance with manufacturers printed instructions.

I. Install volume, smoke and fire dampers where shown on plans.

J. Manual volume dampers shall be installed at all branch connections, divided flow branches, and end-of-run diffuser/register connections for low pressure supply, return, and exhaust duct systems. Manual volume dampers shall be installed within 3 feet of the main duct.

K. Provide access doors at all automatic dampers, fire/smoke dampers, duct heaters, duct mounted coils, thermostats and at all other points requiring inspection or servicing. Duct access doors for fire and smoke dampers shall be permanently labeled with minimum 1/2 inch high letters reading FIRE DAMPER or SMOKE DAMPER. Labeling shall be as specified for equipment nameplates under Section 23 05 53.

L. Fire dampers shall be UL listed for the type assembly in which they are installed.

M. Connection of horizontal ducts to rooftop exhaust fans shall be made using radiused elbows or mitered elbows with turning vanes. Duct transitions shall be as hereinbefore specified.

N. Ductwork installed or stored on site shall be protected such that open ends are covered to prevent construction dust and debris and other foreign matter from being introduced into the duct systems. If at any time during construction, dust or debris is discovered within the duct systems or ducts openings are observed to be unprotected, the Contractor will be responsible for properly cleaning all duct systems in accordance with NADCA procedures for the respective type of ductwork.

O. Grille, Register and Diffuser Installation:
   1. Boots to diffusers shall fit airtight to diffuser necks and diffusers shall be securely fastened thereto.
   2. Where grilles are installed at walls or ceilings, the duct shall be fastened securely to the masonry or panel at each side of the opening and the grille shall be securely fastened snug against the masonry or panel.
   3. If flanged grille frames are used on exposed ducts, runout shall be same size as outside dimension of flange and full depth of register assembly.

4. Unless otherwise indicated in the Contract Documents, sidewall grilles and registers to be installed high shall be installed within 6 inches of the ceiling or nearest overhead projection. Unless otherwise indicated in the Contract Documents, sidewall registers and or grilles to be installed low shall be installed within 6 inches of the floor, but shall be coordinated with cove or base molding. Sidewall registers shall also be coordinated with the block coursing where applicable.
5. Air saddles shall be installed on the light fixtures at the time the light fixture is installed. Air passage knockouts in air handling light fixtures, shall be punched out as required. Cooperation with electrical trade is required.
6. Ceiling diffusers shall be installed in and coordinated with the ceiling tile or other ceiling units. Diffusers, Registers and Grilles shall be centered in each ceiling unit, unless shown otherwise. Mounting frames shall be installed as required to support diffusers, registers and grilles. Grilles, registers and diffusers shall not be supported from the ceiling system, conduit, piping or unrelated ductwork.

P. Patching: Where existing control, monitoring or other penetrating devices are removed from ductwork, the opening shall be patched to match thickness, type and finish of existing ductwork, and sealed airtight.

3.2 DUCT CLEANING:

A. Clean all duct systems included in the scope of work before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.
1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch duct as recommended by duct manufacturer. Comply with paragraph "Air Duct Accessories" in this Section for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:
1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:
1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of ducts or duct accessories.
4. Clean fibrous-glass duct with HEPA vacuuming equipment; do not permit duct to get wet. Replace fibrous-glass duct that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

F. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.
1. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
2. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials such as duct and plenum liners.

G. Cleaning Mineral-Fiber Insulation Components:
1. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR 2006.
2. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
3. Fibrous materials that become wet shall be discarded and replaced.

H. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
3. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
4. Duct system will be considered defective if it does not pass tests and inspections.
5. Prepare and submit test and inspection reports.

3.3 DUCT SCHEDULE:

A. All ductwork shall be fabricated, installed, sealed, and tested in accordance with the schedule below. All testing shall be in accordance with the latest edition of the SMACNA HVAC Air Duct Leakage Test Manual.
1. Testing shall be conducted and the results approved by the Architect/Engineer prior to the application of insulation.
2. The Architect/Engineer shall be notified one week prior to conducting the test. Unless specifically waived, the Engineer and Owner reserve the right to witness the test. Final, signed and dated test results shall be documented as outlined in SMACNA HVAC Air Duct Leakage Test Manual and submitted to the Architect/Engineer.

B. Supply Ductwork
1. Medium pressure duct:
   a. Pressure Class: Positive 6” w.g.
   b. Seal Class: A
   c. Leakage Class for Round Duct: 3
   d. Leakage Class for Rectangular Duct: 6
   e. Testing Requirement: 100%
2. Low pressure duct:
   a. Pressure Class: Positive 2” w.g.
   b. Seal Class: A
   c. Leakage Class for Round Duct: 12
   d. Leakage Class for Rectangular Duct: 12
   e. Testing Requirement: 25%
3. Low pressure duct connected to rooftop air conditioning units/heat pumps in excess of 5 tons:
   a. Pressure Class: Positive 3” w.g.
   b. Seal Class: A
   c. Leakage Class for Round Duct: 6
   d. Leakage Class for Rectangular Duct: 6
   e. Testing Requirement: 25%
4. Ductwork connected to equipment not listed above:
   a. Pressure Class: Positive 2” w.g.

b. Seal Class: A
c. Leakage Class for Round Duct: 12
d. Leakage Class for Rectangular Duct: 12
e. Testing Requirement: N/A

C. Return Ductwork:
1. Ductwork located in unconditioned spaces or fully ducted systems located above ceiling:
a. Pressure Class: Negative 2” w.g.
b. Seal Class: A
c. Leakage Class for Round Duct: 12
d. Leakage Class for Rectangular Duct: 12
e. Testing Requirement: 10%
2. Ductwork exposed in conditioned spaces or installed in ceiling return plenums:
a. Pressure Class: Negative 2” w.g.
b. Seal Class: A
c. Leakage Class for Round Duct: 24
d. Leakage Class for Rectangular Duct: 24
e. Testing Requirement: N/A
3. Ductwork connected to equipment not listed above:
a. Pressure Class: Negative 2” w.g.
b. Seal Class: A
c. Leakage Class for Round Duct: 12
d. Leakage Class for Rectangular Duct: 12
e. Testing Requirement: N/A

END OF SECTION 23 30 00

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SECTION 23 70 00 - CENTRAL HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY:

A. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:
1. Packaged Outdoor Unitary HVAC Equipment

C. Related Sections:
1. Division 01 -- Commissioning
2. Section 23 00 10 – HVAC General Requirements
3. Section 23 05 00 – Common Work Results for HVAC
4. Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment
5. Section 23 05 53 – Identification for HVAC Piping and Equipment
6. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC
7. Section 23 09 00 – Instrumentation and Control for HVAC
8. Section 23 20 00 – HVAC Piping and Pumps
9. Section 23 30 00 – HVAC Air Distribution

1.2 REFERENCES:

A. General: The following standards or codes form a part of this specification to the extent indicated by the reference thereto.

B. Air Moving and Conditioning Association, Inc. (AMCA):

Bulletin 210 Standard Test Code for Air Moving Devices

C. Air Conditioning and Refrigeration Institute (ARI):

Guideline T Thermal Performance for Cool Storage Equipment

Standard 210 Standard for Unitary Air Conditioning Equipment

Standard 410 Standard for Forced Circulation Air Cooling and Heating Coils

Standard 430 Standard for Central Station Air Handling Units

D. American National Standards Institute (ANSI):

Standard B31.1 Code for Pressure Piping

E. American Society of Heating, Refrigeration and Air Conditioning Engineers (ANSI/ASHRAE):

Standard 15 Safety Code for Mechanical Refrigeration

F. National Fire Protection Association (NFPA):

Standard 30 Flammable and Combustible Liquids Code

Standard 90A Air Conditioning and Ventilating Systems of other than Residence Type

G. National Electrical Manufacturers Association (NEMA)

H. Sheet Metal and Air Conditioning Contractors' Association (SMACNA)

Duct Construction Standards (Latest Edition)

I. International Fuel Gas Code (IFGC)

J. International Energy Conservation Code (IECC)

K. Underwriters Laboratories, Inc. (UL)

1.3 EQUIPMENT LABEL:

A. All mechanical equipment and appliances shall be listed and labeled by a nationally recognized testing and inspection agency approved by the authority having jurisdiction. All equipment and appliances shall be installed in accordance with the conditions of the listing. Manufacturer's installation instructions shall be available at the job site at the time of inspection.

1.4 COMMISSIONING OF HVAC SYSTEMS:

A. The Contractor shall provide contact information to the Commissioning Agent indicated in Division 1 for all major items of Equipment.

B. Provide additional submittal copy of major equipment for Commissioning Agent specified in Division 1.

1.5 SUBMITTALS:

A. Submit shop drawings, product data and samples in accordance with Division 1 and Section 23 00 10.

B. Shop drawings, diagrams, catalog data and such other data necessary to fully describe and substantiate compliance with these specifications shall be submitted for all equipment and materials marked with notation set forth in Section 23 00 10.

C. Operation and maintenance data shall be submitted in accordance with Division1, for all items of equipment and materials marked with notation set forth in Section 23 01 00.

D. All fans for use with Variable Frequency Drives (VFD) shall have critical speed and multiples of critical speed indicated on each submittal.

1.6 SPARE PARTS:

A. Each cooling or heating unit shall be provided with 3 sets of filters. At end of construction each unit shall be provided with a clean filter and one set shall be turned over to the Owner as spares.

B. Each belt driven piece of equipment shall be provided with one spare set of belts to be turned over to the Owner at the end of construction.

PART 2 - PRODUCTS

2.1 PACKAGED OUTDOOR UNITARY HVAC EQUIPMENT [S] [O/M]:

A. General: Rooftop air conditioning units shall be Trane, no substitute, factory fabricated units furnished complete with all components as specified herein and as required by application and model number

indicated on drawings. Units shall be packaged direct expansion single-zone draw through type complete with air-tight and weather-tight insulated and gasketed casing, fans, motors, adjustable V-belt drive, belt guards, drain pan, cooling coil, compressors, air cooled condenser, filter, and economizer. Each unit shall have physical dimensions suitable for allotted space and allow complete removal of filters, coils, drain pans and accessories without having to dismantle the unit, adjacent equipment or building components. Units shall be sized to allow piping to enter the unit within the curb and to allow valves and accessories within the unit casing. Hot gas reheat shall be factory installed and shall be complete with all necessary specialties for proper operation.

B. Casings for all sections of the unit shall be double wall galvanized steel construction with removable access panels or access doors as required for each individual section of unit. Casing shall be completely insulated internally with a minimum one-inch thick, one and one-half pound density fiberglass insulation factory coated with manufacturer's standard material to prevent erosion of insulating material. Minimum panel insulation value shall be R-7 for units 15 tons and less and R-13 for units over 15 tons.

C. Condensing section shall be complete with compressor-motor unit, condenser coil, welded-wire or stamped sheet metal condenser coil guards, condenser fans, motor starters, controls and piping enclosed in a sheet steel enclosure recommended for outside installation. Condenser fans shall be vertical or horizontal discharge as shown. Intake and discharge openings shall be provided with welded-wire or stamped sheet metal coil guards. Condensing unit controls shall provide automatic capacity modulation and condenser and evaporator pressure control for operation down to 0°F outside air temperature. Provide controls as required for enthalpy economizer. Crankcase heater shall be provided in compressor body.

D. Supply fan shall be plenum centrifugal type with galvanized steel housing. Fan wheel shall be forward curved type mounted on solid steel fan shaft supported by grease lubricated ball bearing with average minimum life of 200,000 hours. Bearings shall be provided with lubrication facilities located outside of the unit enclosure. Fan shall be provided with unit mounted motor and V-belt drive. Belt drives shall be designed for 150% of the connected motor capacity and sheaves shall be adjustable to provide at least 20% speed variation. Sheaves shall be selected to drive the fan at a speed which will produce the specified capacity when set at its approximate midpoint. Fan shall be statically and dynamically balanced at the factory after unit has been assembled. Fan shall be certified in accordance with ARI 430.

E. Fan casing shall be provided with hinged, gasketed and insulated access door with quick opening latches. Access door shall be located on drive side of fan housing. Location of access shall be coordinated with drawings to assure adequate clearances and service capabilities.

F. Coils:
   1. Duct-mounted heating coil shall be hot water coil as specified in Section 23 80 00.
   2. Cooling coils shall be direct expansion refrigerant type as specified in Section 23 80 00.
   3. Hot gas reheat coils shall be fin and tube type suitable for direct expansion (DX) refrigerant service.
   4. All coils shall be installed within casing sections. Coil casings shall completely enclose all coil items including headers and return bends. Casing shall provide a minimum of six inches between coils to allow for field mounting of sensors or instrumentation. Casing shall provide removable access panels for removal of coils without disassembling remainder of unit. Condensate drain pans are required for all cooling coils. Stacked cooling coils shall be provided with intermediate drain pans internally piped to main drain pan. Coil drain pans shall be insulated to prevent sweating under all conditions. Drain pan shall be provided with mastic coating to prevent corrosion. Drain pan shall slope to drain all moisture collected from the coil. Drain piping connections shall be provided at the lowest point of the drain pan.

G. Combination filter mixing box section shall be factory fabricated of same construction and of physical size to match unit casing as previously specified. Section shall include angular filter holding racks, outside air and return air dampers. Section shall be complete with hinged access doors located on both sides to facilitate filter media installation and replacement. Section shall be provided with block-off panels and means of sealing around filter media to prevent bypass of unfiltered air. Filter face velocity shall not exceed 350 feet per minute. Dampers for outside air and return air shall be full size of unit openings and shall be low leakage type with maximum leakage rate not to exceed 3 cfm per square foot at one inch water gauge. Damper arrangement shall provide proper mixing of outside air and return air while having capability of modulating either air stream.

H. All VAV units shall be provided with an internal and integral airflow monitoring station for measuring minimum outside airflow. Accuracy shall be $\pm$ 5% with an operating temperature range of –20°F to 120°F. Airflow monitoring station shall be compatible with the Building Automation System specified in Section 23 09 00. The airflow signal shall be an industry standard 0-10 vdc, or 4-20 mA for analog input to the Building Automation System.

I. Fiberglass filters shall be pleated media, UL Class 2 listed and labeled, two inches thick. Filter media shall have a rigid frame around entire perimeter and rigid support grille on entering and leaving faces to adequately support the filter media.

J. Economizer section shall be factory fabricated complete with outside air, return air, and barometric relief air dampers. All units shall be furnished with IECC and ASHRAE 90.1 Economizer Fault Detection and Diagnostics (FDD). Where a Building Automation System is present, the FDD shall communicate alarms to the BAS. Where there is no BAS present, the unit shall be capable of reporting faults to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats.

K. Unit Controls shall be factory furnished, installed and coordinated to operate with the system specified in 23 09 00. System shall include all necessary terminal blocks, motor contactors, motor overload protection, grounding lugs, control transformers, auxiliary contactors and terminals for the connection of external control devices or relays. Control system shall be a factory-mounted stand alone microprocessor-based DDC with all necessary sensors and interfaces to monitor and operate all functions as outlined in the equipment/control schedule and required for complete unit operation. The DDC controller shall be a Native BACnet applications controller that can communicate on a RS-485 LAN using the BACnet MS/TP or BACnet IP protocols. Control system shall be mounted in the unit main control compartment. Factory-mounted DDC control system shall be factory-programmed and run-tested prior to shipment to verify functions and logic. A unit-mounted intelligent programmable interface device shall be included for communication, display and setpoint control. A unit-mounted Hand/Off/Auto switch shall be included to allow for servicing. Refer to Section 23 09 93 for Sequence of Operation requirements of the packaged DDC controller. Refer to the Control Schematics on the Drawings to obtain configuration requirements of specific units. All points indicated on the controls diagrams shall be communicated to/with the Building Automation System. The controls shall be capable of receiving start/stop, setpoint, and occupancy signals from the Building Automation System.

L. Unit shall have factory wired non-fused disconnect switch with external handle and non-powered 15A GFI convenience outlet. Unit to have integral phase monitor to protect motors and compressors against problems associated with phase loss, phase imbalance or phase reversal.

M. All duct openings in unit floor over 12 inches wide shall have personnel-load-rated safety grates.

N. Rooftop units shall be provided with factory fabricated curb, 12”-14” high suitable for vibration isolation rail. The roof curb shall be pitched to match the pitch of the roof such that the top of the curb is level without the use of shims or other similar type devices. Curb sidewalls shall be fully insulated to minimum R-5. Top of curb shall be gasketed for airtight fit of rooftop unit.

O. Warranty: Motor-compressor shall be guaranteed for 5 years.

P. See PART 1 for spare parts requirements.

PART 3 - EXECUTION

3.1 GENERAL:

A. All equipment and materials, specified herein or shown on the drawings shall be installed complete, coordinated with all other work, tested and made tight and put into safe controlled operation to perform its intended function as a part of this project.

B. All rooftop equipment shall be secured to the roof framing structure.

3.2 ROOFTOP AIR HANDLING AND AIR CONDITIONING UNITS:

A. Coordinate all openings and location with structural systems.

B. All piping above the roof shall be installed in factory supplied pipe vestibule(s). Vestibule shall be supported on all sides by an integrated extension of the unit curb. Vestibule shall be insulated and match the construction of the unit casing. It shall be sealed and gasketed to be weatherproof with roof pitched to

shed water. Doors shall be provided and located to allow access to all components installed within the vestibule.

C. Contractor's attention is directed to Section 23 05 48 Vibration and Seismic Controls for HVAC Piping and Equipment for requirements.

D. Install and connect unit in accordance with manufacturer's recommendations and contract drawing details. Should conflicts in the two occur notify the Architect/Engineer.

E. Coordinate all control items with Section 23 09 00 Instrumentation and Control for HVAC.

END OF SECTION 23 70 00

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SECTION 23 80 00 - DECENTRALIZED HVAC EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY:

A. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Work Included:

1. Heating Coils
2. Unit Ventilators
3. Miscellaneous Appurtenances

C. Related Sections:

1. Division 01 -- Commissioning
2. Section 23 00 10 – HVAC General Requirements
3. Section 23 05 00 – Common Work Results for HVAC
4. Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment
5. Section 23 05 53 – Identification for HVAC Piping and Equipment
6. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC
7. Section 23 09 00 – Instrumentation and Control for HVAC
8. Section 23 20 00 – HVAC Piping
9. Section 23 30 00 – HVAC Air Distribution

1.02 REFERENCES:

A. General: The following standards or codes form a part of this specification to the extent indicated by the reference thereto.

B. Air Moving and Conditioning Association, Inc. (AMCA):

Bulletin 210	Standard Test Code for Air Moving Devices

C. Air Conditioning and Refrigeration Institute (ARI):

Standard 210	Standard for Unitary Air Conditioning Equipment
Standard 240	Standard for Unitary Heat Pump
Standard 310	Standard for Packaged Terminal Air Conditioners
Standard 410	Standard for Forced Circulation Air Cooling and Heating Coils
Standard 440	Standard for Room Fan Coil Air Conditioners

D. American National Standards Institute (ANSI):

Standard B31.1	Code for Pressure Piping

E. American Society of Heating, Refrigeration and Air Conditioning Engineers (ANSI/ASHRAE):

Standard 15	Safety Code for Mechanical Refrigeration

F. National Fire Protection Association (NFPA):

Standard 90A	Air Conditioning and Ventilating Systems of other than Residence Type

G. National Electrical Manufacturers Association (NEMA)

H. Sheet Metal and Air Conditioning Contractors' Association (SMACNA)

Duct Construction Standards (Latest Edition)

I. Underwriters Laboratories, Inc. (UL)

1.03 EQUIPMENT LABEL:

A. All mechanical equipment and appliances shall be listed and labeled by a nationally recognized testing and inspection agency approved by the authority having jurisdiction. All equipment and appliances shall be installed in accordance with the conditions of the listing. Manufacturer's installation instructions shall be available at the job site at the time of inspection.

1.04 COMMISSIONING OF HVAC SYSTEMS:

A. The Contractor shall provide contact information to the Commissioning Agent indicated in Division 1 for all major items of Equipment.

B. Provide additional submittal copy of major equipment for Commissioning Agent specified in Division 1.

1.05 SUBMITTALS:

A. Submit shop drawings, product data and samples in accordance with Division 1 and Section 23 00 10.

B. Shop drawings, diagrams, catalog data and such other data necessary to fully describe and substantiate compliance with these specifications shall be submitted for all equipment and materials marked with notation set forth in Section 23 00 10.

C. Operation and maintenance data shall be submitted in accordance with Division1, for all items of equipment and materials marked with notation set forth in Section 23 01 00.

1.06 SPARE PARTS:

A. Each cooling or heating unit shall be provided with 3 sets of filters. At end of construction each unit shall be provided with a clean filter and one set shall be turned over to the Owner as spares.

B. Each belt driven piece of equipment shall be provided with one spare set of belts to be turned over to the Owner at the end of construction.

PART 2 - PRODUCTS

2.01 HEATING AND COOLING COILS [S]:

A. General: This specification applies to all coils whether remote mounted, mounted in factory fabricated air handling units or mounted in site-built units and shall be used as a guideline to establish the minimum requirements unless definitely specified otherwise for the particular case involved.

B. Steam coils shall be constructed of cast semi-steel, seamless work hardened copper, or welded steel headers, red brass or copper tubes and aluminum fins mechanically bonded. Tubes shall be rolled and brushed or welded into headers. Tubes shall be 5/8 inch or 1 inch diameter, staggered, full circulating, and completely drainable. Tube wall shall be minimum 0.020 inch thickness. Fins

shall be minimum .0075 inch thickness. Coil support frame shall be heavy gauge galvanized steel with heavy gauge flanges and support plates. Fin tube and header section shall float with the casing to allow free expansion of tubing. Coils shall be factory tested and suitable for 200 psi working pressure. Coils shall be full tube face, steam distributing tube type with orificed distributing tubes installed concentric inside of condenser tubes.

C. Water coils shall be full tube face, fin and tube type constructed of seamless copper tubes and aluminum fins mechanically bonded to tubes. Coil support frame shall be heavy gauge galvanized steel with heavy gauge flanges and support plates. Tubes shall be 1/2 inch or 5/8 inch diameter, staggered, full circulating, and completely drainable. Tube wall shall nominally be minimum 0.020 inch thickness. Fins shall be minimum .0075 inch thickness. Coils shall be factory tested and suitable for 150 psi working pressure. Mount coils for counter flow service. Where coils are furnished in sections, the return connection to each section shall be provided with a balancing cock. Cooling coil ratings shall be certified in accordance with ARI Standard #410. Maximum cooling coil face velocity shall not exceed 550 feet per minute. Fin spacing shall be such that there are a maximum of 12 fins per inch.

D. Direct expansion (DX) refrigerant evaporator coils shall be full tube face, fin and tube type constructed of seamless copper tubes and aluminum fins mechanically bonded to tubes. Coil support frame shall be heavy gauge galvanized steel with heavy gauge flanges and support plates. Tubes shall be 1/2 inch or 5/8 inch diameter. Tube wall shall be minimum 0.020 inch thickness. Fins shall be minimum .0075 inch thickness. Tubes shall be staggered and circuited with equalizing distributing tubes to match the number of compressor refrigerant circuits provided. Coil circuiting shall be full face interlaced type where required for optimum capacity reduction. Units shall be provided with brass liquid distributors for each circuit. Coils shall be factory proof tested at 450 psig and leak tested at 300 psig, cleaned, dehydrated and sealed with dry nitrogen charge. Coils shall be coordinated with the manufacturer of the condensing unit for capacities indicated. Cooling coil ratings shall be certified in accordance with ARI Standard #410. Maximum cooling coil face velocity shall not exceed 550 feet per minute.

E. Heating and cooling coils in the same unit shall be provided as separate coils with independent fin sheets to allow preheat, dehumidification, and individual removal of each coil.

2.02 UNIT VENTILATORS [S] [O/M]:

A. General: Unit Ventilators shall be Trane, no substitute, and shall consist basically of a casing, coil assembly, drain pan, air filters, outside air inlet grille and wall box, fans, motor, fan drive, modulating economizer dampers, control package and motor switch. Each unit shall be fastened securely to the building structure.

B. Enclosure shall have removable front panel and shall be constructed of not less than 16 gauge furniture steel, properly reinforced and braced. Entire casing shall be acoustically and thermally insulated internally with not less than 3/4” thick glass fiber insulation fastened with waterproof adhesive. Supply grilles shall be top discharge steel fixed fin and shall be of such design as to properly distribute air throughout the conditioned space. Plastic discharge or return grilles are not acceptable. All metal surfaces shall be either galvanized or treated with a rust inhibitor. Hinged access doors shall be flush mounted and provided for all piping and control end pockets. All vertical units shall have casing extensions for piping crossover behind the unit. Crossover channels shall be separated from the outdoor air plenum by fully insulated panels. Wall boxes shall be heavy gauge anodized aluminum with front mounting flange and grille, color as selected by the Architect from manufacturer’s submitted color samples.

C. Fans shall be multiblade, centrifugal type, dynamically and statically balanced at the factory after assembly.

D. Coils shall be refrigerant coil type, single circulating type with separate steam coil in reheat position, each constructed of seamless copper tubing expanded into aluminum fins, provided with not less than 1/2” O.D. flare connectors and not less than 1/8” tapped holes with automatic air vent and drain plug. Coils shall be hydrostatically tested at 300 psi and suitable for 200 psi working pressure.

E. Unit dampers shall be fully proportioning outside/return air mixing dampers suitable for 0-100% modulation to provide for minimum outside air, return air and economizer operation. Outside air damper shall be tight-seal type to prevent outside air blow-through and hydronic coil freeze-up.

F. Unit face and bypass dampers shall be insulated, sized and located properly to provide full airflow through the heating coil or full airflow through the bypass section. Dampers shall be tight sealing and designed to prevent heat pick-up in the bypass.

G. Drain pans shall be sized and located properly to collect all water condensed on and dripping from any item within the unit enclosure. Drain pans shall be constructed of galvanized steel, insulated outside to prevent condensation and coated with a waterproofing material on the inside. Not less than 1/2" NPT drain connection shall be provided in drain pans.

H. Filters shall be provided for each unit and shall be 1" thick throwaway.

I. Motor shall be single speed, split capacitor, overload protected, directly connected to unit fan. Motor shall be provided with quick disconnect plug. Motor bearings shall be permanently lubricated.

J. Piping Package shall include 4 ball valves, 2 pressure compensating automatic balancing valves as specified hereinafter, heating and cooling control valves as specified under Section 23 09 00, and necessary piping as required for control specified hereinafter. All valves, piping, and appurtenances shall be installed at the factory and shall be concealed within externally accessible piping compartments in the unit enclosure.

K. Units shall be provided with factory installed control components as follows: 0-10vdc outside/return air actuator, 0-10vdc face and bypass damper actuator, 0-10vdc outside/return air actuator, freezestat and a 24vac start/stop pilot relay prewired into the fan motor circuit. All other unit controls shall be as specified in Section 23 09 00.

L. Units shall be provided with double-pole, single-throw power disconnect to shut off all power to motor, controls and all internal wiring components.

M. Pipe Enclosures shall be provided with each unit to enclose piping mains. Enclosure shall be 16 gauge, provided with a factory finish to match the unit ventilator enclosure, shall be complete with back panel, support strips, pipe hangers and any other accessories required for finished installation. Pipe enclosures shall completely enclose piping from walls or chases to unit casing.

N. Condensing (outdoor) unit for split system unit ventilators, shall be precharged, complete with compressor-motor unit, condenser coil, welded-wire or stamped sheet metal condenser coil guards, condenser fans, motor starters, controls and piping enclosed in a sheet steel enclosure designed for outside installation. Condenser fans shall be vertical discharge as shown. Intake and discharge openings and coils shall be safely guarded. Condensing unit controls shall provide condenser and evaporator pressure control or operation down to 35°F outside air temperature. Each unit shall be provided with hot gas bypass. Crankcase heater shall be provided in compressor body. Condensing unit base shall be constructed of 16 gauge steel or heavier with bolt-down holes for mounting. Unit shall be provided with filter-dryer, liquid line sight glass and service valves, all factory installed. Compressors shall be warrantied for a period of five (5) years from date of start-up.

O. Refrigerant piping and specialties shall be as specified in Section 23 20 00.

P. See PART 1 for spare parts requirements.

2.03 MISCELLANEOUS APPURTENANCES [S] [O/M]:

A. Water level switch shall be Magnetrol TF63 low water cut-off. Install in cooling tower basin at suitable height to de-energize basic heater if water level is less than 1/2" above top of heater.

B. Gravity Dampers [S] shall be Ruskin counter balanced back draft damper constructed of felt edged aluminum blades. Set to open at .10" H_2O.

C. Manometers [S] shall be provided for all filter stations of 2000 cfm capacity or more and shall be Dwyer 260-AF Series inclined type, solid acrylic air filter gauge complete with mounting hardware, static pressure tips, two 5' lengths of 1/4" diameter aluminum tubing, two 3-way vent valves, over-pressure safety trap to prevent loss of oil and any other accessories necessary for effective operation of the gauge. The operating range shall be 0-1.5 inches water column.

D. Miscellaneous electric appurtenances such as transformers, solenoid valves, electric relays, selector switches, on-off switches, pilot lights and other similar items required by the electric sequence control diagrams and not shown to be provided by the Electrical Contractor shall be provided as part of the Mechanical Contract.

1. Solenoid valves shall be Asco or Alco of coil rating and size to accomplish the indicated requirement.

2. On-Off switches shall be toggle type, 20 amp. contract rating complete with engraved cover plate where required.

3. Selector switches shall be manual selector type with the indicated poles and contacts and engraved cover plate. Contact rating shall be a minimum of 20 amps.

4. Relays shall be G.E., Square D, or Cutler-Hammer 20 amp rating with sufficient contacts for the sequence indicated.

E. Time clock [S] [O/M] shall be Paragon Model 7218 or Tork Model W220, seven-day model with 10 hour minimum reserve time feature. Reserve time spring shall rewind itself after power source is restored.

F. Thermostats [S] [O/M] shall be provided as indicated below. The use of thermostats containing mercury is not allowed.

1. Programmable Thermostats (s):

a. Programmable thermostats shall be Honeywell T7300A thermostat and a Q7300 subbase, or approved equal for (conventional heating/cooling) (heat pump) operation. The thermostat shall contain a keyboard for entering the times and temperatures along with a liquid crystal display for reading information. The thermostat shall contain a microprocessor that performs the calculations to control the system.

b. The T7300A thermostat shall contain a three hour override button, enabling programmed temperatures to be overridden from unoccupied mode to occupied mode.

c. The T7300A thermostat with Q7300 subbase shall provide a system that will control with system or fan switching and seven-day flexible programming with two occupied and two unoccupied periods per day for each of the seven days of the week. The system shall have individual setpoints for occupied heat and cool, and unoccupied heat and cool. System shall have auxiliary relay output for occupied/unoccupied control of auxiliary fans and dampers. System shall have capability to provide contact closures for two stages of output for heating and two stages of output for cooling.

2. Heavy duty heating thermostats shall be Johnson Controls T22 rated for 16 amps. at 120 volts.

3. Electric cooling thermostats shall be Johnson Controls T26J rated for 6 amps. at 120 volts.

4. Outdoor thermostats shall be Johnson Controls A19 Series.

5. Firestats shall be UL approved, Johnson Controls A25 manual reset type with an adjustable temperature setting. Set at 125°F.

6. Thermostat guards shall be rectangular plastic with baseplate and all required accessories for wall mounting. Guards shall have ample openings to allow fast sensing of room air conditions. Guards and baseplate shall be selected and sized to suit type of thermostat and mounting where installed.

G. Equipment rails for rooftop condensing units shall be Roof Products and Systems (RPS), Model ER-4 or equal. Equipment rails shall be fabricated of 18 gauge galvanized steel with built-in cant, monolithic construction with integral base plate and continuous mitered and welded corner seams, with factory installed wood 2x4 nailer. Each equipment rail shall include a matching 18 gauge galvanized steel counterflashing cap with integral drip edge, all corners mitered and welded, and screws for attachment. Equipment Rails over 3 feet long shall incorporate 14 gauge internal gusset reinforcing. Rail height shall be 9”-16”.

H. Dampers and Damper Motors:

1. Automatic control dampers shall be opposed blade construction for modulating service and parallel blade construction for two-position service. Dampers shall be of the multi-louver construction with brass bearings, channel iron frame and maximum width of 10”. Damper blades shall be interlocking felt edged and air tight.

2. Damper motors shall be provided for all automatic dampers and shall be sufficient capacity to operate the connected damper. Damper motor shall be electric type.

PART 3 - EXECUTION

3.01 GENERAL:

A. All equipment and materials, specified herein or shown on the drawings shall be installed complete, coordinated with all other work, tested and made tight and put into safe controlled operation to perform its intended function as a part of this project.

B. All rooftop equipment shall be secured to the roof framing structure.

3.02 ROOFTOP AIR CONDITIONING UNITS:

A. Coordinate all openings and location with structural systems.

B. Contractor’s attention is directed to Section 23 05 48 for requirements.

C. Install and connect unit in accordance with manufacturer’s recommendations and contract drawing details. Should conflicts in the two occur notify the Architect/Engineer.

D. Coordinate all control items with Section 23 09 00.

3.03 ROOFTOP CONDENSING UNITS:

A. Rooftop condensing units shall be installed on factory fabricated equipment rails as hereinbefore specified.

END OF SECTION 23 80 00

SECTION 26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED:

A. Every item of labor, material, devices and appurtenances for installing a complete Electrical System and other related systems included in Division 26 of the Specifications.

B. Section 26 05 00 – Common Work Results For Electrical

C. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

D. Section 26 05 23 – Control Voltage Electrical Power Cables

E. Section 26 05 26 – Grounding And Bonding For Electrical Systems

F. Section 26 05 33 – Raceway And Boxes For Electrical Systems

G. Section 26 05 53 – Identification For Electrical Systems

H. Section 26 28 13 – Fuses

I. Section 26 28 16 – Enclosed Switches And Circuit Breakers

1.3 RELATED WORK:

A. General: See all other portions of these Contract Documents and apply to those portions of work, relating to Electrical Work, the same as if repeated herein in its entirety. The Division 26 Electrical Trade shall allow for wiring and controlling all equipment requiring electrical connections as described therein even though not shown on the electrical drawings. The Division 26 Electrical Trade shall provide and install all conduits, standard boxes and grounding for Divisions 27 and 28 Trades. Divisions 27 and 28 Trades shall provide all special boxes, cabinets and enclosures to Division 26 Electrical Contractor for installation. The Division 26 Electrical Contractor shall coordinate with Divisions 27 and 28 Trades for sizes and locations of conduits, boxes, cabinets and enclosures required by Divisions 27 and 28 Trades. The Division 26 Electrical Trade shall provide and install all conduits, standard boxes, cable trays, and grounding for Division 27 & 28 Trades.

B. Section 09 90 00 - Painting

C. Division 11 - Equipment

D. Division 23 – Mechanical

1.4 WORK NOT INCLUDED:

A. Certain electrical equipment will be provided in-place as specified under other Divisions of these Contract Documents and other pieces of equipment such as operating controls, etc., will be provided f.o.b. (freight on board) premises, which shall be mounted and connected to electrically under Division 26.

1.5 DRAWINGS:

A. Where conduit, equipment, devices and other electrical appurtenances are shown on the drawings, the general arrangement of such items on the electrical drawings shall be followed as closely as actual building construction and the work of other trades will permit. Because of the small scale of the electrical drawings, it is not feasible to indicate all offsets, fittings and accessories which may be required. The Contractor shall investigate the construction conditions affecting the work and provide fittings and accessories as required to meet actual conditions.

1.6 QUALITY ASSURANCE:

A. Equipment and material used in the project shall be new and undamaged. The electrical installation shall fit into the space allotted and shall allow adequate, acceptable, clearances for entry, servicing, safety, and maintenance. The Contractor shall coordinate the work to ensure that the equipment may be moved into place without altering building components or other installations. All Electrical work shall be performed by a Commonwealth of Virginia Class-A licensed Electrical Contractor whose technicians, mechanics, or tradesmen shall be skilled in the trade involved. All electrical work shall be performed under the direct supervision of an electrician with a locally recognized and accepted master license.

B. Equipment and material in existing installations may be reused where specifically indicated on the drawings.

1.7 REFERENCES:

A. The complete installation and all materials and equipment under Division 26 shall conform to the Virginia Uniform Statewide Building Code, current issue, including all applicable portions of the National Electrical Code (NEC) and all other governing codes and regulations.

B. All equipment used shall bear the Underwriters Laboratory (U.L.) label for the intended application, or other organizations label if acceptable to the Authority having jurisdiction and concern with product evaluation.

C. In addition, the following codes, standards, and regulations shall apply to the complete installation and all materials and equipment. These are referred to by their accompanying abbreviations.

D.	National Electrical Code (NFPA No. 70) 2017	NEC
E.	National Electrical Manufacturers Association	NEMA
F.	Underwriters Laboratories, Inc.	UL
G.	Telecommunications Building Wiring Standards	TIA/EIA
H.	All Systems' Installation Certification Compliance Documents for Installing Trades	
I.	National Fire Protection Association	NFPA
J.	Uniform Federal Accessibility Standards	UFAS
K.	Americans with Disabilities Act Accessibility Guideline	ADAAG

L. The above standards are intended as a minimum and shall be exceeded if required by the Contract Documents. In the event information contained in the Contract Documents conflicts with one of the above mentioned codes, the codes shall take precedence.

1.8 PERMITS, LICENSES, TAXES AND INSPECTION CERTIFICATES:

A. All permits, bonds, licenses, electrical connection fees, inspection fees and taxes required for the execution of the work shall be obtained and paid for by the Contractor. Under each phase of the Electrical work the Contractor shall furnish three copies of certificates of final acceptance to the Engineer from any inspection authority having jurisdiction.

B. At the completion of the job, provide the Engineer with three (3) copies of an electrical inspection certificate from the local Electrical Inspector, if such inspection is provided and/or required by the locality.

1.9 REGULATIONS AND STANDARDS:

A. The completed installation and all materials and equipment shall conform to local ordinances and codes, other regulations and standards listed herein or in related sections. These are intended as a minimum and shall be exceeded if required by the specifications or Drawings. In the event of a conflict between the codes, standards, or regulations, and information contained in the Contract Documents, the applicable code, standard, or regulation shall take precedence.

1.10 SUBMITTALS:

A. Submit shop drawings, product data and samples in accordance with Division 1 for all items as specified in related sections of these specifications. One (1) electronic (PDF) copy of the submittal shall be submitted. One (1) electronic (PDF) copy of the submittal will be returned to the Contractor. If additional copies are required they will be the responsibility of the Contractor. Where drawings are submitted, the Contractor shall submit a minimum of two (2) sets of full scale prints. One (1) copy will be marked and returned to the Contractor, and the Contractor shall be responsible for all additional copies required for his use. All submittal data shall be correctly identified to show project name, and the exact model, style or size of item being submitted. Improperly identified submittals will not be reviewed by the Engineer. Each item submitted for review shall bear the Subcontractor's stamp which states that they have reviewed the submission, that it is complete, and that in their opinion it meets the contract requirements. Contractor's stamp shall identify the paragraph and page number for which the submittal is being made. Any submission which has not been reviewed and stamped by the Electrical Trade will not be reviewed by the Engineer. No reviews prior to award of Contract will be considered or accepted.

B. Shop drawings, samples, diagrams, catalog data and such other data necessary to fully describe and substantiate compliance with these contract documents shall be submitted as follows:
   1. All the equipment and materials where submissions are specifically required by other Divisions of these Contract Documents.
   2. All the equipment and materials that are indicated with an [S] behind the product title. This shall include submission of the specified products equipment and materials.
   3. All the equipment and materials that are acceptable equal substitution.
   4. If submission is NOT required for the SPECIFIED products "shop drawings and product data" under 1. and 2. above, the Contractor shall NOT submit a shop drawing for the SPECIFIED products.
   5. Samples, in good working order, shall be submitted in accordance with Division 1, complete with all installation and service drawings and instructions. All samples will be returned at the submitter’s expense unless otherwise indicated. Samples may be subject to destructive testing by the Architect/Engineer.

C. Operation and Maintenance manual(s) shall be submitted in accordance with Division 1 and shall include a complete product index, a copy of all accepted shop drawings, installation and maintenance data, sequence of controls, parts lists, and the name, address and telephone number of supplier or nearest representative. All electrical devices, equipment and systems marked [O/M] in these specifications shall be included and all other such electrical items which will require servicing before the duration of its useful life has been reached. The manual(s) shall be presented to the Engineer for review and transmitted to the Owner before the final payment is recommended.

D. Equivalents: Manufacturers, trade names and model numbers indicated herein and on drawings shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition. Unless definitely stated otherwise and upon complying with Division 1, the Contractor may use any article of equal appearance which, in his judgment is equal to that specified and is accepted by the Engineer. Where three or more manufacturers are named in the specifications for any item, the Contractor should use one of the

manufacturers. No others shall be reviewed or accepted. Manufacturers listed first in these specifications and on drawings were used as a basis of design. It will be the responsibility of the Contractor to verify all connections, physical sizes and capacities of all other manufacturer's items, both items named herein, or items proposed. If the equipment necessitates changes in power distribution, conduit, wiring, lighting, ductwork, piping, or any other building systems from that indicated on the drawings, the Contractor shall be responsible for all additional costs included and notify other trades of the changes. Where such changes are required, detail drawings indicating all required changes shall be submitted for review at the same time the manufacturers drawings are submitted for approval. See Division 1 for substitutions.

E. The ten day prior approval requirements of The Instructions to Bidders, AIA 701, are waived for this Division of the Specifications, and unless stated otherwise the Contractor may use items that he deems as equivalent in quality and performance to the specified item subject to final acceptance of substituted items by the Engineer upon his review of shop drawings. (This paragraph cannot be used with BCOM jobs!)

F. Guarantee: Electrical equipment, materials and labor required by these specifications and accompanying drawings shall be guaranteed to be free from defective materials or workmanship, including lamps, for a period of one year after final acceptance of the project except extended warranties as specified elsewhere in these documents on specific items of equipment will be furnished by the Trade providing the equipment. Defects in material or workmanship occurring during this period shall be corrected with new material and equipment or additional labor at no cost to the Owner. Manufacturer's certificates of warranty shall be transmitted to the Owner before final payment is recommended.

1.11 WARRANTIES:

A. The Contractor shall warrant for a period of one year all work provided under the Contract to include, but not necessarily limited to, all systems, equipment, materials, and workmanship. This shall not be construed to limit any extended warranty periods of longer than one year for specific items or systems specified elsewhere in the Contract Documents.

B. The warranty period shall commence on the date of acceptance by the Owner and shall cover all parts and labor as required to fulfill the warranty at no cost to the Owner.

C. Refer to Division 1 for additional warranty requirements.

D. Information on all warranties shall be included in the O&M Manuals specified herein to be provided to the Owner.

1.12 COORDINATION OF WORK:

A. General: The contract documents indicate the extent and general arrangement of the electrical systems. The Contractor shall be responsible for the coordination and proper relation of the electrical work to the building structure and to the work of other trades. No additional compensation or extension of completion time will be granted for extra work caused by the lack of coordination.

B. Miscellaneous loads, such as control panel power, are not always shown on the Drawings. Where additional circuits are needed for such loads, extend wiring to the load from the nearest electrical panel serving receptacle loads and connect to a spare circuit breaker. Where an emergency generator is present and the device to be served is for a controls system or component, the circuit shall be derived from a panelboard fed by the emergency generation optional/standby (NEC 702) system.

C. Cooperation: The Contractor shall provide dimensions and locations of all openings, shafts and similar items to the proper trades and install work as required so as not to interfere with, or delay, the building construction.

D. Locations of lines and equipment shall be determined from actual field measurements. The outlines of the building shown on the electrical drawings are intended only as a guide to indicate relative locations of the electrical work. Refer to architectural and structural drawings for building construction details. If conflicts prevent installation of electrical work at the locations indicated, minor deviations shall be made subject to acceptance by the Engineer, and without additional compensation.

E. Cutting and Patching: Unless stated otherwise, the Electrical Trade shall do all cutting necessary for the installation of his work. All work should be installed sufficiently in advance of new construction in order to

permit installation of supports, sleeves, and similar items without cutting. Cutting which will in any way affect the building structure shall not be performed without permission of the Architect-Engineer. The Electrical Trade is responsible for patching where he does cutting. Patching shall be done to the satisfaction of the Architect-Engineer.

F. Roughing-In: Receptacles, switches, and other similar items shall align vertically or horizontally with each other, hose bibbs, thermostats, the building structure and features thereof when it appears obvious and logical that they should. All mounting heights shall be within the limits of Commonwealth of Virginia USBC and ADAAG.

G. Damage to Other Work: The Electrical Trade is responsible for damage to other work caused by his work or workmen. Repairing of damaged work shall be done by the Trade who installed the work, and as directed by the Architect-Engineer; the cost of which shall be paid for by the Electrical Trade.

1.13 ASBESTOS:

A. Asbestos Free Materials: The intention of these drawings and specifications is that there be no asbestos containing materials installed on this project. To the best of the Architects' and Engineers' knowledge, none of the material or equipment specified herein or shown on the drawings contains asbestos. The Contractor shall make every effort to prevent any asbestos materials from being installed in or used on the construction of the project. At the completion of the project, the Contractor shall certify by letter that to the best of his knowledge, no asbestos containing materials were used for or in the construction of this project.

B. Existing Materials:
1. Discovery: If during the construction of this project, work involving friable asbestos is suspected, or encountered, all work in this area shall be discontinued and the Owner or the Owner’s representative, shall be notified immediately and the Owner with his own forces or by separate contract shall be responsible for complete investigation, removal, and disposition of the friable asbestos hazard in accordance with applicable laws and regulations. If the Contractor claims that delay or additional cost is involved because of such action by the Owner, he shall make such claim as provided elsewhere in the contract documents.
2. Removal: All work involving the removal of friable asbestos will be done under a separate contract.

1.14 GRAPHICS DATABASE:

A. This project’s Computer Aided Design & Drafting (CADD) drawing files may be purchased directly from the Engineer for use in preparing computer graphics specific to this project. See Appendix A at the end of this Section for Letter of Indemnification and ordering instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS AND MATERIALS:

A. General: Manufacturers and materials shall be as specified in subsequent sections of these specifications and as noted on the drawings. Similar types of equipment shall be the products of the same manufacturer unless specified otherwise.

2.2 SLEEVES AND INSERTS:

A. General: Sleeves and inserts shall be provided and correctly located in the structure, as required for the work.

B. Inserts shall be steel and of proper size for loads encountered.

2.3 ACCESS DOORS:

A. Provide for all junction boxes or any item requiring access. Doors shall be of sufficient size and so located that the concealed items may be serviced or completely removed and replaced. Doors required for work shall be furnished as a part of this Division to the General Contractor for installation. Doors in acoustic tile ceilings shall be furnished in multiples of tile sizes. Doors are not required in exposed grid type ceilings where tiles are removable. Doors shall be metal access doors with cam lock, style to match ceiling or wall construction. Doors occurring in rated construction shall be fire rated U.L. labeled access doors correlated to preserve the integrity of the rated construction. Doors shall be prime finish steel except those in toilets, shower rooms, locker rooms, kitchens and other similar areas shall be aluminum with natural anodized finish. Doors shall match the access doors in Division 23 and meet the acceptance of the Architect.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. General: Materials and equipment shall be installed in accordance with manufacturer's instructions to conform to the details and application as specified in subsequent sections of these specifications and indicated on the drawings.

B. Supports: Provide necessary supports for all equipment and appurtenances as required; this includes, but is not limited to, frames or supports for items such as lighting fixtures, disconnect switches, junction boxes, conduit, motor starters, and other similar items requiring supports.

C. Sleeves: Provide sleeves for all conduits passing through concrete or masonry walls, partitions, concrete slabs or beams installed during construction of the wall, partition, slab or beam. Sleeves placed horizontally in walls or in any position in beams shall be standard weight ASTM A53 steel pipe of length equal to the thickness of the wall or beam. Those placed vertically in non-waterproof floors shall be 20 gauge galvanized sheet steel of length equal to the thickness of the slab, flared and nailed to the form, or fastened to reinforcing fabric and filled with sand during pouring to prevent deformation. Sleeves occurring in floors of rooms where hose bibbs or floor drains provided under Division 21 occur, and in pipe spaces, shall be standard weight steel pipe projecting 1/2" above finished floor except in Equipment Rooms they shall project four (4) inches above finished floor. Sleeves in floors with waterproof membrane shall be provided with flanges or flashing rings and shall be clamped or flashed into the membrane. All sleeves shall be of sufficient diameter to allow installation of conduit except sleeves on lines subject to movement, which shall clear the conduit at least one inch all around. Conduits through exterior walls, or floors, below grade shall have seals specified in Section 26 05 43 between the conduit and wall sleeve. Sleeve shall have anchor and water stop plate. The entire assembly shall be tightened and adjusted to make watertight. Sleeves for insulated wiring and conduit, penetrating fire (and smoke) rated partitions, walls and floors shall have seals as specified in Section 26 05 43 and shall be sealed in accordance with the terms of U.L. Listed Through-Penetration Firestop Systems (XHEZ) as published in the U.L. Fire Resistance Directory. Penetrations shall exactly conform to details of the Firestop System indicated for the type of partition, wall and floor construction encountered. All penetrations through nonfireresistance rated floor assemblies and through the ceiling membrane of nonfireresistance rated roof assemblies shall be fireblocked with tightly packed mineral-wool insulation secured in place. All penetrations through equipment room walls and other areas of noise or heat generation shall be tightly sealed with mineral fiber rope. All penetrations through draftstop partitions shall be sealed to maintain the integrity of the partition. All firestopping of sleeves for electrical work shall be provided under Division 26.

D. Temporary Requirements: Openings in equipment shall be kept capped at all times until connection is made to the system. The ends of all conduits and equipment openings shall be kept capped properly with approved devices. Approved devices are items such as specially molded plastic caps and sheet metal caps.

E. Access Doors: Provide access doors for all concealed electric equipment, pull boxes, junction boxes or any item requiring access. Doors shall be of sufficient size and so located that the concealed items may be serviced or completely removed and replaced. Doors required for Electrical work shall be furnished by the Electrical Trade, to the Contractor for installation. Doors in acoustic tile ceilings shall be furnished in multiples of tile sizes. Doors are not required in exposed grid type ceilings where tiles are removable.

F. Painting: All work under this Division shall be painted in accordance with Section 26 05 53, Identification for Electrical Systems. Division 26 shall also paint and identify all conduits and boxes for Divisions 27 & 28 as described in Section 26 05 53.

3.2 EXISTING WORK AND DEMOLITION:

A. Electrical Demolition: Remove all existing electrical conduits, wiring, junction boxes, outlets, lighting fixtures, wiring devices, unused panelboards, etc., indicated for demolition. Additional amounts of demolition may be required to accommodate desired renovations and new construction. Not all demolition may be shown on the drawings. All existing electrical equipment not indicated for demolition shall remain in place.

B. Equipment and Fixtures Removed: The Owner will select and retain such existing electrical equipment and materials which are indicated to be removed and not reused, as he desires. All other existing equipment and materials indicated to be removed, and not reused shall become the property of the Contractor, who shall remove them from the premises within the time frame specified under other Divisions of this Contract Document.

C. Equipment and Fixtures Relocated: All existing lighting fixtures, panelboards and other electrical equipment and materials indicated to be relocated shall be disconnected, removed, and relocated. All electrical equipment and materials shall be protected from damage during demolition. Install new phase, neutral and grounding conductors, if grounding conductor is not already present, in each feeder and branch circuit to be reworked, from the panelboard to the outlet.

D. Power Interruption: Attention is called to the fact that the existing facility shall remain in operation throughout the construction period. All necessary temporary arrangements shall be made as required to keep all electrical circuits in continuous operation during this period except for scheduled outages for circuit change-overs. The outage shall be kept to the minimum and carefully scheduled to suit the Owner.

E. Mechanical Equipment: All existing mechanical equipment being removed or relocated under this contract shall be disconnected electrically, both power and control wise, so that the Mechanical Trade can remove or relocate same.

F. Miscellaneous: In all altered portions of the buildings, the Electrical Trade shall remove or alter as necessary all existing electrical work that does not fit with the new construction. All existing work or areas that are not altered shall be reconnected as required. Where indicated changes to non-electrical facilities require minor electrical changes, these changes shall be accomplished even if not specifically indicated. Only a small portion of the existing work is shown on the drawings. Contractors submitting proposals shall visit the site to determine the scope of work under this heading as no additional compensation will be granted because of existing conditions even though the existing conditions may not be indicated on the drawings. Contractor shall thoroughly inspect the electrical systems in reworked areas and bring to the attention of the Engineer all defective or unserviceable material not scheduled for removal or replacement. Demolition shall not begin until the work schedule is approved by the Owner. The work shall be scheduled to prevent any disruption to the normal operations of the building. Refer to other Divisions for work phasing.

3.3 FIELD QUALITY CONTROL:

A. System Readings: Certain system voltage and current readings shall be taken, the values recorded and submitted in triplicate to the Engineer. Two complete sets of readings are required, one under no load and one under maximum available load. The current and voltage shall be recorded on each phase (plus voltage between all phases) at main panelboard and at each branch circuit panelboard. Additional spot readings shall be made if required. Resistance of grounding system shall be tested and recorded. Forms for submitting this report may be obtained from the Engineer's office. A sample form is bound herewith.

B. Equipment Readings: Voltage and amperage readings on each phase of each motor circuit and each resistance heater circuit installed under this contract shall be measured, the values recorded, and submitted in triplicate to the Engineer. Also record motor nameplate data, actual motor heater protective device ratings and all other data necessary for selection of heater device.

C. Verification [V]: Upon completion of the project, the Contractor shall submit a separate letter of certification (or compliance) to the Owner/Architect/ Engineer that each of the following systems or equipment functions properly, conforms to all requirements of these specifications and all requirements of the manufacturer of the systems.
   1. Section 26 50 00, Lighting.

3.4 MANUFACTURER'S ASSISTANCE:

A. Qualified technical representatives of manufacturers shall be available to visit the project and provide required assistance for any problems or trouble areas of any systems, material or equipment used in the project. Manufacturer's engineering assistance shall also be available for above problems or trouble areas. The Contractor shall purchase all materials, equipment or systems with these services included in the purchase price or otherwise be prepared to have the above service provided when needed or requested by the Engineer without additional compensation. Where one manufacturer's equipment constitutes the majority of the components or devices to make a system, the manufacturer's technically qualified representative shall inspect and accept the completed installation whether or not especially requested by the Engineer.

3.5 INSTRUCTION OF OWNER'S REPRESENTATIVE:

A. The Electrical Trade shall instruct the representative of the Owner in the proper operation and maintenance of all elements of the Electrical systems. Competent representatives of the Contractor shall spend such time as necessary to fully prepare the Owner to operate and maintain the Electrical systems.

3.6 CONSTRUCTION STATUS REPORT:

A. Each item of discrepancies noted on Construction Status Report prepared by the Engineer shall be answered in detail in writing by the Contractor before payment can be recommended.

3.7 RECORD OF UNDERGROUND LINES:

A. On completion of the project, the Contractor shall prepare and submit to the Architect-Engineer a drawing on tracing paper and one full-size print to show the location of any underground lines installed in locations different from those on the Architect-Engineer's drawings. The location and the distance from the building to outside lines and manholes shall be dimensioned.

3.8 DESCRIPTION OF ALTERNATES: Refer to the other Divisions of this Contract Specification (Manual) for description of alternates. (On BCOM projects, use the words “additive bid items”.)

3.9 SCHEDULE OF ABBREVIATIONS:

Electrical Abbreviations:

A	-	AMP
ABV	-	ABOVE
AC	-	AIR CONDITIONING OR ARMOR CLAD
ACB	-	AIR CIRCUIT BREAKER
ACI	-	AMERICAN CONCRETE INSTITUTE
ACS	-	ABOVE COUNTER SPLASHBACK
ADAAG	-	AMERICANS WITH DISABILITIES ACT
AEIC	-	ASSOC OF EDISON ILLUMINATING CO'S.
AFF	-	ABOVE FINISHED FLOOR
ANSI	-	AMERICAN NATIONAL STANDARDS INSTITUTE
ASME	-	AMERICAN SOCIETY OF MECHANICAL ENG.
ASTM	-	AMERICAN SOCIETY FOR TESTING AND MATERIALS
ATS	-	AUTOMATIC TRANSFER SWITCH
AUTO	-	AUTOMATIC
AUX	-	AUXILIARY
BALL	-	BUILDING ACOUSTICS AND LIGHTING LABS
BAT	-	BATTERY
BIL	-	BASIC INSULATION LEVEL
BOCA	-	BUILDING OFFICIALS AND CODE ADMIN.
BRK	-	BREAKER
CAP	-	CAPACITORS
CABO/MEC	-	COUNCIL OF AMER. BLDG. OFFICIALS MDL
CB	-	CIRCUIT BREAKER (CRT BRK)
CBM	-	CERTIFIED BALLAST MANUFACTURERS
CCCT	-	CROSS CURRENT COMPENSATION TRANSFORMER
CF	-	COIL FAN
CMU	-	CONCRETE MASONRY UNIT
CND	-	CONDUIT (COND)
CNDCT	-	CONDUCTOR
COMB	-	COMBINATION
CONC	-	CONCRETE
CONTR	-	CONTRACTOR
CPT	-	NEUTRAL GROUNDING TRANSFORMER
CRT	-	CIRCUIT
CS	-	CORNER SECTION
CT	-	CURRENT TRANSFORMER
CUH	-	CABINET UNIT HEATER
CW	-	COLD WATER
DB	-	DOORBELL
DF	-	DRINKING FOUNTAIN
DH	-	DOOR HOLDER
DISC SW	-	DISCONNECT SWITCH (D.S.)
DO	-	DRAW OUT
DP	-	DOUBLE POLE
DT	-	DOUBLE THROW
DW	-	DISHWASHER
E	-	EXISTING (EXST)
EA	-	EACH
EC	-	ELECTRIC CONVECTOR
EEI	-	EDISON ELECT. INST.
EGC	-	EQUIPMENT GROUNDING CONDUCTOR
EIA	-	ELECTRONIC INDUSTRIES ASSOC.
ELEC	-	ELECTRIC
EMER	-	EMERGENCY (EM)
EMT	-	ELECTRICAL METALLIC TUBING
EN	-	EXISTING OUTLET WITH A NEW DEVICE AND WIRING
ENG	-	ENGINE
EO	-	EXISTING OUTLET
EQUIP	-	EQUIPMENT
EP	-	EXPLOSION-PROOF
EP SW	-	ELECTRO- PNEUMATIC SWITCH
ER	-	EXISTING RELOCATED
ERL	-	ENVIRONMENTAL RESEARCH LABS
ESC	-	ELECTRIC SEQUENCE CONTROLS
ETL	-	ELECTRICAL TESTING LAB
EWC	-	ELECTRIC WATER COOLER
EXP	-	EXPANSION
FA	-	FIRE ALARM
FIN FL	-	FINISHED FLOOR
FIXT	-	FIXTURE
FL	-	FLOOR
FLA	-	FULL LOAD AMPS
FLUOR	-	FLUORESCENT
FS	-	FILLER SECTION
FU	-	FUSE
GBM	-	GROUND BUS MODULE
GEC	-	GROUNDING ELECTRODE CONDUCTOR
GEN	-	GENERATOR
GF	-	GROUND FAULT
GND	-	GROUND
GRS	-	GALVANIZED RIGID STEEL CONDUIT
HOA	-	HAND-OFF-AUTOMATIC
HP	-	HORSEPOWER
HPS	-	HIGH PRESSURE SODIUM
HV	-	HIGH VOLTAGE
HW	-	HOT WATER
HZ	-	HERTZ
IB	-	IN BASEBOARD
IBS	-	IN BASE OF SHELVES
ICEA	-	INSULATED CABLE ENGINEERS ASSOCIATION
ICL	-	IN COUNTER LIP
ICS	-	IN COUNTER SPLASHBACK
IEEE	-	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENG'S
IGC	-	ISOLATED GROUNDING CONDUCTOR
IMC	-	INTERMEDIATE METAL CONDUIT
INCAND	-	INCANDESCENT
INTLK	-	INTERLOCK
ITL	-	INDEPENDENT TESTING LABORATORIES
JB	-	JUNCTION BOX
KV	-	KILOVOLTS
KVA	-	KILOVOLTS-AMPS
KVARS	-	KILOVAR
KW	-	KILOWATT
LA	-	LIGHTNING ARRESTOR
LV	-	LOW VOLTAGE
MAX	-	MAXIMUM
MC	-	METAL CLAD
MDH	-	MAGNETIC DOOR HOLDER
MECH	-	MECHANICAL
MFG	-	MANUFACTURER
MIN	-	MINIMUM
MH	-	MANHOLE
MO	-	MOTOR OPERATED
MOD	-	MOTOR OPERATED DAMPER
MP	-	MAIN PANEL
MP SW	-	MOTOR PROTECTIVE SWITCH
MS	-	MOTOR STARTER
MTD	-	MOUNTED
MTS	-	MANUAL TRANSFER SWITCH
MW	-	MEGAWATTS
NC	-	NORMALLY CLOSED
NCS	-	NURSES CALL SYSTEM
ND	-	NEW DEVICE IN EXISTING OUTLET
NEC	-	NATIONAL ELECTRIC CODE
NEMA	-	NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
NESC	-	NATIONAL ELECTRICAL SAFETY CODE
NFPA	-	NATIONAL FIRE PROTECTION ASSOC
NIC	-	NOT IN CONTRACT
NEUT	-	NEUTRAL
NO	-	NORMALLY OPEN
OCB	-	OIL CIRCUIT BREAKER
OPR	-	OPERATED
OS	-	OIL SWITCH
OSHA	-	OCCUPATIONAL SAFETY & HEALTH ACT
P	-	POLE
PA	-	PUBLIC ADDRESS
PB	-	PULLBOX
PC	-	PHOTOCELL (PEC)
PD	-	PLUG DUCT
PE	-	PNEUMATIC ELECTRIC
PM	-	PLUG MOLD
PNL	-	PANEL
PS	-	PLUG STRIP
PT	-	POTENTIAL TRANSFORMER
PW	-	PART WINDING (MOTOR STARTER)
PWR	-	POWER
R	-	REMOVE
RR	-	REMOVE & REINSTALL
R&C	-	REMOVE DEVICE & CAP OUTLET
REC	-	RECEPTACLE
RHC	-	RE-HEAT COIL
RLY	-	RELAY
SEC	-	SECONDARY
SGA	-	SURGICAL GAS ALARM
S/N	-	SOLID NEUTRAL
S/O	-	SPACE ONLY
SP	-	SINGLE POLE
ST	-	SINGLE THROW
SURF	-	SURFACE
SUSP	-	SUSPENDED
SW	-	SWITCH
SYNCH	-	SYNCHRONIZE
TC	-	TIME CLOCK
TEL	-	TELEPHONE
TIA	-	TELE-COMMUNICATIONS INDUSTRY ASSOC
TRANS	-	TRANSFORMER (XFMR)
TYP	-	TYPICAL
UCL	-	UNDER COUNTER LIP
UFAS	-	UNIFORM FEDERAL ACCESSIBILITY STANDARDS
UH	-	UNIT HEATER
UL	-	UNDERWRITERS LAB
UV	-	UNIT VENTILATOR
V	-	VOLT
VDOT	-	VIRGINIA DEPARTMENT OF TRANSPORTATION
W	-	WATTS
WH	-	WALL HEATER
WM	-	WIRE MOLD
WP	-	WEATHERPROOF
Y	-	WYE
ι	-	PHASE

END OF SECTION 26 05 00

ELECTRICAL TEST DATA REPORT

Ascent Engineering Group
5228 Valleypointe Pkwy, Suite #4
Roanoke, VA 24019

PROJECT: _____
_____
_____
_____

Electrical Contractor: _____
Date tests were made: _____ Date Submitted: _____

Current Characteristics: _____Volts _____ Phase _____ Wires

Type voltmeter used: _____ When calibrated:_____
Type ammeter used: _____ When calibrated:_____

Service ground - Resistance in ohms _____
Resistance test must be made with hand crank, magneto type, megger.

PANEL	VOLTAGE - NO LOAD		VOLTAGE - MAX. LOAD		MAX. LOAD AMPERAGE			
	PH TO PHASE	PHASE TO GND	PHASE TO PHASE	PH - GND	PH A	PH B	PH C	NEUT

A.

MOTOR OVERLOAD PROTECTION

REQUIRED ON ALL PHASES
(SEE N.E.C. SECT. 430 FOR
MAX. PERCENT ALLOWABLE)

PROJECT:

CONTRACTORS:

GEN.:

MECH.:

ELEC.:

DATE:

NOTES:

1. IDENTIFY EACH MOTOR THUS: CWP-1, H&V-1, F-1, ETC. SAME AS SHOWN ON DWGS.
2. SMALL MOTORS MAY BE RATED THUS: HP, WATTS OR FLA.
3. ALL DATA BY ELECTRICAL CONTRACTOR.
4. SERVICE FACTOR -- IF NOT AVAILABLE ENTER DEGREE C. RISE.
5. MOTOR CONTROLLER TYPE -- FVNR, RVPW, 2-SPD/1W, 2-SPD/2W, Y/Δ, MANUAL, ETC.
6. MOTOR PROTECTION -- INCLUDE COPIES OF HEATER TABLES WITH THIS REPORT.

EQUIP. MARK (1)	MOTOR DATA						MOTOR CONTROLLER		N.E.C.	MOTOR PROTECTION (6)		
	HP (2)	VOLTS	PHASE	N'PLATE AMPS	SERVICE FACTOR (4)	RUN AMPS*	TYPE (5)	NEMA SIZE	MAX. % ALLOWED	MIN. & MAX. AMPS	HEATER NO.	MFGR.

*AS MEASURED WITH AMMETER AT SITE.

APPENDIX A

LETTER OF INDEMNIFICATION

Project Name:

Project Location:

The contractor may purchase from Ascent Engineering Group a CD-ROM or electronic mail version of the projects CADD database. The minimum fee on any request is $250.00, subject to receiving a signed Letter of Indemnification. There is an additional charge of $10.00 per sheet on projects greater than 20 sheets. Drawing files will consist of floor plan views only, of Electrical plan sheets. All seals, details, schematics, tables, controls, etc. will be deleted. All drawings will be provided in Autocad™ 2010 format. Payment shall be returned with a signed copy of the Letter of Indemnification. Payment shall be received before shipment or transfer of data.

Ascent Engineering Group reserves all rights to the original drawing files.

The Purchaser agrees, to the fullest extent permitted by the law, to hold harmless and indemnify Ascent Engineering Group and the Architect, as defined in the Bid Documents, from and against all claims, liabilities, losses, damages, and costs, including but not limited to attorney's fees, arising out of or in any way connected with the use, modification, misinterpretation, misuse, or reuse by the Purchaser or others of the machine readable information and data provided by Ascent Engineering Group under this Agreement. The foregoing indemnification applies, without limitation, to any use of the project documentation on other projects, for additions to this project, or for completion of this project by others, excepting only such use as may be authorized, in writing, by Ascent Engineering Group.

The electronic drawing files are not part of the Contract Documents for the Project. The Purchaser assumes all risks associated with the use of the transmitted files. Ascent Engineering Group will not be responsible for any differences in the information included in the transmitted files and the information shown on the Contract Documents. Modifications to the Contract Documents made before or during construction may or may not be included in the transmitted electronic drawing files.

The Purchaser further agrees that the drawing files will only be used in graphics preparation for the above-referenced project.

Company Name of Purchaser: _____

Purchaser's Designated Representative: _____

Title: _____

Signature: _____

Address: _____

Return to: Ascent Engineering Group
5228 Valleypointe Pkwy #4,
Roanoke, VA 24019
AEG # 23190

SECTION 26 05 19 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL:

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED:

A. Wires and Cables, Under 600 Volts.

B. Connectors and Lugs, Under 600 Volts

1.3 RELATED WORK:

A. Division 23 – Mechanical

B. Section 26 05 26 – Grounding And Bonding For Electrical Systems

C. Section 26 05 33 – Raceway And Boxes For Electrical Systems

D. Section 26 05 36 – Cable Management For Electrical Systems

E. Section 26 05 53 – Identification For Electrical Systems

F. Section 26 20 00 – Low-Voltage Electrical Distribution

G. Section 26 55 61 – Theatrical Lighting

H. Section 26 60 00 - Connections And Systems' Interfaces To Elevators

I. Division 27 – Communications

J. Division 28 – Electronic Safety and Security

1.4 REFERENCES:

A. All wire, cables, connectors and lugs shall be U.L. listed for the application intended, and meet NEMA applicable standards.

B. All wiring methods shall meet with NFPA applicable codes.

1.5 CONDUCTOR CODING: (208Y/120-Volt)

A. Color Code Conductors of 208Y/120-volt system power and lighting conductors as follows:

Neutral	White
Ground	Green

Phase A	Black
Phase B	Red
Phase C	Blue

B. No. 12 and No. 10 conductors shall have continuous insulation color. Color code conductors larger than No. 10 which do not have continuous insulation color by application of at least two laps of colored tape on each conductor at all points of access. Tape shall be “Scotch,” “Highland,” or “Timflex,” vinyl plastic electrical tape No. 35, or accepted equal. Wrap-around "Brady" markers or shrinkable PVC sleeving with hot-stamped lettering may be used and shall state the appropriate conductor identification.

C. Number code all control and instrumentation wiring at all points of access.

1.6 CONDUCTOR SIZES:

A. All conductor sizes (AWG) are based on copper. (See Section 2.2A.1 for provisions to utilize aluminum building wiring – Spec Writer to decide whether or not to permit aluminum feeder conductors)

1.7 SUBMITTALS:

A. Submit shop drawings and product data in accordance with Section 26 05 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. All wires and cables shall be as manufactured by General Cable, Capital Wire & Cable, Carol Cable, American Insulated Wire, Southwire, Senator, Rome, Cerro Wire and Cable, Circle Wire & Cable.

B. All connectors and lugs shall be as manufactured by T & B, Buchanan, 3M, Burndy, or accepted equal.

2.2 MATERIALS AND TYPE:

A. Wiring, Power and Control:
   1. General:
      a. Conductors shall be **soft annealed copper** unless otherwise indicated.
      b. Feeder conductors, indicated to be size #1/0 and larger, may be aluminum in lieu of copper. Where substitution of aluminum is made, the Contractor shall take responsibility for resizing all conductors and conduits for the affected circuits in accordance with each individual overcurrent device, equipment buss rating and the NEC. In no case shall an aluminum feeder conductor, or set of conductors, have a smaller ampacity than the circuit size based on copper. **(Spec. Writer verify you wish to retain this paragraph!)**
      c. All conductors #8 AWG or larger shall be stranded (except in surface raceway SR, all conductors shall be stranded).
      d. All power wiring shall be #12 AWG minimum unless otherwise indicated.
      e. All control wiring shall be #14 AWG minimum for NEC Class I and #16 AWG minimum for NEC Class II, **extra fine stranding.**
      f. All insulation shall be rated for 600 volts unless otherwise indicated.
   2. Building Wiring: Conductors shall be type "THWN" or "THHN" unless otherwise indicated. "THHN" shall not be used in damp or wet locations.
   3. Flexible Metal Conduit (Liquidtight) Connections and Motor Starter Enclosures: Power and line voltage control wiring Type MTW stranded copper unless otherwise indicated for all motor connections, HVAC equipment, transformers, all other equipment subject to movement and vibration, and motor starter enclosures.
   4. Flexible Cable:
      a. Shall be hard service cord, type "SO" with equipment ground conductor in addition to normal current carrying conductors, and "safety-yellow" jacket.

b. Connectors shall be Crouse-Hinds series CG, Appleton, Kellems, O.Z./Gedney, Raco, or T & B, complete with locknut, sealing gasket, gland nut and tapered neoprene bushing.
c. In hazardous areas, connectors shall be Crouse-Hinds CGBS.

B. Connectors and Lugs, 600 Volts and Under:
1. Material: Copper, or suitable copper alloy, for all current carrying parts and all parts coming in contact with conductors.
2. Connectors and Lugs, No. 8 and Larger Conductors: Compression type T & B "Color-Keyed", or accepted equal by Burndy or Kearney. Mechanical compression lugs furnished with equipment are acceptable. Provide insulating covers or heat shrinkable insulators where required.
3. Connectors, No. 10 and Smaller Conductors: Permanently indented self-insulated pressure connectors T & B, Buchanan, or accepted equal. Snap-on insulating caps are acceptable insulation. "Scotch-loks" by the 3M Company, "Wing-Nut" by Ideal, "Legrands" by Pass & Seymour (P&S) are acceptable wing type wire connectors.
4. Lugs, No. 10 and Smaller Conductors: Permanently indented or compression type by Buchanan, Burndy, T & B, or accepted equal. Washer head screw terminals without lugs are acceptable on neutral bars, circuit breakers, wiring devices and other equipment, unless otherwise indicated. Mechanical compression lugs furnished with equipment are acceptable.
5. Exterior Splices: Compression type T & B "Color-Keyed", complete with T & B Shrink-Kon series HS heat shrinkable insulators, or accepted equal by Burndy or Kearney.
6. Connectors and Lugs, Aluminum: All connectors, lugs and fittings shall be UL listed for use with aluminum alloys, and aluminum to copper alloys where encountered.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Clean out raceway system before pulling wire.

B. Thoroughly inspect all existing raceway systems for burrs, deformation, rust, water, and other hazards. Inform Architect/Engineer in writing of any raceway conditions that would be detrimental to wiring, or not in compliance with Codes or practices. All existing raceways shall meet the requirements of Section 26 05 33.

C. Utilize an approved compound as required to facilitate pulling wires and cables, unless otherwise indicated.

D. 600 Volts and Under Wiring Methods:
1. Conductor Ties:
a. Inside each enclosure, other than outlet and junction boxes, conductors shall be bundled and trained utilizing T & B "Ty-Rap", 3M Brand Cable Ties, Tyton Cable Ties, or accepted equal, ties. All Switchboards, Panelboards, Motor Starters, Disconnects, etc. require at least one (1) conductor tie for each circuit entering and each circuit leaving the Switchboard, Panelboard, Motor Starter and Disconnect.
2. Conductor Sizes:
a. Line Voltage Power Wiring: No. 12 AWG minimum. Circuits and feeders larger than 20 amp. to have conductors sized for equal or greater ampacity than their protective device ratings unless otherwise indicated. All wires for 20 amp. circuits shall be #10 on runs 100 feet to 250 feet, #8 on runs 251 feet to 500 feet and #6 on runs 501 feet and above.
b. Control Wiring:
1) 120 Volt: If not carrying motor current, No. 14 AWG unless otherwise indicated, or required by load or distance encountered.
3. Terminal Strips: Where equipment does not have terminal strips, provide terminal strips to terminate and splice control, power limited and communication cables. Indicate wire numbers on strip with indelible pen.
4. Conductor Identification:
a. Wire Markers:
1) Identify lighting branch circuit wiring by panelboard name and circuit number at all accesses.
2) Identify feeders by name of equipment from which they originate, circuit number, and phase.
3) Identify all control wiring with a unique number for each wire.
b. Color Code: Color code conductors to designate neutral conductor, ground conductor and phase conductors as described in Part 1 of this Section.

5. Splices:
    a. Feeders: Feeder conductors installed between electrical distribution equipment (i.e., switchboards, transformers, and panelboards) shall be free from splices, no exceptions. Any feeder conductor splices proposed by the Contractor shall be approved in advance by the Engineer; otherwise, they are not permitted.
    b. No splices shall be made in any conductor beyond the exterior walls of the Building, except in exterior pullboxes, and where approved by the Engineer.
6. Flexible Cable, Type SO: Flexible cable shall be used to connect portable equipment in kitchens, laboratories, shops, etc., as indicated and limited by the Codes.
7. Each applicable system shall have a separate conduit system unless the applicable system's manufacturer, Codes and Regulations permit other systems conductors to be installed in the same conduit.
8. Type RHH/USE/RHW conductors shall be used for exterior underground lighting branch circuits in schedule 40 PVC conduit. Refer to Section 26 05 43 for the exceptions to the specified complete concrete encasement. Direct burial of the RHH/USE/RHW wire is not permitted. The type UF conductors shall be used within the exterior lighting fixture pole or standard.
9. Type XHHW-2 conductors shall be used for the secondary underground service entrance cables unless otherwise indicated.

END OF SECTION 26 05 19

SECTION 26 05 23 – CONTROL VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL:

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED:

A. Power Limited Shielded Cable

1.3 RELATED WORK:

A. Division 23 - Mechanical

B. Section 26 05 26 – Grounding And Bonding For Electrical Systems

C. Section 26 05 33 – Raceway And Boxes For Electrical Systems

D. Section 26 05 36 – Cable Management For Electrical Systems

E. Section 26 05 53 – Identification For Electrical Systems

1.4 REFERENCES:

A. All wire, cables, connectors and lugs shall be U.L. listed for the application intended, and meet NEMA applicable standards.

B. All wiring methods shall meet with NFPA applicable codes.

1.5 CONDUCTOR SIZES:

A. All conductor sizes (AWG) are based on **copper**.

B. Number code all control and instrumentation wiring at all points of access.

1.6 SUBMITTALS:

A. Submit shop drawings and product data in accordance with Section 26 05 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. All connectors and lugs shall be as manufactured by T & B, Buchanan, 3M, Burndy, or accepted equal.

B. All **power limited shielded twisted pair** shall be as manufactured by Manhattan, Belden, Alpha, West Penn, Anixter [S].

2.2 MATERIALS AND TYPE:

A. Wiring, Power and Control:
1. General:
a. All control wiring shall be #14 AWG minimum for NEC Class I and #16 AWG minimum for NEC Class II, **extra fine stranding.**
b. All insulation shall be rated for 600 volts unless otherwise indicated.
2. Plenum rated power limited twisted pair cable.
a. For Remote Control, Signaling and Power-Limited Circuits as per NEC-725 for Class 2 and 3 circuits.
1) General: Cable shall be UL classified, Subject 13, non-conduit application in ceiling air plenum in accordance with NEC 725 and as specified below.
2) Control and Instrumentation (24 volt) (Heating, Ventilating and Air Conditioning): Control and instrumentation (24 volt) shall be the minimum of two (2) #16 twisted pair configuration, type CL2P and CL3P insulated stranded tinned copper conductors with 1-1/2 minimum lay, flame retardant, low smoke insulation as required by Class, insulated jacket, color coded, 100% aluminum polyester tape shield, #18 AWG tinned copper drain wire or as indicated otherwise herein.
3) Control and Instrumentation (Heating, Ventilating and Air Conditioning): Thermocouple extension wire shall be compatible with the specific thermocouple material and shall have the same features as "(2)", except the wire shall meet ANSI standard MC96.1 (Temperature Measurement Thermocouples) and have proper amount of pairs for the application.
4) Direct Digital Control System: Wiring between pilot relays, sensors, DDC's and control processing unit shall have proper amount of pairs and be the type as required by Digital Control System installed by temperature control system trade, and shall have similar features of "(2)".
5) Other Systems: Wiring on the applicable systems load side shall be gauge, pairs and shield as required by the applicable system's manufacturer and shall have similar features as to "(2)". Provide shield if required by applicable system's manufacturer or Codes.
b. For Fire Protective Signaling System Circuits per NEC-760:
1) The cable shall be UL Classified, Subject 13, non-conduit application in ceiling air plenum in accordance with NEC 760 and as specified below.
2) Cable features shall be twisted pair configuration, type FPLP, color coded, solid tinned copper conductor, flame retardant, low smoke insulation, 100% aluminum polyester tape shield complete with tinned copper drain wire. The quantity of pairs, gauge and shielding requirements shall be determined by the fire alarm system manufacturer. Provide shield if required by the fire alarm system's manufacturer or codes.
3. Power limited twisted pair cable (Not for air plenums):
a. For Remote Control, Signaling and Power-Limited Circuits as per NEC-725 for Class 2 and 3 circuits.
1) General: Cable shall be UL classified for non-conduit application in ceiling void (non-air plenum) in accordance with NEC 725 and for application in multi system common raceway in accordance with NEC 725 and as specified below.
2) Control and Instrumentation (24 volt) (Heating, Ventilating and Air Conditioning): Control and instrumentation (24 volt) shall be the minimum of two (2) #16 twisted pair configuration, insulated stranded tinned copper conductors with 1-1/2 minimum lay, types CL2 or CL3, or riser type cables CL2R or CL3R, as required by Class, insulated, jacket, color coded, 100% aluminum polyester tape shield, #18 AWG tinned copper drain wire or as indicated otherwise herein.
3) Control and Instrumentation (Heating, Ventilating and Air Conditioning): Thermocouple extension wire shall be compatible with the specific thermocouple material and shall have the same features as "(2)", except the wire shall meet ANSI standard MC96.1 (Temperature Measurement Thermocouples) and have proper amount of pairs for the application.
4) Direct Digital Control System: Wiring between pilot relays, sensors, DDC's and control processing unit shall have proper amount of pairs and be the type as required by Digital Control System installed by temperature control system trade, and shall have similar features of "(2)".

5) Other Systems: Wiring on the applicable systems load side shall be gauge, pairs and shield as required by the applicable system's manufacturer and shall have similar features as to "(2)". Provide shield if required by applicable system's manufacturer or Codes.

b. For Fire Protective Signaling System Circuits per NEC-760:
1) The cable shall be UL Classified for non-conduit application in ceiling void in accordance with NEC 760 and as specified below.
2) Cable features shall be twisted pair configuration, type FPL or riser type FPLR as required, color coded, insulated solid tinned copper conductor, insulated jacket, 100% aluminum polyester tape shield complete with tinned copper drain wire. The quantity of pairs, gauge and shielding requirements shall be determined by the fire alarm system manufacturer. Provide shield if required by the fire alarm system's manufacturer.

4. Terminal Strips shall be 600 volt barrier type with marking strip suitable for marking with indelible pens.
5. Pulling compound shall be U.L. listed.
6. Wire markers shall be wrap-around tags made of shrinkable PVC sleeving with hot-stamped blocks or slip-on beads.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Clean out raceway system before pulling wire.

B. Thoroughly inspect all existing raceway systems for burrs, deformation, rust, water, and other hazards. Inform Architect/Engineer in writing of any raceway conditions that would be detrimental to wiring, or not in compliance with Codes or practices. All existing raceways shall meet requirements of Section 26 05 33.

C. Utilize an approved compound as required to facilitate pulling wires and cables, unless otherwise indicated.

D. 600 Volts and Under Wiring Methods:
1. Conductor Ties:
a. All power limited cable shall be bundled and trained for each system in the ceiling voids. Each bundle shall be supported from the structure with proper metallic (Caddy) clamp or hanger at the required distances. Proper type of T & B Halar™ cable ties are permitted for use in air plenums.
2. Conductor Sizes:
a. Control Wiring:
1) 120 Volt: If not carrying motor current, No. 14 AWG unless otherwise indicated, or required by load or distance encountered.
2) 30 Volts or Under: No. 16 AWG unless otherwise indicated, or required by load or distance encountered.
3. Control and instrumentation wiring specified in Divisions 21 and 22 shall be furnished and installed by Division 26.
4. Control and instrumentation wiring specified in Division 23 shall be furnished and installed as follows:
a. All line voltage control wiring, 101 volts, 60 Hertz or higher voltage shall be provided under Division 26.
b. All low voltage control raceways and wiring, 100 volts and lower voltages and thermocouple extension wiring, shall be provided under Division 23, according to Section 26 05 33 and Section 26 05 23 product and material requirements, and installation methods.
5. Direct Digital Control System wiring specified in Division 23 shall be furnished and installed as follows:
a. All line voltage control wiring, 101 volts, 60 Hertz or higher voltage, wired through the Digital Control System; and 120 volts, 60 Hertz power source wiring to the Direct Digital Control System shall be provided under Division 26.
b. All low voltage control wiring (100 volts and lower voltages) for the Direct Digital Control System shall be provided under Division 23, in the manner as noted above for control and instrumentation wiring.
6. Plenum Rated (and Non-Plenum) Power Limited Shielded Twisted Pair Cable:
a. All plenum rated (and non-plenum) shielded power limited cable shall be installed in accordance with NEC Article 725, 760 or 800 on the "load" side of the applicable system.
b. Provide proper number, shielding and size of wires as required for operation of the applicable system in accordance with the manufacturer's instructions and applicable NFPA codes.
c. Raceway Requirements:

1) Where an accessible ceiling system or demountable partitions are installed; hollow spaces in casework are available; or similar accessible void is available; a conduit system will not be required. If a conduit system is not utilized cables shall be installed using the specified “Open Wire Management” system.
2) Where cable is in inaccessible ceiling voids, in inaccessible wall void, penetrates a floor or wall, or exposed on wall or at ceiling, the cable shall be in conduit.
3) Where partial, detached or “floating” ceilings are provided or no finished ceiling is provided, the cable shall be in conduit, terminating in an accessible corridor ceiling void.
4) The above conduits shall terminate in an accessible void and shall be bushed to prevent damage to cable. All conduits shall also be grounded to the BGES.

d. Wiring splices are to be avoided to the extent possible, and if needed, they must be made only in accessible junction boxes and shall be crimp connected.
e. Transposing or changing color coding of wires shall not be permitted.
f. Wire nut-type connections are not acceptable. All connections shall be made on terminal strips (in boxes or cabinets).
g. All conductors shall be labeled on each end with "E-Z markers" or equivalent.
h. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal.
i. Cabinet terminals shall be numbered and coded. All controls, function switches, etc., shall be clearly labeled on all equipment panels.
j. All connections to components and equipment shall be made with crimp type terminal connections, or method approved by applicable systems manufacturer.
k. All wiring shall be checked and tested to ensure that there are no grounds, opens or shorts.
l. Ground all shields only at termination point (originating).
m. If shield is not to be grounded, pull shield back over cable jacket and insulate with heat shrink tubing to prevent accidental grounding.
n. Install cable connectors on all power limited cables entering enclosures except where cable is in protective conduit.
o. All cables installed in ceiling voids shall be attached to or supported from a vertical surface, a structural member or electrical conduit with a Caddy flexible cable support, bridle ring or cable clamp; or specified conductor tie (plenum rated where required). Absolutely **do not** support from ceiling system or fixture support wires **except** where accessing a ceiling mounted device. The cable(s) shall **not** block lay-in lighting fixtures, ceiling mounted HVAC equipment or ceiling tiles in order to allow **full** access to the ceiling void.

7. Terminal Strips: Where equipment does not have terminal strips, provide terminal strips to terminate and splice control, power limited and communication cables. Indicate wire numbers on strip with indelible pen.
8. Conductor Identification:
   a. Wire Markers:
      1) Identify all control wiring with a unique number for each wire.
   b. Splices:
      1) No splices shall be made in any conductor beyond the exterior walls of the Building except in exterior pullboxes, and where approved by the Engineer.
      2) Shielded power limited cable for Digital Control System wiring shall be splice free between sensors, DDC's and central processing unit.
9. Each applicable system shall have a separate conduit system unless the applicable system's manufacturer, Codes and Regulations permit other systems conductors to be installed in the same conduit.

END OF SECTION 26 05 23

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED:

A. Service Entrance Electrode Grounding System

B. Separately Derived System's Electrode Grounding System

C. Equipment Grounding Conductor (EGC)

1.3 RELATED WORK:

A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

B. Section 26 05 23 – Control Voltage Electrical Power Cables

C. Section 26 05 33 – Raceway and Boxes for Electrical Systems

1.4 REFERENCES:

A. NFPA 70 (NEC), Article 250

1.5 DESCRIPTION:

A. The service entrance grounding electrode system shall be in accordance with NEC 250.64 and 250.66, and other applicable NEC Articles. The minimum grounding electrode system shall be a connection to the cold water main valve inside the building or structure plus the minimum of three (3) ground rods in a triangular pattern outside the building and the metal frame of the building or structure, where effectively grounded.

B. The separately derived system grounding electrode system shall be in accordance with NEC 250.30 and other applicable NEC Articles.

C. An insulated equipment grounding conductor, color coded per section 26 05 19, and the NEC, shall be provided for each alternating current circuit without exception.

1.6 TESTS:

A. The grounding electrode system shall have a resistance of 25 ohms or less as per N.E.C. 250.56. Resistance of the grounding electrode system shall be measured separately, with this system disconnected from the building, using the three-point "fall-of-potential" method. Measurements shall be made with appropriate ground resistance meters as manufactured by James G. Biddle; Associated Research, Inc.; or accepted equal.

B. The equipment grounding conductor shall be tested for continuity and proper bonding to metallic equipment enclosures, outlet boxes, wiring devices and similar items.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Ground Rods: 3/4" X 10' copper-clad steel ground rods as manufactured by Copperweld, "Permaground" stainless steel clad ground rods as manufactured by Teledyne Metal Forming, or accepted equal. The copper shall have a minimum thickness of .013 inch at any point on the rod. If necessary to install ground rods deeper than 10'-0", then sectional ground rods shall be installed.

B. Ground Clamps: Thomas & Betts “GUV,” O. Z. Gedney “CG” series or Blackburn “GUV” series, as required by water pipe size and/or grounding electrode conductor size.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. The service, which includes the service entrance conductors and raceways, and service equipment shall be grounded where required and in accordance with requirements of the National Electric Code.

B. Multiple-Rod Grounding Electrode System: The ground rods and ground grid system shall be of adequate design sufficient to allow for seasonal changes in soil characteristics and possible corrosion of the ground system by the soil, and shall be installed in virgin, undisturbed soil. Multiple-rod grids should be arranged in either a triangular arrangement or in a "hollow square" if of more than 3 rods, with spacing between adjacent rods not less than the average depth of the rods in the system. If the soil has been disturbed, either by the present construction or previous occupancies, then the ground rods shall be deep-driven, so that there shall be a minimum length of 10 feet in undisturbed soil.

C. Ground conductors shall be connected to the ground rod(s) by exothermic welding as manufactured by:
   1. "Cadweld" process by Erico Products, Inc., or
   2. The “ThermOweld” process by Continental Industries Inc.

D. Equipment Grounding Conductor (EGC):
   1. Provide a separate insulated grounding conductor, color-coded as per Section 26 05 19, enclosed in the same raceway with the phase conductors for all alternating current circuits, even though not necessarily shown on the drawings.
   2. The equipment grounding conductor shall be secured to the equipment enclosure at the source of power and at the apparatus being served by the alternating current supply.
   3. The minimum size for the grounding conductor shall be as specified in Table 250.122 of N.E.C.
   4. Existing alternating current circuits: If an equipment grounding conductor is not present in the existing feeder or branch circuit to be reworked, Division 26 shall provide new phase, neutral and grounding conductors from the related switchboard or panelboard to the indicated outlet.

END OF SECTION 26 05 26

SECTION 26 05 33 – RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL:

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED:

A. Rigid Conduit (Heavy Wall, Intermediate Metal Conduit, Electrical Metallic Tubing and Rigid Non-Metallic Conduit)

B. Flexible Conduit (Liquidtight and "Greenfield")

C. Surface Raceway (SR) and Wireway

D. Fittings for Conduits, Flexible Metal Conduit, Surface Raceway (SR), Wireway.

E. Pull Boxes

F. Junction Boxes

G. Outlet Boxes

H. Exterior Pullboxes

1.3 RELATED WORK:

A. Section 26 05 36 - Cable Management for Electrical Systems

B. Section 26 05 53 – Identification For Electrical Systems

C. Section 26 20 00 – Low-Voltage Electrical Distribution

D. Section 26 50 00 – Lighting

1.4 SUBMITTALS:

A. Submit shop drawings and product data in accordance with Section 26 05 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Rigid Heavy Wall Conduit (GRS): Essex, Allied Tubing, Republic, Steelduct, Triangle, L.T.V., Wheatland, or accepted equal.

B. Intermediate Metal Conduit (I.M.C.): L.T.V., Berger Industries, Inc., Allied Tubing, or accepted equal.

C. Electrical Metallic Tubing (E.M.T.): L.T.V., Wheatland, Republic, Steelduct, Berger Industries, Inc., or accepted equal.

D. Rigid Non-Metallic Conduit: Carlon "PLUS" Schedule 40, 90ºC, U.L. listed, Queen City Plastics, Sedco, Can-Tex Industries, or accepted equal.

E. Liquidtight Flexible Metal Conduit: Anaconda "Sealtite", O.Z./Gedney "Flex-Guard", Electri-Flex Co. "Liquid-Tight", or accepted equal.

F. Galvanized Single Strip Steel Flexible Conduit: American Flexible Conduit, Anaconda, Electri-Flex Co., or accepted equal.

G. Fittings (All fittings to be same materials as specified for conduit):
1. Rigid Heavy Wall and Intermediate Metal Conduit Fittings: O.Z., T & B, Efcor, Berger Industries, or accepted equal.
2. Electrical Metallic Tubing Fittings: T & B, Raco, Steel City, O.Z./Gedney, Berger Industries, Inc. or accepted equal.
3. Flexible Metal Conduit Fittings: T & B, O.Z./Gedney, Midwest, Steel City, or accepted equal.
4. Conduit "L's": Crouse Hinds, Killark, O.Z./Gedney, Shamrock Conduit Products, or accepted equal.
5. Cable Supports: O.Z. type M, or accepted equal.
6. **Underground Raceway Seals:** O.Z., Spring City Electrical MFG., or accepted equal [S].
7. Fire Wall and Smoke Partition Seals:
   a. O.Z. type CFS fire seals or T & B "Flame Safe" Fire Stop System or 3M Brand Fire Barrier Penetration Sealing System #7904, 3M Brand Fire Barrier Caulk CP-25 and Putty 303, Nelson "Flameseal" fire stop putty, or accepted equal for each conduit or cable as required [S].
   b. Wiremold FlameStopper™ FS series Thru-Wall Fitting, STI EZ-Path, or other accepted equal for installation of power limited cabling through fire wall [S].
8. Rigid Non-Metallic Conduit Fittings: Carlon, Queen City Plastics, Sedco, Can-Tex Industries, or accepted equal.
9. Insulated Throat Metallic Bushings: O.Z./Gedney Type B or BLG, T & B nylon insulated metallic, or acceptable equal by Efcor. Provide grounding lug type where required.
10. Service Heads: Appleton type F, or accepted equal by O.Z./Gedney, Steel City, or Crouse-Hinds.

H. Wireway: Square D or equal by Walker, or Hoffman.

I. **Surface Raceway:** Surface metal raceway and fittings shall be by the Wiremold Co. or acceptable equal by Walker and Mono-Systems [S].

J. Pull and Junction Boxes: General Metals, Electromate Mfg. Corp., Hoffman, or accepted equal.

K. Outlet Boxes: Appleton, Raco, Steel City, or accepted equal.

L. Outlet Box Brackets: E-Z Mount Bracket Co., Inc., Montvale, Virginia 24122 (540-947-5500), or accepted equal by Caddy, Raco.

M. **Exterior Pullboxes:** Quazite Corporation, Blackburn-Weaver, Bell, Perfect-Line, O.Z./Gedney, Carlon, or accepted equal [S].

2.2 MATERIALS AND USE:

A. Rigid Heavy Wall Conduits (GRS): Of mild steel tube, electro or hot-dipped galvanized and U.L. labeled.

B. Intermediate Metal Conduit (I.M.C.): Of mild steel tube in sizes 3/4" to 4", hot-dipped galvanized or electro-galvanized and U.L. labeled. Refer to limitations under Part 3 - EXECUTION.

C. Electrical Metallic Tubing (EMT): Of mild steel tube in sizes 3/4" to 4" hot-dipped galvanized or electro-galvanized and U.L. labeled. Refer to exceptions under Part-3.

D. Flexible Metal Conduit:

1. Liquidtight flexible metal conduit: Flexible galvanized steel tubing covered with extruded liquid-tight jacket of PVC and a continuous copper bonding conductor wound spirally between the convolutions. Refer to limitations in Part 3 - EXECUTION.
2. Galvanized single strip steel flexible conduit (Commercial Greenfield): UL 1 listed. Refer to limitations in Part 3 - EXECUTION.

E. Rigid Non-Metallic Conduit: Schedule 40 PVC (polyvinyl chloride) conduit that meets and exceeds UL 651, NEMA TC2-1978 for above ground, direct burial, concrete and exposed applications. Refer to limitations in Part 3 - EXECUTION.

F. Fittings:
1. For Rigid and Intermediate Conduit: Couplings to be galvanized or sherardized steel. Double galvanized steel locknuts shall be used where required by code. Single locknut and bushing may be used elsewhere. Insulated throat metallic bushings to be installed on all rigid conduit terminations where such bushings are required by NEC to protect the wires from abrasion. Use ground lug type where required.
2. For E.M.T.: Steel set screw connectors, permanently indented or gland compression type. **Do not use cast metal type.**
3. For Flexible Metal Conduit: Standard liquidtight fittings for liquidtight conduit. Standard steel flexible metal conduit fittings for standard flexible metal conduit.
4. Conduit "L's": Galvanized steel, threaded, "LB" or "LBD".
5. Cable Supports: To be installed for the support of all conductors and cables as per NEC Article 300-19.
6. Underground Raceway Seals: Provided on each underground electrical raceway entering building. Provide type "FSK" "thruwall" seals on each conduit passing through the outside wall or floor. Provide type CSBG conduit sealing bushing on each underground conduit at the first pullbox, panel or other location as noted on drawings.
7. Fire Resistance Rated Wall and Smoke Partition Seals:
   a. Provide fire-seals for each conduit or cable passing through fire rated walls and floors where the floor, wall or smoke partition has a rating up to three (3) hours in accordance with Manufacturer's application data. All penetration systems shall have been tested per ASTM B14-88 fire test and UL listed for "Through-Penetration Fire Stop System".
   b. Provide UL approved thru-wall fittings for passage of power-limited cabling where cable tray, path of cable hooks, or other major cable pulling route intersects fire wall. The system shall expand rapidly where exposed to fire or high temperature to provide the required firestopping. The fittings shall be complete with built-in firestopping material and through-wall penetration. Each penetration shall be equivalent size of a 4” conduit sleeve or greater and shall remain fully accessible to add or remove cables without disturbing the firestopping material. The fittings shall have been UL-tested and meet the requirements of ASTM E814 UL1479 and shall be rated for 4 hours. Fittings shall be UL approved for use in air plenums.
8. For Rigid Non-Metallic Conduit: PVC fittings, elbows and cement shall be provided by the same manufacturer who provides the rigid non-metallic conduit.
9. Conduit Expansion Joints: O.Z. mechanical type, or accepted equal, on each conduit run crossing building expansion joint.
10. Service Heads: As required by conduit size.

G. Surface Raceway:
1. The raceway shall consist of a base and cover section factory assembled and designed to accommodate pulling conductors through the raceway. Raceway shall be U.L. labeled.
2. The base section shall have a nominal material thickness of .040" and be manufactured of zinc plated or galvanized steel. 6000 base shall be .060" thickness.
3. The cover section shall have a nominal material thickness, as listed below, and be painted with a baked enamel finish which is capable of being over-painted in the field if required.

Mark	Series	Cover Thickness
SR2	Wiremold 200	.025”
SR5, SR7	Wiremold 500, 700	.040”
SR22	Plugmold	.040”
SR3	Wiremold 3000	.040
SR4	Wiremold 4000 (w/divider)	.040"
SR6	Wiremold 6000 (w/divider)	.040"

4. Raceway dimensions shall be as follows:

Mark	Series	Dimensions
SR2	Wiremold 200	½” W x 11/32” H
SR5	Wiremold 500	¾” W x 17/32” H
SR7	Wiremold 700	¾” W x 21/32” H

SR22	Plugmold 2200	2-3/8” W x 3/4” H
SR3	Wiremold 3000	2-3/4” W x 1-17/32” H
SR4	Wiremold 4000 (w/divider)	4-3/4" W x 1-3/4" H
SR6	Wiremold 6000 (w/divider)	4-3/4" W x 3-9/16" H

5. Fittings:
   a. General: A full complement of fittings must be available including, but not limited to, bushings to prevent wire abrasion, single and multiple gang boxes to accommodate device installation, adapters from conduit to raceway, transitions to both larger and smaller surface metal raceways, receptacle covers, wiring device brackets, take-off connectors, pre-wired receptacle harnesses, 90 degrees elbows, tees, fixture boxes and flexible sections to allow uninterrupted continuation of raceway along semi-circular or curved surfaces.
   b. SR4 (4000) Wiring Device Plates: Each receptacle location shall have a Wiremold #4048B device cover plate and specified duplex receptacle. Each Data/Comm. Location shall have a Wiremold #V4007C-1 Device cover plate and a blank faceplate per section 26 27 26 selection with color to match raceway.
6. Refer to limitations under PART 3 - EXECUTION.

H. Wireway:
1. Wireways shall be listed to meet UL 870.
2. Wireway covers and troughs shall be constructed from a minimum of 14 gauge steel before finishes are applied. The end flanges shall be constructed from ten gauge steel. All lengths and fittings shall have smooth, rounded edges to prevent damage to wire and cable insulation. Wireway shall be furnished without knockouts.
3. Wireway covers shall have oil-resistant closed cell gasketing for sealing purposes. A solid oil-resistant neoprene joint gasket shall be used between flanges for rigidity when sections and fittings are bolted together.
4. A gasketed captive hinged connector which interlocks with the covers shall be used at each joint. The connector shall be such that the covers cannot be closed and latched without closing the sealing connector.
5. Wireway shall be provided with quick-release cover latches which hold the cover securely in place when closed. Latches shall have provision for a sealing wire to be used when covers and latch are in the closed position.
6. Wireway covers shall be secured to the troughs with leaf type hinges which all allow full opening access to the wireway interior.
7. Provide NEMA-1, NEMA-3R, NEMA-4X, NEMA-12 or other NEMA enclosure where required by NEC or environmental conditions.

I. All boxes to be sherardized or galvanized (after fabrication) sheet steel (except floor boxes) code gauge boxes.

J. The minimum size of all boxes shall conform to the requirements of the National Electrical Code, unless noted to be larger on the drawings, and shall have adequate braces and supports.

K. Pull and Junction Boxes: All boxes shall have screw-on or hinged covers. All flush mounted boxes shall have 3/4" overlapping covers with flush-head cover retaining screws and covers in finished areas shall be prime coated with paint.

L. Stud Wall Outlet Box Brackets: Provide #E-Z 1-4, #E-Z 4-1116 or #E-Z 23-1 outlet box brackets with extension brackets or acceptable equal.

M. Outlet Box Bar Hangers: Provide adjustable or solid bar metal hangers by Appleton Electric Manufacturing or accepted equal.

N. Exterior Pullboxes: Provide reinforced polymer concrete service box, extension, and cover with proper logo with a minimum of 7.4 cubic feet of interior space unless otherwise indicated and meets ASTM D-756, D-543, D-570, D-790 and D-365 test requirements.

O. Plugging Boxes: C.W. Cole & Co., Inc. recessed stage floor pockets and wall boxes, with outlets as indicated on the drawings. Housing to be 16 gauge steel. Floor boxes to have cast-iron cover, nonskid tread design, self-closing door, cord clearance slots, baked black enamel finish, and suitable for mounting in wood or concrete floors. Wall boxes to have cast aluminum cover with self-closing door, lock plus two keys (all units keyed alike), baked aluminum enamel over corrosion-resistant primer, suitable for mounting in stud wall.

P. Multi-Service Recessed Floor Boxes (FB): Walker Inc., #RFB4-CI-1, cast iron recessed four (4) compartment combination box complete with combination wire tunnel/mounting bracket, two (2) internal duplex receptacle

brackets as required, internal blank brackets as required, telephone/data brackets as required (Contractor to match telephone and data jacks' specification), flush access hatch with floorport flanged activation kit consisting of die-cast aluminum trim ring in finish color selected by Architect and insert areas for carpet or tile cutouts to match surrounding finish, or doors with 1" conduit openings for furniture feeds, as required. Box assembly shall meet UL 514 scrub water exclusion requirements in areas where hard floors are encountered, and in areas where scrub water is anticipated.

Q. Wood Floor Boxes: Unless otherwise noted, provide Walker #880 Series steel floor box (one, two, or three gang with removable barriers for multi-service applications as required) with flush mount brass combination flange and multiple #828 brass duplex cover plates having flip lids and locking screws (3828GFITC plate for GFI receptacle applications and low voltage connectivity requirements). Provide all inserts, modules and jack to match Owner's requirements and as indicated on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Provide raceway systems to achieve required distribution, switching and circuit control. All wires for all systems shall be installed in rigid metal raceways and terminated in boxes or cabinets, unless otherwise specified herein as partial conduit or non-conduit installation. Allow for making connections to all outlets, motors, etc., indicated and check plans to insure that all outlets, etc., have a designated circuit. Notify the Engineer of any discrepancies found.

B. Conduit runs are not shown on the drawings, unless specifically noted or indicated otherwise.

C. Conceal all (new) raceways (in existing and new construction) except where specifically noted on drawings or permitted as exposed. Runs in mechanical room areas may be exposed. Exposed conduit must be run parallel with the building walls and supported in a neat substantial manner. Refer to surface raceways under PART 3 - EXECUTION.

D. **Cap** raceway systems during course of construction and thoroughly clean inside before installation of conductors.

E. Provide a completely separate raceway system for all emergency lighting and exit sign circuits as required by N.E.C.

F. No rigid raceway for line voltage wiring shall be smaller than 3/4", except for flexible conduit, unless specifically indicated otherwise. The Electrical Trade shall size all other raceways based on the N.E.C. and verify the sizes shown on the drawings, increasing same if required by local authorities and/or codes.

G. All conduit feeding from one building area to another shall remain within the confines of the building, unless shown or noted otherwise on the drawings.

H. Field made conduit bends shall be made with an acceptable bending machine or conduit bender.

I. Flexible Metal Conduit:
   1. Liquidtight flexible metal conduit cannot be used in any return air plenum. Standard galvanized single strip steel flexible conduit shall be used in all return air plenum spaces.
   2. Liquidtight flexible metal conduit for **all** flexible connections, **plus** all short (less than 6' long) motor connections, transformers and all equipment subject to movement or vibration and where permitted by the Engineer. For flexible connections in return air plenums, flexible metal conduit shall be substituted for liquidtight flexible metal conduit.
   3. Galvanized single strip steel flexible conduit (6' maximum length) limited to use as the flexible connection to recessed lighting fixture assemblies *(only)* (and in existing wall voids).

J. Rigid Metal Heavywall Conduit (GRS):
   1. All joints shall be properly threaded and made tight in standard conduit couplings.
   2. All thread conduits or nipples are not acceptable.
   3. All conduit cuts shall be square, made with a hacksaw or approved cutting machine, and reamed after threading and before installation to remove burrs.

4. All threads, both field-cut and factory-cut, not otherwise protected, shall be painted after installation with two coats of asphaltum paint if concealed and two coats of primer base paint if installed in an exposed location.
5. GRS shall be used in service entrance raceways where exposed.
6. Clamps to be malleable two (2) hole galvanized iron and hangers to be rod type steel.

K. Where conduits are exposed to occupants, up to 8'-0" feet above the floor, the conduits shall be snug to the wall and secured with two (2) hole clamps (utilizing specified detention type fasteners).

L. Intermediate Metal Conduit (IMC):
1. Applicable specifications for installation of rigid metal conduit applies to IMC.
2. IMC can be substituted for GRS per the NEC.

M. Electrical Metallic Tubing (EMT):
1. Applicable specifications for installation of rigid metal conduit applies to E.M.T.
2. E.M.T. shall **not** be used underground, cast in concrete, exposed on exterior of buildings, and exposed interior locations below 8'-0" (above finished floor).
3. E.M.T. may be routed down exposed interior walls to top of panelboards, motor starters, disconnect switches, light switches, etc.
4. E.M.T. is permitted in electrical and mechanical equipment rooms, per detail on drawings.

N. Rigid Non-Metallic Conduit (PVC):
1. All elbows and nipples to be same material as specified for conduit.
2. All joints to be solvent welded in accordance with conduit manufacturer's instructions.
3. Hanger clamps to be PVC coated malleable iron and hangers to be PVC coated rod type steel.
4. Conduit clamps to be PVC coated, two hole clamps complete with nylon hardware.
5. PVC conduit shall be limited to the following applications:
    a. Underground secondary service entrance concrete encased conduits outside the perimeter of the building and routed under the concrete floor slab on grade to the service entrance equipment.
    b. Underground branch circuit and feeders (under 600 volts), telephone, fire alarm, sound system, control conduits in specified concrete encasement outside the perimeter of the building and in or under the concrete floor slab on grade. The PVC conduit can be routed from the concrete floor slab on grade directly into the masonry unit wall cavities, metal wall stud cavities up to the first wall box only, maximum 4’ aff. PVC shall not be exposed within the building except if within a floor mounted enclosure or panelboard to floor conduit enclosure. The PVC conduits under a concrete floor slab on grade will not require concrete encasement if the slab is more than 2-1/2" thick. Exposed PVC conduit stubs above the concrete slab shall not be permitted. Only exposed rigid metal conduit stubs are permitted.
    c. Underground branch circuit and feeders (under 600 volts) for outdoor lighting only.
    d. Provide specified concrete encasement per Section 16115.
6. PVC shall not be acceptable in areas where subject to ambient temperatures exceeding those for which PVC conduit is approved, for the support of fixtures or other equipment and other areas not permitted by Codes.

O. Supports: Provide metallic supports as required for the proper installation of the raceway or conduit systems and all other equipment installed under this contract. **Wire shall not be used to support or tie down any conduit system.**

P. Empty Conduits: Pull #12 stranded gauge galvanized fishing wires or stranded nylon line through all empty conduits for all systems. These wires or lines to remain in the conduits.

Q. Exposed Masonry: Where wall finish is exposed masonry, raceways shall be so placed in wall that the masonry unit can be neatly set around it with minimum cutting and without injury to the exposed masonry face.

R. Wireways:
1. Furnish and install a complete lay-in wireway system where required. Wiring capacity shall be determined by NEC unless larger dimensions are indicated.
2. Wireway lengths and fittings shall be securely bolted together with same size slotted paint cutting hex-headed shoulder bolts and hex nuts with captive external tooth lock washers which maintain electrical ground continuity across the joint. Each joint shall be gasketed between end flanges. The sealing cover connector shall be installed so as to be held captive and maintain the lay-in ability of the wireway.
3. Wireway shall be installed in accordance with the National Electrical Code requirements.

4. Wireways shall be supported at intervals not exceeding five feet unless specially approved for supports at greater intervals. The ten-foot straight sections of wireway shall be Underwriters Laboratories, Inc. listed for support at ten-foot intervals.

S. Surface Raceway:
1. Install surface raceway in accordance with manufacturer's recommendations and instructions. Raceway capacity shall be determined by NEC unless larger capacity is indicated.
2. Refer to drawings and elevations for routing of all surface raceways and multi-outlet systems.
3. Surface raceway systems shall be limited to the applications and locations indicated on drawings.
   a. Existing solid masonry or concrete walls without furred out drywall, plaster lathe, paneling or other wall covering or if the furred out space is less than the dimension of a conduit or metal clad cable, surface raceway shall be permitted.
   b. Existing hollow core masonry walls where indicated. All other hollow core masonry walls shall have recessed outlets unless cores are blocked with mortar or structural member.
   c. Unless otherwise indicated, route all surface one-piece raceways vertically to floor or ceiling with no horizontal runs except under whiteboards, tackboards, windows, or casework. Short horizontal runs shall be permitted with two (2) surface raceway outlets less than 48" apart.
4. Multi-system divided raceways, SR4 and SR6, are intended for power on one side and power limited cabling in the remaining side. Fire alarm system wiring shall be type MC cable if installed in the multi-systems raceways per NEC. Provide divided (or multiple) junction boxes at the termination of multi-system raceways to allow the "homerun" conduits to be routed to the various power sources and power limited cabled systems. Separation of the various wiring systems shall be governed by the NFPA codes. Provide snap-in wire retainers to keep wiring in raceway during installation before cover is installed, and to facilitate future work.

T. Pull and Junction Boxes: Provide all necessary pull and junction boxes where indicated or required by National Electrical Code. Certain pull and junction boxes may be shown on the drawings for specific design reasons but is not to preclude the fact that additional boxes will be required to conform to codes and good practice.
1. Local Switch Outlets: Prior to the installation of the local switch outlet boxes, the Contractor shall verify the door swings to insure the proper location of the box. This outlet shall be installed with a minimum of 4" of separation from door jamb trim. Refer to typical elevation for mounting outlet boxes at doors.

U. Conduit Termination: All rigid heavy wall metal conduits (G.R.S, I.M.C. and E.M.T.) and rigid non-metallic conduits (P.V.C.) shall terminate with locknut and bushing in all boxes, cabinets, panels, etc. Where a grounding means is not provided in the box, cabinet, panel, etc. provide a locknut and grounding bushing.

V. Exterior Pullboxes: Install flush with finished grade on a minimum of tamped 6" gravel base.

END OF SECTION 26 05 33

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SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL:

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED:

A. Prepare and paint Division 26 equipment supports and miscellaneous materials located in Equipment Rooms, Mechanical Rooms, and other utility areas housing mechanical and/or electrical equipment.

B. Identification of conduits, junction boxes, pull boxes, cabinets, panelboards, switchgear, motor starters, disconnect switches, motor protective switches, and Division 26 system enclosures.

1.3 WORK NOT INCLUDED:

A. Painting of factory finished Division 26 Equipment such as Switchboards, Panelboards, Emergency Generator Sets, etc.

1.4 RELATED WORK:

A. Division 23 – Mechanical

B. Section 26 05 00 – Common Work Results For Electrical

C. Section 26 05 33 – Raceway And Boxes For Electrical Systems

D. Section 26 28 16 – Enclosed Switches And Circuit Breakers

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Except as otherwise specified, materials shall be the products of the following manufacturers:
1. Sherwin-Williams
2. Pratt and Lambert
3. Devoe
4. Benjamin Moore

2.2 MATERIALS:

A. Deliver all paints and materials to the project site in their original containers with all labels intact and legible at the time of use.

B. Sherwin-Williams Industrial Maintenance Coatings System 4000 products are listed below to establish color and a standard of quality.
   1. All Hangers and Supports: One coat Series 54 Gloss Black Alkyd Enamel.
   2. Uninsulated diesel engine exhaust and other similar hot surfaces shall be painted with two coats of No. B59S8 Heat Resistant Aluminum.
   3. Exterior of belt guards and other protective guards shall be finished with two coats of Series 54 Alkyd Gloss Enamel No. SW4084 safety yellow color. Interior of and all items covered by belt guards and other protective guards shall be finished with two coats of No. SW4083 safety orange color.
   4. Factory Finished Equipment finishes shall be cleaned and properly touched up with equipment manufacturers touch-up paint unless finish is severely damaged or of unacceptable quality. In the latter case, the entire finish shall be restored in accordance with painted procedures herein specified.

PART 3 - EXECUTION

3.1 WORKMANSHIP:

A. The work shall be accomplished by qualified mechanics skilled in the painting trade. Painting of equipment and other materials shall not commence until all testing is complete and systems are ready for operation. Materials shall be evenly spread, and smoothly flowed on without runs or sags. Each coat shall be thoroughly dry before application of succeeding coats.

3.2 PROTECTION OF WORK:

A. The painters shall protect all adjacent surfaces with drop covers during the process of painting. Upon completion, paint spots, if any, shall be removed from all surfaces not intended to be painted.

3.3 PREPARATION OF SURFACE:

A. Surfaces to be painted shall be completely dry before applying paint. Metal surfaces shall be cleaned with mineral spirits before applying materials. Rust and scale shall be removed by wire brushing or sanding. Galvanized surfaces shall be chemically treated with crystalline zinc phosphate in strict accordance with the manufacturer=s recommendations. Surfaces shall not be painted when the temperature is, or is likely to be, near the freezing point, nor when they are exposed to hot sun.

3.4 IDENTIFICATION OF PIPES AND EQUIPMENT:

A. After **all** painting is completed, operating and control parts of the equipment and systems such as switchgear, panelboards, telephone cabinets, system cabinets, disconnect switches, motor starters and control cabinets shall be properly identified with laminated engraved plastic nameplates fastened with sheet metal screws, bolts or permanent adhesive. Pressure sensitive tape is **not** acceptable. Identification symbols or designations shall be the same as shown on the contract documents.

B. Boxes; Concealed and Surface Mounted: Each junction box, pullbox or similar enclosure shall be **neatly** identified by stencil marking which shall indicate service contained, and circuit numbers. Stencil letters shall be upper case (Capital) not less than one-half inch high and painted with Series 54 black gloss enamel.

C. Conduit:
   1. Color bands shall be painted on each conduit where exposed or accessible. Bands shall be six inches wide and shall be placed along the conduit run immediately preceding the passage of the conduit through walls, ceiling or floor, and at each equipment connection or junction box. Where sub-bands are specified, they shall be two inches wide and centered in the color band. Adjacent to each color band, the abbreviation of the name of the service contained in the conduit shall be **neatly** stenciled. Stencil letters shall be one-half inch high upper case, applied with Series 54 black gloss enamel. Color bands shall be Series 54 Alkyd Gloss Enamel of colors listed below.

2. In lieu of painted color bands, the Contractor may use pressure sensitive tape a minimum of 2" wide. Each color band will require wraps as necessary to provide the full 6" wide band with or without the 2" sub-band.
3. In lieu of stenciled names of the pipe service, the Contractor may use vinyl "snap around" markers as manufactured by Seton, Bunting, Brady and Thomas & Betts (T&B).
4. Color Banding:

System	Abbrev./Color	Color Band	Color Sub-Bands
120/208 Volts (Normal)	208V/Black	Black	Yellow
120/208 Volts (Emergency)	208V/Red	Black	Yellow
Fire Alarm	FA/Red	Red	Black

D. The main panelboard, generator control panel, and other similar systems shall have an engraved informational laminated nameplate with the installing trade's name, telephone number and address for the Owner to obtain preventive maintenance, service or parts. The nameplate shall include the job order number, shop number or other identification which will identify the related equipment.

If the above address and telephone number is a branch office, the main office or manufacturers address and telephone number shall be included.

END OF SECTION 26 05 53

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SECTION 26 28 13 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED:

A. Fuses [S]

1.3 RELATED WORK:

A. Section 26 28 16 – Enclosed Switches And Circuit Breakers

1.4 SUBMITTALS:

A. Submit product data in accordance with Section 26 05 00.
   1. Product Data: Submit application, technical, and installation data.

PART 2 - PRODUCTS [O/M]

2.1 MANUFACTURERS:

A. All Fuses shall be as manufactured by Cooper Industries, GEC Alsthon, Littlefuse, Gould-Shawmut (Nippon Mining). [S] [O/M]

B. **Fuse Cabinet** shall be as manufactured by the above fuse manufacturer, Hoffman, Austin or acceptable equal. [S]

2.2 MATERIALS AND TYPE:

A. Motor and Panelboard Fuses: Rejection type **C** class RK-1, dual element, time-delay, current limiting, cartridge type, by 300™ Low-Peak Yellow™ by Bussman, LoIp© by CEFCo, Power-Pro® by Littlefuse, "AMP-TRAP 2000" by Gould-Shawmut (Nippon Mining), with a minimum interrupting rating of 200,000 amperes rms symmetrical.

B. For applications 601 amps and higher, utilize time-delay, current limiting, silver linked **UL** class **"L"** fuses by 300™ Low-Peak™ Bussman, Short Check® by CEFCo, Power-Pro© by Littlefuse, A4BQ "AMP-TRAP 2000" by Gould-Shawmut (Nippon Mining) with a minimum interrupting rating of 200,000 amperes rms symmetrical.

C. Cabinet: Wall mounted enclosure complete with shelves for storage of spare fuses and instruction manual. Door shall be lockable with same key as panelboards.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Fuses for motor circuits shall be sized in accordance with the fuse manufacturer's sizing chart for **"motor running overload protection"**, unless otherwise required for a specific motor. All other fuses for other than motor circuits shall be of size and type as required by the connected equipment manufacturer's written instructions unless otherwise indicated. Labels indicating size and type of replacement fuses shall be glued to inside of door on all fusible switches, fusible motor starters and panels.

3.2 SPARE FUSES:

A. 600 Amp Fuses and Smaller: Furnish spare fuses not to exceed 10% of each rating with a minimum of three (3) per rating.

B. 601 Amp Fuses and Larger: Furnish three (3) spare fuses of each rating.

C. Contractor shall deliver the spare fuses with invoice to the Owner's Maintenance Operations Center.

END OF SECTION 26 28 13

SECTION 26 28 16 – ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED:

A. Disconnect Switches

B. Circuit Breakers

1.3 RELATED WORK:

A. Section 26 05 53 – Identification For Electrical Systems

B. Section 26 20 00 – Low-Voltage Electrical Distribution

C. Section 26 28 13 – Fuses

1.4 REFERENCES:

A. All disconnect switches and circuit breakers shall meet and comply with applicable sections of U.L., N.E.C. and NEMA.

1.5 SUBMITTALS:

A. Submit shop drawings and product data in accordance with Section 26 05 00.
   1. Shop Drawings for Disconnect Switches shall include:
      a. Scale drawing of enclosure and internal components.
      b. Roughing-in requirements.
   2. Circuit Breaker shop drawings shall include:
      a. Frame type and ampere rating.
      b. Trip amperage.
      c. Interrupting rating in RMS symmetrical amps.
      d. Accessories.
   3. Product Data: Submit application, technical, and installation data.

B. Submit Operation and Maintenance Manuals in accordance with Section 26 05 00.

PART 2 - PRODUCTS [O/M]

2.1 MANUFACTURERS:

A. All disconnect switches shall be Square D (Group Schneider) Class 3110 Heavy Duty Visible-Blades® safety switches, General Electric Spec-Setter© Heavy Duty Type TH (to 600A), and Type TC (800A & 1200) safety switches [S][O/M], Cutler-Hammer/Eaton Heavy Duty Type DH series safety switches, and Siemens Vacu-Break VBII™ Heavy Duty safety switches.

B. All circuit breakers shall be as manufactured by Square D or acceptable equal by Cutler-Hammer/Eaton, General Electric (GE) or Siemens.

2.2 MATERIALS AND TYPE:

A. Disconnect Switches [S] [O/M]: Rated for voltage encountered, poles and amperage as required. Heavy Duty, NEMA enclosures, fusible for rejection type class R fuses only, solid neutral assembly, equipment grounding kit, unless otherwise indicated. Refer to NEMA type under PART 3 - EXECUTION.

B. Fuses: Provide specified fuses, sizes as required.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Provide disconnect switches for all motors and appliances for the project where required by the National Electrical Code; and rated for the voltage encountered complete with required poles, amperage rating and all accessories. Not all disconnect switches required by NFPA-70 are necessarily indicated on the drawings.

B. Provide rain-tight NEMA-3R, NEMA-4, NEMA-4X, explosion-proof or other NEMA enclosures for switches where required by NEC and environmental conditions.

C. Certain fusible disconnect switches shall be fully U.L. Service Equipment rated and labeled as indicated by the electrical distribution system.

3.2 FIELD QUALITY CONTROL:

A. Technical Assistance: The electrical gear manufacturer’s representative shall generally provide installation supervision of this equipment if requested by the contractor.

B. Calibration and Testing: The electrical gear manufacturer’s representative shall provide a factory trained technician for initial calibration of circuit breaker trip and time delay settings to indicated values. All calibration and testing shall be in accordance with the manufacturer’s written instructions, and all applicable codes and industry standards. Written records of the calibration and test procedures shall be submitted to the Owner, Engineer and Authority Having Jurisdiction (if required). These test procedures shall also include an insulation test, torquing of all connections, electrical interlocking verification, etc. The Engineer and/or Owner’s representative shall have the option of witnessing the testing procedures. The contractor shall coordinate the testing with all parties concerned.

END OF SECTION 26 28 16