Omaha Public Schools
Department of District Operational Services
Purchasing Division

BID No.: 27-010
Date: October 27, 2026

Addendum No. 1
to
Bid Documents for

OPS Marrs Cooling Tower Replacement Project

The purpose of this Addendum No. 1 is to modify Bid 27-010, OPS Marrs Cooling Tower Replacement Project. Except as specifically modified by this Addendum No. 1, the Bid Documents shall remain in effect as originally issued.

The Bid Documents are hereby amended as follows:

1- Specification Changes

PROJECT MANUAL

CONSTRUCTION SET

DIVISIONS 23 AND 26

OPS MARRS MIDDLE SCHOOL

COOLING TOWER REPLACEMENT

OMAHA, NE

BID No: 27-010

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SECTION 23 0000
HVAC GENERAL PROVISIONS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This section includes general requirements for HVAC systems and HVAC motors.

1.03 CONTRACT DOCUMENT COORDINATION

A. Contract Documents are diagrammatic in showing certain physical relationships between architectural, structural, mechanical, plumbing and electrical work.
   1. Verification and coordination of these relationships is the responsibility of the Contractor.
   2. Contractor shall verify existing conditions before starting work.
   3. Floor plan drawings do not necessarily indicate all required offsets, fittings, valves, etc.
   4. Provide all necessary piping, fittings, valves, ducts, offsets, and other specialties required without additional cost to the Owner.

B. Should Contract Document requirements appear to make it impossible to provide a complete and operational system, or should discrepancies appear among Contract Documents, Contractor shall request clarification before proceeding with work.

1.04 QUALITY ASSURANCE

A. Comply with all State, and local codes and ordinances.

B. Obtain and pay for all required permits, fees and certificates of inspection of the work.

C. Install equipment and devices to provide required access for servicing and maintenance.

D. Mechanical Code Compliance: Comply with applicable portions of Local, City, and State Mechanical Code pertaining to mechanical materials construction and installation of products.

1.05 SUBMITTALS

A. General: See Division 01, Section Submittal Procedures.
   1. Shop Drawing Submittals shall include specially prepared technical data for this project, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information.
   2. Shop Drawing Submittals may also include product data which includes standard printed information on materials, products and systems; not specially prepared for this project, but with the designation of selections from among available choices for this project clearly identified.

B. Submittal Requirements:
   1. Coordination and Sequencing: Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittals. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination of Architect/Engineer's review with another.
   2. Preparation of Submittals: Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, submittal name, specification section and similar information to distinguish it from other submittals.
   3. Provide General Contractor’s and Subcontractor’s stamp, signed or initialed certifying that review, approval, verification of Products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with the requirements of the Contract Documents. Submittals which are received from sources other than through Contractor's office will be returned by Architect/Engineer "Without Action".

4. Items from each specification section shall be prepared as separate submittals, not grouped or bound with other items. Submittals shall clearly indicate the applicable specification section.

C. Alternate Equipment Submittal by Contractor:
   1. Equipment of greater or larger dimensions, weight, capacity, or rated performance than that which is specified may be submitted provided all connecting mechanical and electrical services, including ductwork and piping connections, circuit breakers, electrical conduit and conductors, motors, equipment supports, building structure, and equipment spaces are modified as required by the proposed equipment. If performance ratings or efficiencies of the equipment are specified, the equipment must meet or exceed these design requirements as well as any specified commissioning requirements. **NO ADDITIONAL COST WILL BE APPROVED FOR ANY SUCH CHANGES RELATED TO THE ALTERNATE EQUIPMENT.**
   2. Should proposed alternate equipment involve rearrangement of other designed equipment, a complete layout of the area involved shall be submitted by the Contractor along with the alternate equipment submittal, and shall be approved in writing by the Architect/Engineer prior to ordering, purchasing, delivery or installation of any such items of equipment.
   3. **CONTRACTOR SHALL BE RESPONSIBLE FOR ALL ADDITIONAL EXPENSE AND COORDINATION WITH OTHER TRADES RESULTING FROM THE SUBSTITUTION OF EQUIPMENT OTHER THAN THAT SPECIFIED IN THE CONTRACT DOCUMENTS.**

D. Submittal Review:
   1. Review of submittal data is only for general conformance with the design concept of the Project and general compliance with the information given in the Contract Documents. Any action shown is subject to the requirements of the plans and specifications.
   2. Review of shop drawings does not release the Contractor from further satisfactory equipment operating responsibilities. Equipment shall be approved for final acceptance when installation is completed and all equipment and systems have been operated, tested, adjusted and balanced in compliance with the contract documents.
   3. Re-submittals: When revised for resubmission, clearly indicate all changes since previous submission. Only those items required to be resubmitted shall be included.

E. Operation and Maintenance (O&M) Manuals:
   1. Prepare and submit three (3) copies of operation and maintenance instructions for all Division 23 equipment furnished.
      a. Provide individual 3-ring binders with a table of contents and tabbed sections for each specification section.
      b. Identify equipment included in the manuals by the equipment mark used in the contract drawings.
      c. Include emergency instructions, spare parts listing, copies of warranties, wiring diagrams, shop drawings, product data, signed letters of certification of inspection and similar information.
      d. Provide documentation that training was performed for each item specified to include Owner training. Include name of Owner's representative(s) present, date and time of training.
      e. Provide a list of manufacturer's representatives for each item of equipment including company name, address and phone number.
      f. Provide documentation that Extra Materials were received by the Owner for each section requiring Extra Materials.
   2. All information contained in equipment manufacturer's operation and maintenance manual shall be specific to equipment provided. Contractor shall mark out or not include all unrelated information.
   3. Electronic O&M Manuals: Provide electronic version of project O&M Manuals in pdf format in addition to hardcopy version of the manuals.

F. Required Submittals List:
   1. Shop Drawings shall be submitted for the items listed in each section of the specifications. Submittals in addition to those listed may be required by the Architect/Engineer.

1.06 RECORD DRAWINGS

A. See Division 01, Section Project Record Documents.

B. Provide a set of mechanical drawings marked-up with actual as-built conditions for Division 23 work. Record drawings shall include all addenda and change orders.

1.07 CONTRACT DRAWING FILE REQUESTS

A. As an instrument of service to aid in Shop Drawing Submittals, Farris Engineering (FEI) will provide AutoCAD drawing files upon request. The files will be sent upon return receipt of the "Request for Drawings" agreement signed by an officer of the requesting firm. FEI does not assure that the drawings represent all changes, addenda items, change orders or modifications that may have occurred. The drawings are simply a tool for use in producing shop drawing submittals. The drawing files will be "cleaned-up" by having the FEI logo, Professional Engineer seal, and all extraneous notes and details removed. FEI must be compensated for this additional service by the requesting firm. A minimum fee of $400.00 for up to eight (8) sheets and $50.00 per sheet for each additional requested drawing will be invoiced to the requesting firm once the signed agreement is received.

1.08 MECHANICAL/ELECTRICAL COORDINATION

A. General: See Division 01, Multiple Contract Summary.

B. Mechanical Contractor shall coordinate with Electrical Contractor and verify that proper electrical power connections to mechanical equipment which requires electrical power is provided. Unless specifically shown otherwise Electrical Contractor shall provide power connections to the equipment and Mechanical Contractor shall provide wiring required for start-stop, temperature control and safety interlock functions.

C. If mechanical contractor has proposed alternate equipment to that specified in the contract documents, and such alternate equipment requires modified electrical power connections, mechanical contractor shall coordinate these requirements with electrical contractor prior to ordering, purchasing, delivery or installation of any electrical conduits, conductors, circuit breakers and other electrical devices serving the alternate equipment.

D. Types of work, normally recognized as electrical but provided as mechanical include but are not necessarily limited to the following:
   1. Motors for mechanical equipment.
   2. Starters for motors of mechanical equipment, but only where specifically indicated to be furnished integrally with equipment.
   3. Wiring from motors to disconnect switches or junction boxes for motors of mechanical equipment, when specifically indicated to be furnished integrally with equipment.
   4. Electrical power connections for mechanical equipment that are not indicated on the electrical drawings.

1.09 ELECTRIC MOTORS

A. Basic Motor Requirements
   1. Motors smaller than 1 HP: Single-phase.
   2. Motors 1 HP and Larger: Polyphase.
   3. Frequency Rating: 60 Hz.
   4. Voltage Rating: Determined by voltage of circuit to which motor is connected.
   5. Service Factor: According to NEMA MG-1, unless otherwise indicated.
   6. Capacity and Torque Characteristics: Rated for continuous duty and sufficient to start, accelerate, and operate connected loads at designated speeds, in indicated environment,

with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

7. Enclosure: Open drip proof unless otherwise indicated.

1.10 FINAL COMPLETION

A. The Mechanical Contractor shall not call for a final completion check until all Mechanical Systems have been installed, adjusted, tested, and balanced and in full and complete satisfactory operation and the following certifications of inspection from equipment suppliers have been completed. Certifications of Inspection are required on the following equipment:
   1. Temperature Control Equipment.
   2. Variable Frequency Controllers.
   3. Cooling Towers.

B. Certifications of Inspection shall consist of letters signed by Factory-Trained and -Authorized Service Personnel stating the following:
   1. They have inspected all of their equipment on the project.
   2. They approve the condition of the equipment and its installation.
   3. They have fully checked its operation and certify that it is operating properly.
   4. They have noted any problems, conditions or objections that could lead to future operating problems.

C. Documentation of the signed letters of Certification of Inspection shall be furnished in the Operations and Maintenance Manuals, included with the associated equipment.

1.11 GUARANTEE

A. The one year guarantee period shall not start until the project is fully completed and the Contractor has received the Final Payment and Certificate of Completion.

B. All equipment and all work shall be fully guaranteed, parts and labor, for one full year from the date of the Certificate of Completion. Repairs made during this period must be fully guaranteed for an additional one year period from the date of repairs.

C. The Mechanical Contractor has the full responsibility to guarantee all equipment and work and shall assume full responsibility to repair any equipment at his cost that the manufacturer refuses to guarantee.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.01 ELECTRICAL WORK PROVIDED BY MECHANICAL

A. All electrical equipment provided and the wiring and installation of electrical equipment shall be in accordance with the requirements of the equipment manufacturer, this Section and Division 26.

3.02 PIPE HANGING AND SUPPORT

A. All piping systems shall be supported from building structural systems capable of supporting the applied load.

B. Piping shall not be supported from metal roof decking.

3.03 PAINTING AND FINISHING

A. Painting of exposed mechanical work is specified and performed under other divisions of these specifications, or as indicated on the drawings.

B. Where factory finishes are provided on equipment and no additional field painting is specified, all marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish at the time of final inspection.

C. Paint inside of ductwork black, where it can be seen from occupied spaces through diffusers, grilles or louvers (under any lighting condition).

3.04 WORK IN EXISTING BUILDINGS

A. Work under this Contract includes additions and/or renovations to an existing building. It shall be the responsibility of each Bidder to fully inform himself of all conditions which affect the work contemplated by these specifications and accompanying drawings. The submission of proposal by any Bidder will be construed as an admission by him that he has examined and is fully familiar with the premises and all conditions thereon and adjacent thereto, and has included in this proposal a proper and adequate amount to cover rearrangement of existing work for the proper installation and operation of the new and existing equipment as shown on the drawings or as required by these specifications. Such work shall be neatly and properly done.

B. Maintain existing mechanical services to occupied areas and operational facilities unless otherwise indicated or when otherwise authorized in writing by Owner and Architect.

C. The operation of all existing equipment, fixtures and devices designated to remain shall be maintained. Provide temporary connections and devices as necessary to maintain the proper operation of the equipment designated to remain if required during construction.

3.05 REBATES

A. Contractor shall assist the Owner with filing of applicable forms to obtain rebates. This shall include but not be limited to determination of qualifying equipment and materials and furnishing invoices for equipment and materials as required to support the rebate application.

END OF SECTION

SECTION 23 0010
MECHANICAL SUBMITTALS

PART 1 GENERAL

1.01 GENERAL

A. Submittals shall include specially prepared technical data for this project, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information not in standard printed form for general application to a range of similar projects.

B. Submittals shall also include product data which includes standard printed information on materials, products and systems; not specially prepared for this project, but with the desi

C. gnation of selections from among available choices for this project clearly identified.

1.02 SUBMITTAL REQUIREMENTS

A. Coordination and Sequencing: Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittals. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination of Architect/Engineer's review with another.

B. Preparation of Submittals: Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, submittal name and simi

C. lar information to distinguish it from other submittals. Show Contractor's executed review and approval marking and providing space for Architect's/Engineer's "Action" marking. Package each submittal appropriately for transmittal and handling. Submittals which are received from sources other than through Contractor's office will be returned by Architect/Engi

D. neer "Without Action".

E. Provide Contractor's certification on form, ready for execution, stating that information submitted complies with requirements of contract documents.

F. The Contractor shall be responsible for and bear any expense of alterations to the building or its appurtenances resulting from the substitution of equipment to that specified in the Contract Documents.

G. Review of submittals does not release the Contractor from further satisfactory operating responsibilities. Material and equipment shall be approved for final acceptance when construction is completed and all units and systems have been operated, tested, adjusted and balanced to the satisfaction of the Architect/Engineer. Should proposed approved alternate equipment involve rearrangement of designed equipment, a complete layout of the area involved shall be submitted by the Contractor, and shall be approved in writi

H. ng before

I. installation of any such items of equipment. Any additional expense involved shall be a Contractor-borne expense.

J. Electronic Submittals: All submittals for shop drawings, O & M Manuals and Record Drawings shall be in electronic PDF format. Identify and incorporate information in each electronic submittal file as follows:

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.
   a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., North HS-23 05 00). Resubmittals

shall include an alphabetic suffix after another decimal point (e.g., North HS-23 05 00-A).

3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Architect and/or Construction Manager.
4. Transmittal Form for Electronic Submittals: Use software-generated form from electronic project management software acceptable to Architect, Engineer and Owner**,** containing the following information:
   a. Project name.
   b. Date.
   c. Name and address of Architect.
   d. Name of Construction Manager.
   e. Name of Contractor.
   f. Name of firm or entity that prepared submittal.
   g. Names of subcontractor, manufacturer, and supplier.
   h. Category and type of submittal.
   i. Submittal purpose and description.
   j. Specification Section number and title.
   k. Specification paragraph number or drawing designation and generic name for each of multiple items.
   l. Drawing number and detail references, as appropriate.
   m. Location(s) where product is to be installed, as appropriate.
   n. Related physical samples submitted directly.
   o. Indication of full or partial submittal.
   p. Transmittal number, numbered consecutively.
   q. Submittal and transmittal distribution record.
   r. Other necessary identification.
   s. Remarks.

1.03 SUBMITTAL LIST

A. Submittals shall be submitted for, but not limited to, the items listed in each section of the specifications. Submittals, in addition to those listed, may be required by the Architect/Engineer. The following submittal register is a summary list of submittals required for the project.

SUBMITTAL REGISTER	
SECTION	ITEM
23 0000	O&M Manuals
23 0000	Record Drawings
23 0000	Certification of Inspection
23 0500	Valves
23 0500	Meters and Gauges
23 0500	Supports and Anchors
23 0500	Mechanical Identification
23 0500	Vibration Control
23 0500	Joint Sealants
23 0593	Test & Balance Report
23 0700	HVAC Insulation Materials Schedule
23 0915	Variable Frequency Drives
23 0990	HVAC Instrumentation and Controls
23 0993	Sequence of Operation
23 2113	Hydronic Piping & Fittings
23 2500	Hydronic System Cleaning & Treatment

SUBMITTAL REGISTER	
SECTION	ITEM
23 6500	Cooling Tower and Accessories

END OF SECTION

SECTION 23 0593
HVAC TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes testing, adjusting and balancing the following systems and equipment:
   1. Balancing Hydronic Piping Systems:
      a. Primary-secondary hydronic systems.
   2. Equipment:
      a. Cooling Tower.
      b. Pumps.

1.03 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.04 SUBMITTALS

A. Information Submittals:
   1. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
   2. Instrument calibration reports, to include the following:
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.
   3. Contract Documents Examination Reports: Within 30 days of Contractor’s Notice to Proceed, submit the Contract Documents review report as specified in part 3.
   4. Strategies and Procedures Plan: Within 30 days of Contractor’s Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in “Preparation” Article.
   5. System Readiness Checklists: Within 30 days of Contractor’s Notice to Proceed, submit system readiness checklists as specified in “Preparation” Article.
   6. Examination Report: Submit a summary report of the examination review required in “Examination” Article.

B. Closeout Submittals:
   1. Certified TAB reports.

1.05 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Engage a TAB entity certified by AABC, NEBB or TABB.
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB OR TABB.
   2. TAB Technician: employee of the TAB specialist and certified by NEBB OR TABB AS A TAB Technician.

B. Certify TAB field data reports and perform the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

E. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.06 PROJECT CONDITIONS

A. Do not proceed with Closeout Submittal until work has been completed and systems and equipment are operable. Ensure that there is not latent residual work still to be completed.

B. Do not proceed with schedules for testing, adjusting, and balancing until systems and equipment are clean and free from debris, dirt and discarded building materials.

C. Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.07 COORDINATION

A. Coordinate with other trades for scheduled test dates and times.

B. Perform TAB work after leakage and pressure tests on distribution systems have been satisfactorily completed.

PART 2 PRODUCTS

2.01 PATCHING MATERIALS

A. Except as otherwise indicated, use same products as used by original Installer for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs and similar purposes. At Tester’s option, plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.

2.02 TEST INSTRUMENTS

A. Utilize test instruments and equipment for TAB work required, of type, precision, and capacity as recommended in NEBB’s Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine equipment performance data including fan and pump curves.
   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

E. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

F. Examine test reports specified in individual system and equipment Sections.

G. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

H. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

I. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

J. Examine system pumps to ensure absence of entrained air in the suction piping.

K. Examine operating safety interlocks and controls on HVAC equipment.

L. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

A. Complete system-readiness checks and prepare reports. Verify the following:
1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

3.04 GENERAL PROCEDURES FOR BALANCING HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5%.

B. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gauge for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.

5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.05 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.06 PROCEDURES FOR COOLING TOWERS

A. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:
1. Measure condenser-water flow to each cell of the cooling tower.
2. Measure entering- and leaving-water temperatures.
3. Measure wet- and dry-bulb temperatures of entering air.
4. Measure wet- and dry-bulb temperatures of leaving air.
5. Measure condenser-water flow rate recirculating through the cooling tower.
6. Measure cooling-tower spray pump discharge pressure.
7. Adjust water level and feed rate of makeup water system.
8. Measure flow through bypass.

3.7 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.

5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.

END OF SECTION

SECTION 23 0915

VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

1.02 WORK INCLUDED

A. Extent of variable frequency drives work is indicated by drawings and schedules and by requirements of this section.

B. The variable frequency drives for this Project shall be of the pulse width modulated type.

C. Provide the following electrical work as work of this section, in compliance with electrical specifications.
   1. Control and interlock wiring between operating controls, indicating devices, unit temperature control panels and variable frequency drive.

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of variable frequency drives, of types and capacities required, where products have been in satisfactory use in similar service for not less than five (5) years.

B. Installer's Qualifications: A firm specializing and experienced in variable frequency drive installations for not less than five (5) years.

C. Codes and Standards:
   1. Electrical Standards: Provide electrical components of variable frequency drives which have been UL Listed and labeled, and comply with NEC Standards.
   2. NEMA Compliance: Comply with NEMA Standards pertaining to components and devices.
   3. ETL Compliance: Provide variable frequency drives with ETL approved label.

1.04 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights, furnished specialties, contactors and accessories; and installation and start-up instructions.

B. Coordination Data: Submit nameplate information for each motor to be operated by VFD.

C. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances and methods of assembly of components.

D. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring for variable frequency drives. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field installed.

E. Operating Conditions: Submit manufacturer's printed information clearly stating ambient temperature requirement and carrier frequency at rated conditions.

F. Maintenance Data: Submit maintenance data and parts list for each variable frequency drive, control, and accessory; including "Trouble-Shooting" Maintenance Guide. Include this data and product data in Maintenance Manual.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Handle variable frequency drives carefully to prevent damage, breaking, denting and scoring. Do not install damaged units or components; replace with new.

B. Store variable frequency drives in clean, dry place. Protect from weather, dirt, fumes, water, construction debris and physical damage.

C. Comply with manufacturer's rigging and installation instructions for unloading variable frequency drives and moving units to final location for installation.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide variable frequency drives from the following:
   1. Yaskawa

B. All VFD's shall be of the same manufacturer. The Contractor shall verify that the size of the equipment supplied by the selected manufacturer does not exceed the available mounting space.

C. The Contractor shall verify lead length between the VFD and associated motor. Output reactor or other device shall be provided as required to operate associated motor without damage to the motor windings.

2.02 GENERAL

A. Establish requirements for variable voltage variable frequency motor controls, for speed control of fans, blowers or pumps driven with AC motors.

B. Contractor shall coordinate exact locations of all motors controlled from a VFD and provide motors rated for VFD operation. In addition, motors shall be suitable for across-the-line starting.

2.03 VARIABLE FREQUENCY MOTOR CONTROL

A. Pulse Width Modulation VFD:
   1. The controller shall produce an adjustable AC voltage/frequency output. It should have an output voltage regulator to maintain correct output V/Hz. despite incoming voltage variations.
   2. The VFD shall be of the Pulse-Width Modulated type and shall consist of a full-wave diode bridge converter to convert incoming fixed voltage/frequency/ to a fixed DC voltage.
   3. The inverter output shall be generated by power transistors or IGBT's (isolated gate bipolar transistors).
   4. The logic control section shall be microprocessor based.

2.04 SPECIFICATION

A. Verify power input requirements with drawings.
   1. Nominal input voltage +/ - 10%
   2. Input frequency stability 48-62 HZ

B. Provide minimum 3% AC Input Line Reactor.

C. Output power; 3-phase, 1.5 to 60 Hz with variable voltage to give proper and efficient operation of variable torque load.

D. Displacement power factor - Minimum of 90% over the entire speed range.

E. VFD shall be rated for HP rating indicated on drawings. Additionally, amp rating shall not be less than National Electrical Code, Table 430-150 for corresponding HP size indicated. HP and current ratings noted above shall be minimum values after any/all derating factors such as frequency, elevation, ambient temperature, etc. have been applied. Ratings shall be based on 40°C ambient temperature and a carrier frequency of 4,500 to 8,000 KHz.

F. Minimum overload capacity of 110% for one (1) minute.

2.05 MINIMUM REQUIREMENTS FOR CONTROL OPERATION

A. Fused input door interlocked disconnect.

B. Isolated 115VAC control transformer.

C. Annunciated or digital display and time stamp of the following fault and limit functions for:
   1. Thermal overload relay trip.

2. Microprocessor self-check function.
3. Output overcurrent trip.
4. DC bus overvoltage trip.
5. Inverse time overload trip.
6. Heat sink overtemperature trip.
7. DC bus fuse open.
8. DC bus overvoltage (regen. limit).
9. Output ground fault.
10. Inverter ready light.
11. Inverter run light.
12. Inverter safety lockout light (red).
13. Power line on light.
14. Control voltage enabled light.

2.06 MINIMUM REQUIRED STANDARD FEATURES

A. Provide input disconnecting means, either a switch or circuit breaker. Disconnects shall be capable of being locked in the open position.

B. Provide VFD input fuses rated for protection of semiconductors.

C. Door Mounted Components:
   1. Inverter run indication.
   2. Digital speed (frequency or percent speed) and motor ammeter.
   3. Manual speed adjustment.
   4. Inverter / Off.
   5. Reset for fault and enable.
   6. Manual / Auto reference selector.

D. DC bus charged indicator.

E. Current limit circuit active to prevent nuisance tripping during acceleration or run conditions.

F. Regeneration limit circuit active to prevent nuisance OV tripping during deceleration.

G. Minimum and maximum speed set, separate and non-interactive.

H. Power loss restart selectable for Auto Restart in auto mode only.
   1. Automatic restart from undervoltage, power failure, or control fault or both.

I. Critical frequency lockout for up to two (2) points, available from 10% to 100% speed with at least a 6 Hz bandwidth.

J. Only non-filament type indicating lights may be used.

K. Control shall survive without component failure and annunciate output phase to phase and phase to ground faults.

L. Control shall have isolated instrument signal followers that are compatible with the temperature control system.

M. Loss of reference protection, VFD shall reset to predetermined minimum speed until such time as the control is commanded to stop or the analog reference returns to normal.

N. Control shall have available 15 selectable volts per hertz patterns.

O. Volts per hertz ratio shall be automatic, tracking motor load requirements to achieve most efficient operation within the parameters set by the volts per hertz pattern. Potentiometer adjustments not allowed.

P. VFD shall have adjustable automatic restart capabilities and be capable of starting into a spinning motor.

Q. Control must be capable of starting into a spinning motor and switching from inverter to bypass back to inverter without delay and without tripping off line of the inverter, also must be capable of stopping a motor rotating in the reverse direction and then accelerating that motor in the proper direction

R. All components must be supplied in an enclosure.

S. Manual Bypass Control. A bypass control shall be provided for the purpose of running the AC motor at full speed with line power while the VFD is being serviced. Bypass and drive shall be electrically interlocked. The VFD package shall be configured so that the VFD can be removed for service with the bypass control left in place.

T. The bypass control enclosure shall include the following:
   1. NEMA 3R Enclosure
   2. Door Interlock Disconnect
   3. Line Select Light
   4. Drive Off-line Selector
   5. Power On Light
   6. VFD Select Light
   7. Overload Relay
   8. 115 VAC Control Transformer

   *VFD Input Contactor shall be manually operated.

U. System shall have an adjustable setting to allow a power line dip ride through of four (4) cycles.

V. Up to four (4) programmable pre-set speeds.

W. Drive output reference signal:
   1. 0 to 10 vdc
   2. 4 to 20 ma

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which variable frequency drive systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 INSTALLATION OF VARIABLE FREQUENCY DRIVE SYSTEMS

A. General: Install system and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Install electrical components and use electrical products complying with requirements of applicable electrical specifications. Mount controllers at convenient locations and heights.

3.03 CLEANING

A. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of variable frequency drives, including electrical connections. Report results in writing.
   1. Test and adjust controls and safeties.
   2. Replace damaged and malfunctioning controls and equipment.

3.05 COMMISSIONING

A. Startup Services: Engage a factory-authorized service representative to perform startup services and field report.

B. Operate motors and verify proper rotation and connections.

C. Operate controls and verify proper response to control inputs.

D. Submit a list of all adjustable and non-adjustable operating parameters along with actual settings and adjustment ranges.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
   1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing and preventive maintenance.
   2. Review data in the maintenance manuals.
   3. Schedule training with Owner, through Engineer, with at least seven (7) days' advance notice.

END OF SECTION

SECTION 23 2113
HYDRONIC PIPING AND SPECIALTIES

PART 1 GENERAL

1.01 WORK INCLUDED

A. This Section includes piping systems for Cooling Tower Condenser Water Piping.

B. Types of hydronic piping and specialties specified in this section include the following:
   1. Piping and Fittings
   2. Air Vents

1.02 SUBMITTALS

A. Product Data: From manufacturer's, for each hydronic specialty and special duty valve specified, include rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions.
   1. Furnish flow and pressure drop curves for calibrated plug valves, based on manufacturer's testing.

B. Shop Drawings: Detailing dimensions, weight loadings, required clearances, methods of assembly of components, and location and size of each field connection.

C. Maintenance Data: For hydronic specialties and special duty valves, for inclusion in operation and maintenance manual.

D. Quality Control Submittals:
   1. Welders' certificates certifying that welders comply with the quality requirements specified in Quality Assurance below.
   2. Certification of compliance with ASTM and ANSI manufacturing requirements for pipe, fittings, and specialties.
   3. Submit reports specified in Part 3 of this Section.
      a. Hydronic Piping System Testing Report.
      b. Hydronic Piping System Cleaning Report.

1.03 QUALITY ASSURANCE

A. Qualifications for Welding Processes and Operators: ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification."

B. Regulatory Requirements:
   1. ASME Compliance: Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.04 MAINTENANCE

A. Maintenance Stock: Furnish a sufficient quantity of chemical for initial system start-up and for preventive maintenance for one (1) year from Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide hydronic piping system products from one (1) of the following:
   1. Grooved Mechanical Joint Pipe, Fittings, and Couplings:
      a. Gruvlok; Anvil Industries.
      b. Tyco-Grinnell
      c. Victaulic Company of America
   2. Pressfit Mechanical Joint Pipe, Fittings and Couplings:
      a. Pro Press System, Viega Company
      b. Victaulic Company of America

3. Air Vents (manual and automatic):
   a. Hays Fluid Controls
   b. TACO, Inc.
   c. Bell & Gossett
   d. Pro Hydronic Specialties

2.02 PIPE AND TUBING MATERIALS OPTIONS (SELECTED OPTIONS SHALL COMPLY WITH ALL LOCAL CODES)

A. Material Options for Cooling Tower Piping:
   1. Chlorinated Polyvinyl Chloride (CPVC) Plastic Pipe: ASTM F 441, Schedule 80, plain ends.
   2. Polyvinyl Chloride (PVC) Plastic Pipe: ASTM D 1785, Schedule 80, plain ends.
   3. Steel Pipe, 2-1/2-inch to 12-inch NPS (DN65 to DN300): ASTM A 53, Type E (electric-resistance welded), Grade A, Schedule 40, plain ends with mechanical couplings (above ground only).

2.03 FITTINGS

A. Chlorinated Polyvinyl Chloride (CPVC) Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 439 for Schedule 80 pipe.

B. Polyvinyl Chloride (PVC) Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2467 for Schedule 80 pipe.

2.04 JOINING MATERIALS

A. Chlorinated Poly(Vinyl Chloride) (CPVC) Solvent Cement: ASTM F 493.

B. Poly(Vinyl Chloride) (PVC) Solvent Cement: ASTM D 2564.

2.05 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 175 PSIG working pressure, 250°F operating temperature; manually operated with screwdriver or thumbscrew; and having 1/8-inch discharge connection and 1/4-inch inlet connection.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and non-ferrous internal parts; 150-PSIG working pressure, 250°F operating temperature; with 1/4-inch NPS discharge connection and 1/2-inch NPS inlet connection.

C. Scale Free System: Electronic scale free system to be installed by OPS contracted contractor at each chiller and cooling tower. Contractor to coordinate with the OPS installing contractor for timing of work. This contractor to install hot taps with ball valve at the existing chillers.

2.06 HEAT TRACING SYSTEMS

A. Systems shall meet requirements of NFPA 70.

B. Provide tracing for outdoor piping subject to freezing temperatures below 38 degrees F as follows:
   1. Condenser water piping for cooling towers.
   2. Make-up water.

C. Heat tracing shall be provided to the extent shown in the contract documents.

D. Heating Cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.
   1. Provide end seals at ends of circuits. Wire at the ends of the circuits is not to be tied together.

2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 36 degrees F minimum during winter outdoor design temperature, but not less than the following:
   a. 3 inch pipe and smaller with 1 inch thick insulation: 6 watts per foot of pipe.
   b. 4 inch pipe and larger 1-1/2 inch thick insulation: 8 watts per foot of pipe.

E. Electrical Heating Tracing Accessories:
1. Power supply connection fitting and stainless-steel mounting brackets. Provide stainless-steel worm gear clamp to fasten bracket to pipe.
2. 1/2 inch wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 12 inch intervals.
3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 1/2 inch NPT conduit hub, SPST switch rated 20 amps at 480 volts ac, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 34 degrees F.
4. Signs: Manufacturer's standard (NFPA 70), stamped "ELECTRIC TRACED" located on the insulation jacket at 10 feet intervals along the pipe on alternating sides.

PART 3 EXECUTION

3.01 PIPING INSTALLATIONS

A. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

B. Extreme care shall be exercised by the Contractor to prevent dirt and other foreign matter from entering pipe or components of system during construction. Pipe stored on Project shall have open ends capped and equipment shall have all openings fully protected. Before erection, each piece of pipe, fitting or valve shall be visually examined and all dirt removed.

C. Install piping at a uniform grade of 1-inch in 40-feet upward in the direction of flow.

D. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.

E. Install branch connections to mains using Tee fittings in main with take-off out the bottom of the main, except for up-feed risers which shall have take-off out the top of the main line.

F. Install unions in pipes 2-inch and smaller, adjacent to each valve, at final connections each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

G. Install flanges on valves, apparatus, and equipment having 2-1/2-inch and larger connections.

H. Install flexible connectors at inlet and discharge connections to pumps (except inline pumps) and other vibration producing equipment.

I. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated. Install nipple and ball valve in blow down connection of strainers 2-inch and larger.

J. Anchor piping to ensure proper direction of expansion and contraction.

K. Support: The requirements of MSS-SP-69 "Pipe Hangers and Support - Selection and Application" shall, in general, govern the installation of hangers and supports, in accordance with the manufacturer's recommendations and with the following minimum spacings:

Nominal Pipe Size (Inches)	Max. Span Between Supports (Feet)
3/4	8
1	9
1-1/4	11

1-1/2	12
2	12
2 1/2	12
3	12
4	14
5	14
6	16
8	18
10	20
12	22
16	22

3.02 VALVE APPLICATIONS

A. General Duty Valve Applications: The Drawings indicate valve types to be used. Where specific valve types are not indicated the following requirements apply:
   1. Shut-off duty: Use ball and butterfly valves.
   2. Throttling duty: Use ball and butterfly valves.
   3. Install shut-off duty valves at each branch connection to supply and return mains, at supply and return connection to each piece of equipment, and elsewhere as indicated.
   4. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

B. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

C. Note that all valves required by this Section may not be shown on the drawings.

3.03 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in the system, at heat transfer coils, and elsewhere as required for system air venting. For inaccessible vent locations, the vent piping shall be piped to a location where vent will be accessible.

B. Note that all hydronic specialties required by this Section may not be shown on the drawings.

3.04 FIELD QUALITY CONTROL

A. Testing Preparation: Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Flush system with clean water. Clean strainers.
   4. Isolate equipment that is not subjected to test pressure from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Flanged joints where blinds are inserted to isolate equipment need not be tested.
   5. Install relief valve set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Testing: Test hydronic piping as follows:
   1. Use ambient temperature clean water as testing medium.
   2. Use vents installed at the high points of system to release trapped air while filling system. Use drains installed at low points for complete removal of liquid.
   3. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low-pressure filling lines are disconnected.
   4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or

other component in system under test. Check to verify that stress due to pressure at bottom of vertical runs does

5. not exceed either 90% of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, Code for Pressure Piping, "Building Services Piping."
6. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.
7. Prepare written report of testing and submit to Project Engineer and Owner's Representative for review. Written report shall be made available to phase 2 contractor for their final connections.

C. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens.

3.05 ADJUSTING AND CLEANING

A. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

B. Close drains and refill systems for operation under normal closed loop conditions. HVAC Contractor shall add trisodium phosphate in an aqueous solution to system, prepared in a proportion of 1 lb/50 gallons of water in the system. After system is filled with this solution, the circulating pump should be started, trapped air vented, and the boiler set to supply approximately 100^{o}F loop temperature. Solution shall circulate for approximately three (3) hours.

C. System then shall be drained completely and refilled with fresh water. After system has been completely cleaned as specified herein, it shall be tested by litmus paper or other dependable methods and left on slightly alkaline side (PH 7.5). If system is still on acid side, cleaning by use of trisodium phosphate shall be repeated.

D. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

E. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

3.06 COMMISSIONING

A. Fill system and perform initial chemical treatment.

B. Perform these steps before operating the system:
   1. Open valves to fully open position. Close coil bypass valves.
   2. Set automatic fill valves for required system pressure.
   3. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or bleed air completely (manual type).
   4. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
   5. Lubricate motors and bearings.

END OF SECTION

SECTION 23 6500

COOLING TOWERS AND ACCESSORIES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Open-circuit, induced-draft, cross-flow cooling towers.
   2. Condenser water treatment.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, pressure drop, fan performance data, rating curves with selected points indicated, furnished specialties, and accessories.
   1. Maximum flow rate.
   2. Minimum flow rate.
   3. Drift loss as percent of design flow rate.
   4. Volume of water in suspension for purposes of sizing a remote storage tank.
   5. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
   6. Performance curves for the following:
      a. Varying entering-water temperatures from design to minimum.
      b. Varying ambient wet-bulb temperatures from design to minimum.
      c. Varying water flow rates from design to minimum.
      d. Varying fan operation (off, minimum, and design speed).
   7. Fan airflow, brake horsepower, and drive losses.
   8. Motor amperage, efficiency, and power factor at 100%, 75%, 50%, and 25% of nameplate horsepower.
   9. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings: Complete set of manufacturer's prints of cooling tower assemblies, control panels, sections and elevations, and unit isolation. Include the following:
   1. Assembled unit dimensions.
   2. Weight and load distribution.
   3. Required clearances for maintenance and operation.
   4. Sizes and locations of piping and wiring connections.
   5. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of support structure.
   2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
   3. Certificates: For certification required in "Quality Assurance" Article.
   4. Seismic Qualification Certificates: For cooling towers, accessories, and components, from manufacturers.
      a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

5. Warranty: Special warranty specified in this Section.

D. Closeout Submittals:
1. Startup service reports.
2. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.
3. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by CTI.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. CTI Certification: Cooling tower thermal performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

F. FMG approval and listing in the latest edition of FMG's "Approval Guide."

1.05 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
1. Fan assembly including fan, drive, and motor.
2. All components of cooling tower.
3. Warranty Period: Five years from date of Substantial Completion.

1.07 SOURCE QUALITY CONTROL

A. Verification of Performance: Test and certify cooling tower performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

B. Factory pressure test heat exchangers after fabrication and prove to be free of leaks.

PART 2 PRODUCTS

2.01 OPEN- CIRCUIT, INDUCED-DRAFT, CROSSFLOW COOLING TOWER

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one (1) of the following:
1. Baltimore Aircoil Company.
2. Marley Cooling Technologies; an SPX Corporation.
3. Reymsa

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of 30 lbf/sq. ft..

D. Casing and Frame:
1. Casing and Frame Material: Galvanized steel, ASTM A 653/A 653M, G235 coating.
2. Fasteners: Galvanized steel.

3. Joints and Seams: Sealed watertight.
4. Welded Connections: Continuous and watertight.

E. Collection Basin:
1. Material: 301L Stainless Steel.
2. Removable stainless-steel strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Outlet Connection: ASME B16.1, Class 125 flange.
6. Equalizer connection for field-installed equalizer piping.
7. Depressed side sump outlet with trash screen and anti-vortex plate.

F. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

G. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.

H. Single bottom inlet connection per cell with self-balancing 8” internal PVC piping.

I. Fill:
1. Materials: PVC, with maximum flame-spread index of 5 according to ASTM E 84.
2. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.

J. Vibration Switch: For each fan drive.
1. Vibration Detection: Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
2. Switch shall, on sensing excessive vibration, shut down the fan.

K. Controls: Comply with requirements in Division 23 Section "Building Management and HVAC Control System."

L. Electrical: Provide single point power connection location with tower. Single point power connection shall have main disconnect and connections for external fan VFD’s and basin heaters. Single point connection shall be NEMA 3R.

M. Personnel Access Components:
1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

PART 3 EXECUTION

3.01 EXAMINATION

A. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting tower performance, maintenance, and operation.
1. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

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

3.02 INSTALLATION

A. Install cooling towers on existing supports. Provide steel beam to increase height of existing supports by 12”.

B. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Maintain manufacturer's recommended clearances for service and maintenance.

D. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.03 CONNECTIONS

A. Install piping adjacent to cooling towers to allow service and maintenance.

B. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

C. Provide drain piping with valve at cooling tower drain connections and at low points in piping.

D. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

E. Domestic Water Piping: Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.

F. Supply and Return Piping: Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gauge, and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a union, flange, or mechanical coupling.

G. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Cooling towers will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.05 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.
   1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
      a. Clean entire unit including basins.
      b. Verify that accessories are properly installed.
      c. Verify clearances for airflow and for cooling tower servicing.
      d. Check for vibration isolation and structural support.
      e. Lubricate bearings.
      f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
      g. Adjust belts to proper alignment and tension.
      h. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
      i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
      j. Check vibration switch setting. Verify operation.

k. Verify water level in tower basin. Fill to proper startup level. Check makeup water-level control and valve.
l. Verify operation of basin heater and control.
m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.06 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION

SECTION 26 0500
GENERAL ELECTRICAL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 RESPONSIBILITIES

A. The Bidding Requirements, Conditions of Contract, General Specifications and General Requirements, and this Division shall be binding on the Contractor and shall apply to all electrical work to be completed under this section.

B. The Contractor shall be responsible for the work from the date of his Contract until its acceptance by the Owner and must make good all damages sustained from whatever cause. He shall use proper care and diligence in bracing and securing all parts of the work and shall in all cases j

C. udge as to the amount of protection required.

1.03 ORDINANCES, LAWS AND CODES

A. All work shall conform to the rules and regulations of the National Electrical Code, Local Code, "Occupational Safety and Health Act" and the State Fire Marshall's Office. All certificates of approval shall be delivered to the Architect before final payment will be made.

B. Should any change in the drawings and/or specifications be required to conform to the abovementioned laws and ordinances, the Architect shall be notified by the Bidder prior to the Bid Date, that the necessary changes may be completed. After the Bid Date, all work necessary to meet the requirements shall be at Contractor's expense, with no additional cost to the Owner.

C. The Contractor shall pay all fees, permits or taxes for inspections, etc., in connection with the work under this Contract. Any costs, charges or connection fees which the Power Company assesses the Owner or Contractor in order to obtain permanent and temporary electrical service to the Project Facility will be paid by the Contractor as part of this Contract.

1.04 DATA AND MEASUREMENT

A. The data given herein and on the drawings is as exact as could be secured insofar as building construction and existing conditions are concerned. Extreme accuracy is not guaranteed. The drawings and specifications are intended for the assistance of the Contractor in achieving the end result. Exact locations, measurements, distance, levels, etc., will be governed by conditions at the Job Site.

B. The Contractor shall verify that the size of the equipment supplied by the selected manufacturers does not exceed the available mounting space.

C. The Architect reserves the right to change location or size of conduits, outlets, luminaires or other pieces of equipment as may be necessary to avoid conflicts. No extra compensation will be allowed for such changes unless additional cost to the Contractor is caused.

D. The Bidder shall visit the Project Site that he or she may have knowledge of conditions at the Job Site and adapt his work to such conditions.

1.05 DRAWINGS AND SPECIFICATIONS

A. Anything mentioned in this specification and not shown on the drawings or vice versa shall be of like effect, as shown or mentioned in both. In any case of discrepancy or differences in the figures, drawings or specifications, the Bidder shall promptly report such discrepancies to the Architect who shall make a decision in writing. Any adjustment by the Contractor without this decision shall be at the expense of the Contractor.

1.06 QUALITY OF WORKMANSHIP

A. The Contractor shall give his personal superintendence and direction to the work. He shall also keep a competent foreman or superintendent on the Project.

B. All equipment, controls and junction boxes shall be located for ready access, operation, repair or maintenance.

C. Any additional drawings necessary for the prosecution of the work will be furnished by the Architect as promptly as possible. The Contractor shall request any additional instructions needed and shall do no work without drawings and instructions.

D. Any discrepancies between the Mechanical, Electrical and Architectural Drawings shall be reported to the Architect prior to the Bid Date.

1.07 GUARANTEE

A. This Contractor shall guarantee all materials, workmanship and the successful operation of all apparatus furnished and installed by him for a period of one (1) year from the date of the final acceptance of the whole work, and shall guarantee to repair or replace at his own expense any part of the apparatus which may show defect during that time, provided such defect is, in the opinion of the Architect, due to imperfect material or workmanship and not to carelessness or improper operation. Guarant

B. ee period

C. for the replacement shall begin with the date of replacement.

D. The Owner shall notify the Contractor of any failure of any part or parts which occur during the guarantee period.

E. The Contractor shall also guarantee the systems and the apparatus to be working properly to meet all conditions as specified.

1.08 SHOP DRAWINGS

A. Shop Drawings shall be submitted in accordance with the requirements of Paragraph "Shop Drawings" of the General Conditions. The Contractor shall submit Shop Drawings of all fabricated work and equipment to be purchased. Data shall be sufficiently completed to permit evaluation and comparison with specified equipment and material. Each item shall be prepared as a separate submittal, not grouped or bound with other items.

B. All drawings shall bear the Contractor’s stamp of approval and must be dated.

C. See individual specification sections for required submittals.

D. A notation shall be made on each item submitted as to its specified use or description of specific location in the work.

E. None of the preceding items shall be purchased, delivered to the site or installed until the item has been properly submitted in writing and reviewed by the Architect.

F. Submittals shall be made even though the item is exactly as specified.

G. Should the Contractor fail to comply with any of the requirements as stated, the Architect reserves the right to select a full line of materials, appliances and equipment, which shall be final and binding upon the Contractor.

1.09 SUBMITTAL DATA

A. Review of submittal data is only for general conformance with the design concept of the Project and general compliance with the information given in the Contract Documents. Any action shown is subject to the requirements of the plans and specifications. Contractor is responsible for: Dimensions, which shall be confirmed and correlated at the job site; fabrication processes and

techniques of construction; coordination of his work with that of all other trades and the satisfactory performance of his work.

B. Contractor will be limited to one (1) review on a singular piece of equipment.

C. The listing of a manufacturer as "acceptable" does not imply automatic compliance with Contract Documents. It is the sole responsibility of the Contractor to ensure that any price quotations received and submittals made are for equipment/systems, which meet or exceed the specifications included herein.

1.10 EQUAL MANUFACTURERS/EQUIPMENT

A. Any requests for manufacturer/equipment to be considered as equal other than as specified herein shall be submitted to the Engineer not less than 10 days prior to Bid Date.

B. Requests for review shall be sufficiently complete to permit evaluation and comparison with specified equipment and material.

PART 2 PRODUCTS

2.01 PROTECTION OF LUMINAIRES AND WARES

A. This Contractor shall apply the necessary protective coverage to luminaires and other equipment to prevent scratches and mars to such equipment as a result of falling objects or work of other trades.

2.02 STORAGE

A. This Contractor shall provide and be responsible for safe storage of his materials and such storage shall not interfere with the work of others or progress of the Project in any manner.

2.03 EQUIPMENT ENCLOSURES

A. Provide enclosures, which mate properly with the equipment to be enclosed and are NEMA rated to suit the atmospheric conditions of the equipment surroundings.

B. Equipment in corrosive atmosphere shall be rated NEMA 4X. All NEMA 4X equipment shall be fabricated from suitable non-metallic material or shall be stainless steel. Painted steel is not acceptable for NEMA 4X applications.

PART 3 EXECUTION

3.01 COORDINATION

A. Before installing any work, this Contractor shall coordinate the electrical work with all other Contractors on the Project, with the Electric Utility Company and the City Code enforcing department.

B. All electrical work shall be installed in proper sequence and so arranged with other trades that there will be no delay in the proper installation and completion of any part or parts of all piping systems and mechanical equipment.

C. This Contractor shall carefully examine the drawings and shall be responsible for the proper fitting of equipment and conduit as indicated without major alteration. If alterations are required, a detailed drawing of the proposed departure due to actual field conditions or other causes shall be submitted to the Architect for approval.

D. Whenever interferences might occur, before installing any of the work in question, the Electrical Contractor shall consult with other Contractors and shall come to an agreement with them as to the exact location and level of his conduit bus duct, luminaires and/or parts of his installation.

E. Where recessed electrical devices (speakers, luminaires, etc.) are installed in fire-rated ceilings, Contractor shall provide an enclosure approved by authorities having jurisdiction to surround each device as required to maintain the fire integrity rating of the ceiling. Adequate clearance between device and enclosure shall be provided in accordance with device manufacturer's

recommendations. Verify clearance requirements with device manufacturer prior to installation of luminaire.

F. Multiwire branch circuits as defined by the National Electrical Code (circuits with common neutral) shall not be used. Exception: Where an equipment manufacturer requires a multiwire branch branch circuit for only one utilization equipment and where all ungrounded conductors of that circuit are opened simultaneously by the branch circuit overcurrent device.

G. A cable raceway type wiring method, installed in exposed or concealed locations near metal-corrugated sheet roof decking, shall be installed and supported so the nearest outer surface of the cable raceway is not less than 6-inches from the nearest surface of the roof decking. Exception: Rigid metal conduit and intermedIate metal conduit shall not be required to maintain this clearance.

H. All changes in the work of this Contractor, caused by his neglect to follow these instructions, shall be made at this Contractor's expense.

3.02 DITCHING, EXCAVATION AND BACKFILLING

A. Contractor shall do all excavation required to install conduits and equipment shown on drawings or required for proper operation. Excess excavation below the required level shall be backfilled with earth and thoroughly tamped.

3.03 CONNECTIONS FOR EQUIPMENT

A. Coordinate the hook up of the following equipment with the Contractor required to furnish and install them. See the appropriate sections in the General Construction Work specifications for further information.
   1. Mechanical Equipment
   2. Fire Alarm Equipment
   3. HVAC Controls Equipment
   4. Cabinetry Equipment
   5. Owner Furnished Equipment

B. Verify fuse and/or circuit breaker requirements for electrical connections to equipment and provide overcurrent devices accordingly.

C. The plans indicate the locations of system devices. The Contract shall include the wiring system required to interconnect the indicated devices to result in a complete, operating system. The interconnecting wiring shall be in conformity with the requirements of the manufacturer of the equipment as well as with other requirements set out herein. The basic wiring method to be employed is indicated herein. The Contractor's Shop Drawing submittal shall indicate the specific routing and type of wireway and the number and type of conductors to be installed.

3.04 WORK IN EXISTING BUILDING

A. Inasmuch as work under this Contract includes adding to in the existing building, it shall be the responsibility of each Bidder to fully inform himself of any and all conditions which influence or are influenced by work contemplated by these specifications and accompanying drawings. The submission of a proposal by any Bidder will be construed as an admission by him that he has examined and is fully familiar with the premises and all conditions thereon and adjacent thereto, and has included in this proposal a proper and adequate amount to cover rearrangement of old work for the proper installation and operation of the new and existing equipment as shown on the drawings specified herein or as required. Such work shall be neatly and properly done.

B. Maintain existing electrical service and feeders to occupied areas and operational facilities, unless otherwise indicated or when authorized otherwise in writing by Owner or Architect. Provide temporary service during interruptions to existing facilities. When necessary, schedule momentary outages for replacing existing wiring systems with new wiring systems. When that

"cutting-over" has been successfully accomplished, remove, relocate or abandon existing wiring as indicated.

C. The operation of all special systems within the building shall be maintained, including but not limited to fire alarm, telephone, intercom, communication, data, security, emergency call, etc. Provide temporary connections/equipment as necessary for required sequence of construction. Any necessary momentary outages shall be scheduled with the Owner prior to starting such work.

3.05 DEMOLITION AND REMOVAL OF EXISTING EQUIPMENT AND MATERIALS

A. Existing conduits that are made spare by demolition work shall be removed unless concealed in existing construction.

B. All existing unused wiring shall be removed.

C. All conduits and conductors shown to be reused shall be thoroughly tested and checked for insulation breakdown and continuity.

D. Electrical items must be removed where they interfere with or are not concealed by new construction such as new ceilings, walls, etc.

E. Existing luminaires, outlets, receptacles and other equipment and material shall be relocated, removed, reconnected or left in place as indicated on the drawings. Where an existing device is shown removed from an existing circuit, new wiring shall be provided as required to insure continuity of existing circuit. If existing devices or other electrical items, such as electrically operated equipment interfere with the location of a new partition, relocation of existing equipment, new equipment, etc., the existing items including electrical components of electrically operated equipment shall be disconnected and removed or satisfactorily relocated and reconnected even though not specifically indicated on the drawings. All material removed which is considered salvageable by the Owner and is not specifically designated to be reused on the drawings or not practical to be reused shall remain in the property of the Owner and shall be neatly stockpiled in a specially designated location.

3.06 CLEANING

A. This Contractor shall at all times keep the premises free of all waste or surplus materials, rubbish and debris which is caused by his employees or resulting from his work.

B. After all equipment and luminaires have been installed and building is ready for occupancy, the Electrical Contractor shall remove all stickers, rust stains, labels, temporary covers, plaster marks, paint spots, etc. All foreign matter shall be vacuumed out of all conduits, panels, motors, devices, switches, luminaires, etc.

C. Identification plates and trims on all equipment shall be free of paint and polished.

D. The Contractor shall leave the electrical portion of the work in a safe clean and very neat condition ready for operation.

3.07 REBATES

A. The Contractor shall assist the Owner with filing of applicable forms to obtain rebates. This shall include but not be limited to determination of qualifying materials and furnishing invoices for materials with corresponding quantities.

3.08 RECORD DRAWINGS

A. The Contractor shall maintain an up-to-date set of plans and specifications on the Job Site. He shall mark all Addendum Items and any field changes on this set and see that a copy of all changes is furnished to the Architect at the end of the Project.

B. The drawings shall also include as-built conditions such as equipment locations, routing of service entrance and major feeders, etc.

3.9 INSTRUCTION IN OPERATION BOOKS AND SPARE PARTS

A. After all tests and adjustments have been made, the Contractor shall furnish the necessary qualified personnel to place the special systems in continuous operation, during which time he shall provide complete Operating and Maintenance Instructions to the Owner's representative with an outline of instructions in written form. These personnel shall reserve adequate time to instruct an Owner's representative on proper operation (including all phases of the system

B. and each of its component parts).

C. Contractor shall furnish Owner with two (2) sets of all operating instructions, maintenance instruction and spare parts lists of all equipment furnished under this Contract. Lists shall include current unit prices and source of supply for each item of operable equipment.

3.10 FIRESTOPPING

A. Openings around electrical penetrations through fire-resistant rated walls, partitions, floors or ceilings shall be firestopped using listed materials to maintain the fire rating. Installation shall be done in accordance with manufacturer's recommendations. Materials shall be UL Listed and labeled and FM approved for fire ratings consistent with penetrated barriers.
   1. Foamed-in-place type firestopping shall only be permitted in concealed-from-view locations. Sealant type firestopping shall be used in exposed-to-view locations.
   2. Cable tray, conduit sleeves (2-inch and larger) and similar penetrations of fire-rated walls, floors or ceilings shall be sealed by a method that permits cables to be easily added or removed without damage to the firestopping materials. Products similar to Grace Construction Products Flamesafe Bags, Specified Technologies, Inc. EZ Path Fire Rated Pathway and Wiremold Flamestopper FS Series are acceptable when rated for the application. Coordinate requirements with product manufacturer and authority having jurisdiction. Foamed in place or sealant type firestopping are not acceptable at these locations.

3.11 TESTS AND ADJUSTMENTS

A. Upon completion of installation of electrical connections, and after circuitry has been energized with rated power source test connections to demonstrate capability and compliance with requirements. Ensure that direction of rotation of each motor fulfills requirement. Correct malfunctioning units at site, then retest to demonstrate compliance.

B. During the progress and after completion of the work included under this specification, the Contractor shall make all required tests at his own expense in the presence of the Architect as required hereinafter and by local ordinances, codes, laws and regulations. Such tests shall be in accordance with other sections of this division. The Architect shall be notified five (5) days in advance as to the time when such tests are to be performed that a representative of the Architect may be present.

END OF SECTION

SECTION 26 0519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.

1.03 DEFINITIONS

A. VFC: Variable frequency controller.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 PRODUCTS

2.01 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

B. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2, Type XHHW-2.

2.02 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.03 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 3 EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper Stranded for all feeder conductors.

B. Branch Circuits: Copper. Stranded for all branch circuit conductors. All stranded wire connections to wiring devices shall be made with compression type wire terminations. Minimum wire size shall be #12 AWG. #14 AWG wiring shall be permitted for control wiring.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway

D. Feeders Concealed in Concrete, Below Slabs-on-Grade, in Wet / Damp Locations and Underground: Type XHHW-2, single conductors in raceway.

E. Feeders Serving Emergency Systems: In addition to the requirements above feeders classified as emergency systems shall meet one of the requirements below. Emergency Systems shall be those feeders that are a part of the Life Safety Branch. Emergency systems feeders located in an enclosed ceiling space shall also conform to the conditions below. See fire protection plans and specs for areas protected by a fully automatic protection system.

1. The cable or raceway is installed in spaces or areas that are fully protected by an approved automatic fire suppression system.
2. The cable or raceway is protected by a listed electrical circuit protective system with a minimum of 2-hour rating.
3. The cable or raceway is a listed fire resistive cable system.
4. The cable or raceway is protected by a listed fire rated assembly that has a minimum rating of 2 hours and contains only emergency circuits.
5. The cable or raceway is encased in a minimum of 2 inches of concrete.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

J. VFC Output Circuits: Type XHHW-2 in metal conduit.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 26 0533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 26 0529 "Hangers and Supports for Electrical Systems."

G. Switch legs shall be color coded to distinguish them from Hot or Phase Conductors.

H. Switch legs occurring in the same box or enclosure shall be color coded separately.

3.04 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables per Section 26 0553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.06 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly per Section 07 8413 "Penetration Firestopping."

END OF SECTION

SECTION 26 0533
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Metal conduits, tubing, and fittings.
   2. Boxes, enclosures, and cabinets.

1.03 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

1.04 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

PART 2 PRODUCTS

2.01 METAL CONDUITS, TUBING, AND FITTINGS

A. Manufacturers:
   1. Rigid Metallic Conduit: Allied Tube and Conduit Corporation or equivalent.
   2. Flexible Metallic Conduit: American Brass “Sealtite” or equivalent.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
   1. Fittings for EMT:
      a. Material: Steel.
      b. Type: Setscrew.
   2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
   3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

I. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers:
   1. Raco, Steel City or equivalent.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:
   1. Material: Cast metal.
   2. Type: Fully adjustable.
   3. Shape: Rectangular.
   4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).

H. Gangable boxes are allowed.

I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
   2. Nonmetallic Enclosures: Fiberglass.
   3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

PART 3 EXECUTION

3.01 RACEWAY APPLICATION

A. Indoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed, Not Subject to Severe Physical Damage: EMT.
   3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
      a. Mechanical rooms.
   4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations and mechanical rooms.
   6. Damp or Wet Locations, including mechanical rooms: GRC.
   7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

B. Minimum Raceway Size: 3/4-inch (21-mm) trade size. 1/2-inch (21-mm) trade size for control wiring.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
   2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
   3. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.
   4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

E. Install surface raceways only where indicated on Drawings or where limited due to existing construction methods.

3.02 IDENTIFICATION OF BOXES

A. All junction box covers shall be labeled with the panel and circuit.

B. All concealed box covers shall be painted with enamel spray paint, using the following system:
   1. Fire Alarm - Red
   2. Emergency Power - Yellow
   3. Security and Access Controls - Orange
   4. HVAC Controls - Blue

3.03 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches (300 mm) of enclosures to which attached.

I. Raceways Embedded in Slabs:
   1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   3. Arrange raceways to keep a minimum of 1 inch (25 mm) of concrete cover in all directions.
   4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
   5. Change from ENT to GRC before rising above floor. Where acceptable to authority having jurisdiction, rigid non-metallic conduits may be stubbed up no more than 6-inches above floor where concealed within walls.

J. Stub-ups to Above Recessed Ceilings:
   1. Use EMT, IMC, or RMC for raceways.
   2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35 mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Surface Raceways:
   1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
   2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where an underground or above ground raceway enters a building or structure. Include empty raceway with a removable seal.
   3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:
   1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
   2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
      c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
      d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires**.** Use a maximum of 24 inches at equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

AA. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

BB. Locate boxes so that cover or plate will not span different building finishes.

CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

EE. Set metal floor boxes level and flush with finished floor surface.

3.04 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies.

3.05 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 0553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Identification for raceways.
   2. Identification for conductors.

1.03 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.04 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.

C. Comply with ANSI Z535.4 for safety signs and labels.

D. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

E. Room numbers must be identified with OPS room numbers and names for labeling panel directories for electrical power, intercom, fire alarm, and electronic security.

1.05 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes and standards. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 PRODUCTS

2.01 BOXES AND RACEWAY IDENTIFICATION MATERIALS

A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label. Protective Overlay only required at exterior or wet locations. Provide at the following locations:
   1. Box covers labeled with panel and circuit number.

2.02 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.

B. Self-Adhesive, Self-Laminating Polyester Labels: Preprinted, 3-mil- (0.08-mm-) thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the cable diameter such that the clear shield overlaps the entire printed legend.

2.03 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

PART 3 EXECUTION

3.01 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape with adhesive appropriate to the location and substrate.

G. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

H. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.02 IDENTIFICATION SCHEDULE

A. Power-Circuit Conductor Identification, 600 V or Less: For conductors in pull and junction boxes, and handholes, use color-coding conductor tape to identify the phase.
   1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
      a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
      b. Colors for 208/120-V Circuits:
         1) Phase A: Black.
         2) Phase B: Red.
         3) Phase C: Blue.
      c. Colors for 480/277-V Circuits:
         1) Phase A: Brown.
         2) Phase B: Orange.
         3) Phase C: Yellow.
      d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

B. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
   1. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

END OF SECTION