PROJECT MANUAL

FOR

HVAC RENOVATION

AT

READING FIRE DEPARTMENT
FIRE HOUSE RESCUE 1 & TOWER 1
614 FRANKLIN STREET
READING, PA 19602

FOR

CITY OF READING
815 WASHINGTON STREET
READING, PA 19601

BY

GANNETT FLEMING

Bid Documents

ENGINEER'S PROJECT NO. 066466

JULY 27, 2022

THE CITY OF READING

TECHNICAL SPECIFICATIONS

PROJECT TITLE:

READING FIRE DEPARTMENT, RESCUE 1 AND TOWER 1 –
PLUM AND FRANKLIN HVAC & IAQ UPGRADE

CONTENTS:

DIVISION 00 – ADMINISTRATIVE
- 00 4100 Bid Form

DIVISION 01 – GENERAL REQUIREMENTS
- 01 9113 General Commissioning Requirements

DIVISION 02 – EXISTING CONDITIONS
- 02 4100 Demolition
- 02 4119 Selective Electrical Demolition

DIVISION 23 – HEATING, VENTILATING, AND AIR-CONDITIONING
- 23 0519 Meters and Gauges for HVAC Piping
- 23 0523 General-Duty Valves for HVAC Piping
- 23 0529 Hangers and Supports for HVAC Piping and Equipment
- 23 0553 Identification for HVAC Piping and Equipment
- 23 0593 Testing, Adjusting, and Balancing for HVAC
- 23 0713 Duct Insulation
- 23 0719 HVAC Piping Insulation
- 23 0800 Commissioning of HVAC
- 23 0913 Instrumentation and Control Devices for HVAC
- 23 0934 Variable-Frequency Motor Controllers
- 23 2113 Hydronic Piping
- 23 2114 Hydronic Specialties
- 23 2300 Refrigerant Piping
- 23 3100 HVAC Ducts and Casings
- 23 3300 Air Duct Accessories
- 23 3423 HVAC Power Ventilators
- 23 3600 Air Terminal Units
- 23 3700 Air Outlets and Inlets
- 23 4000 HVAC Air Cleaning Devices
- 23 8101 Terminal Heat Transfer Units
- 23 8126.13 Small-Capacity Split-System Air Conditioners
- 23 8200 Convection Heating and Cooling Units

DIVISION 26 – ELECTRICAL

26 0500	Common Work Results for Electrical
26 0519	Low-Voltage Wire, Cable, and Accessories
26 0526	Grounding and Bonding for Electrical Systems
26 0528	Hangers and Supports for Electrical Systems
26 0533	Raceways and Boxes for Electrical Systems
26 0553	Identification for Electrical Systems
26 0563	Acceptance Electrical Testing
26 2200	Low Voltage Transformers
26 2416	Panelboards
26 2816	Enclosed Switches and Circuit Breakers

END OF TABLE OF CONTENTS

SECTION 01 1100
SUMMARY OF WORK

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. General Description of Project and Location.

1.02 SITE LOCATION

A. Spring & McKnight Firehouse, 614 Franklin St, Reading, PA 19602

1.03 WORK COVERED BY CONTRACT DOCUMENTS

A. Design Goals and Objectives: The project intent is to provide replace the HVAC systems in like kind and upgrade the indoor air quality of the facility with the use of bi-polar ionization (BPI) technology.

B. Without intending to limit or restrict extent of work required under Contract, Work to be performed by the **Contractor** includes, but is not limited to the following.
   1. Remove and replace one (1) split system direct expansion (DX) cooling, hot water heater air handling unit, refrigerant piping, and condensing unit.
   2. Remove and replace twelve (12) hot water unit heaters.
   3. Remove and replace two (2) unit ventilators with hot water heating coils and DX cooling coils.
   4. Remove and replace three (3) ceiling-mounted fan-coil units with hot water heating coils and DX cooling coils.
   5. Remove and replace hydronic convector and baseboard heater valves and controls..
   6. Remove and replace exhaust fans and controls.
   7. Provide BPI units inside of air-moving equipment and standalone in certain areas.
   8. Clean all existing ductwork to be reused.
   9. Procure testing, adjusting, and balancing (TAB) subcontractor. Provide airside and waterside TAB of all HVAC systems.
   10. Commission all new mechanical equipment.
   11. Disconnect and reconnect existing electrical circuits and provide new electrical circuits as needed to support HVAC Equipment.
   12. Procure testing, adjusting, and balancing (TAB) subcontractor. Provide airside and waterside TAB of all HVAC systems.

1.04 CONSIGNED EQUIPMENT

A. No items of equipment have been pre-purchased by the owner.

B. All equipment, piping, instruments, accessories, and controls required to complete the work is to be furnished and installed by the contractor.

1.05 DRAWINGS

A. Project Drawings: The drawings listed on Sheet G001 and the LIST OF DRAWINGS specification section are included as part of all Contracts. The Work relative to each Contract is indicated on each Sheet; however, the full scope of work cannot be fully and correctly interpreted without reference to all drawings.

1.06 CONSTRUCTION SEQUENCE

A. Refer to the BID FORM and INSTRUCTIONS TO BIDDERS.

1.07 PHASING PLAN

A. The mechanical contractor is responsible for providing an updated phasing plan to the City of Reading within two weeks of Notice to Proceed (NTP) and updating this plan throughout the length of the project.

1.08 MODIFICATIONS

A. Owner and Engineer of Record reserve the right to make changes in order and execution of Work of Contract as, in the judgement of the Owner or Engineer, may be necessary or expedient to carry out intent of design and Contract. No increase in unit prices over Contract rates will be paid to Contractor on account of such changes.

1.09 PHYSICAL DATA

A. Become fully informed concerning location of facilities, structures, and utilities which may interfere with Project. Contractor must prepare bid and enter into Contract with full understanding of conditions to be encountered and responsibilities in connection with that.

B. From investigations and field surveys, location of utilities and equipment have been brought to attention of Engineer are indicated on Drawings, but locations of existing conditions are not guaranteed. Indication on Drawings of such items will not be assumed to relieve Contractor of any responsibility with respect to it nor will Owner or Engineer be held responsible for omission or failure to give notice to Contractor of any other utilities or equipment.

1.10 DAMAGE

A. Any damage done by the Contractor to City of Reading property or adjacent property and right-of-way will be restored immediately to the owner’s satisfaction at the Contractor’s expense.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

SECTION 00 4100
BID FORM

THE PROJECT AND THE PARTIES

1.01 TO:

A. The City of Reading

B. 815 Washington St, Reading, PA 19601

1.02 FOR:

A. Plum & Franklin Fire House HVAC & IAQ Upgrades

B. 614 Franklin St, Reading, PA 19602

1.03 DATE: _____

1.04 SUBMITTED BY:

A. Bidder's Full Name _____
   1. Address _____
   2. City, State, Zip_____

1.05 OFFER

A. Having examined the Place of The Work and all matters referred to in the Instructions to Bidders and the Bid Documents prepared by Gannett Fleming for the above mentioned project, we, the undersigned, hereby offer to enter into a Contract to perform the Work for the Sum of:

B. _____
_____ dollars
($_____), in lawful money of the United States of America.

C. We have included the required performance assurance bonds in the Bid Amount as required by the Instructions to Bidders.
   1. The cost of the required performance assurance bonds is _ _____ _dollars ($_____), in lawful money of the United States of America.

D. We have included costs in the Bid Amount to meet the design intent of the bid documents.
   1. The cost of equipment procurement (e.g. air handling unit, terminal equipment, BPI units, electrical equipment) is _____ dollars ($_____), in lawful money of the United States of America.
   2. The cost of testing, adjusting, and balancing (TAB) is _____ dollars ($_____), in lawful money of the United States of America.
   3. The cost of commissioning is _____ dollars ($_____), in lawful money of the United States of America.

E. All applicable federal taxes are included and State of Pennsylania taxes are included in the Bid Sum.

1.06 ACCEPTANCE

A. This offer shall be open to acceptance and is irrevocable for sixty days from the bid closing date.

B. If this bid is accepted by Owner within the time period stated above, we will:
   1. Execute the Agreement within seven days of receipt of Notice of Award.
   2. Furnish the required bonds within seven days of receipt of Notice of Award.
   3. Commence work within seven days after written Notice to Proceed of this bid.

C. If this bid is accepted within the time stated, and we fail to commence the Work or we fail to provide the required Bond(s), the security deposit shall be forfeited as damages to Owner by reason of our failure, limited in amount to the lesser of the face value of the security deposit or the difference between this bid and the bid upon which a Contract is signed.

D. In the event our bid is not accepted within the time stated above, the required security deposit shall be returned to the undersigned, in accordance with the provisions of the Instructions to

Bidders; unless a mutually satisfactory arrangement is made for its retention and validity for an extended period of time.

1.07 CONTRACT TIME

A. If this Bid is accepted, we will:

B. Complete the Work by _____ (Bidder to enter completion date or time frame.)

1.08 CHANGES TO THE WORK

A. When Owner establishes that the method of valuation for Changes in the Work will be net cost plus a percentage fee in accordance with General Conditions, our percentage fee will be:
   1. _____ percent overhead and profit on the net cost of our own Work;
   2. _____ percent on the cost of work done by any Subcontractor.

B. On work deleted from the Contract, our credit to Owner shall be Engineer-approved net cost plus _____ of the overhead and profit percentage noted above.

1.09 ADDENDA

A. The following Addenda have been received. The modifications to the Bid Documents noted below have been considered and all costs are included in the Bid Sum.
   1. Addendum # _____ Dated _____.
   2. Addendum # _____ Dated _____.

1.10 BID FORM SIGNATURE(S)

A. The Corporate Seal of

B. _____

C. (Bidder - print the full name of your firm)

D. was hereunto affixed in the presence of:

E. _____

F. (Authorized signing officer, Title)

G. (Seal)

H. _____

I. (Authorized signing officer, Title)

END OF SECTION

SECTION 01 9113
GENERAL COMMISSIONING REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. The Contractor will procure a Commissioning Authority (CA). The CA must be:
   1. Independent and a disinterested party from the General Contractor, Electrical Contractor, Plumbing Contractor, the Mechanical Contractor, the Engineers of Record, and the Architect of Record.
   2. Registered Commissioning Agent (CxA) in good standing with the AABC Commissioning Group (ACG) or a registered Building Commissioning Professional (BCxP) in good standing with the American Society of Heathing, Ventilating, and Air Conditioning Engineers (ASHRAE).

B. Commissioning is intended to achieve the following specific objectives; this section specifies the General Contractor's responsibilities for commissioning:
   1. Verify that the work is installed in accordance with the Contract Documents and the manufacturer's recommendations and instructions, and that it receives adequate operational checkout prior to startup: Startup reports and any Prefunctional Checklists executed by the General Contractor, Mechanical Contractor, or Electrical Contractor are utilized to achieve this.
      a. The Commissioning Authority will execute all Pre-Functional Checklists.
   2. Verify and document that functional performance is in accordance with the Contract Documents: Functional Tests executed by Mechanical or Electrical Contractor and witnessed by the Commissioning Authority are utilized to achieve this.
      a. The Commissioning Authority will execute all Functional Performance Checklists with the assistance of the General Contractor, Mechanical Contractor, and Electrical Contractor to startup and operate equipment as needed.
   3. Verify that operation and maintenance manuals submitted to Owner are complete: Detailed operation and maintenance (O&M) data submittals by Contractors are utilized to achieve this.
   4. Verify that the Owner's operating personnel are adequately trained: Formal training conducted by Contractor is utilized to achieve this.

C. The Commissioning Authority directs and coordinates all commissioning activities; this section describes some but not all of the Commissioning Authority's responsibilities.

D. The General Contractor, Mechanical Contractor, and Electrical Contractor will assist the Commissioning Authority with startup and operation of equipment as necessary to complete commissioning activities.

1.02 SCOPE OF COMMISSIONING

A. The following are to be commissioned:
   1. HVAC System:
      a. Cabinet Unit Heaters
      b. Exhaust Fans
      c. Unit Ventilators
      d. Relief Air Motor Operated Dampers
      e. Variable frequency drives.
      f. Air Handling Units
      g. Bipolar Ionization Units
         1) Utilize manufacturer provided indoor air quality monitors for functional testing.
      h. Electric and Hot Water Baseboard Heaters
   2. Electrical Systems:
      a. Lighting controls other than manual switches.

B. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.

1.03 SUBMITTALS

A. See General Conditions for submittal Procedure.
   1. The General Contractor, Mechanical Contractor, Plumbing Contractor, and Electrical Contractor shall provide the Commissioning Authority with all necessary equipment submitals for reference.

B. The Commissioning Authority shall submit the following documents for review by the Engineer of Record no greater than 120 calendar days following Commissioning Authority's Notice to Proceed:
   1. Commissioning Plan

C. The Commissioning Authority shall submit the following documents for review by the Engineer of Record no less than 28 calendar days prior to planned execution:
   1. Pre-Functional Checklists Templates
   2. Functional Performance Test Templates

D. The Commissioning Authority shall submit the following documents for review by the Engineer of Record prior to Substantial Completion:
   1. Executed Pre-Functional Checklists
   2. Executed Functional Performance Tests
   3. Complete Commissioning Issues Log

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

A. Calibration Tolerances: Provide testing equipment of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:
   1. Temperature Sensors and Digital Thermometers: Certified calibration within past year to accuracy of 0.5 degree F and resolution of plus/minus 0.1 degree F.
   2. Pressure Sensors: Accuracy of plus/minus 2.0 percent of the value range being measured (not full range of meter), calibrated within the last year.
   3. Calibration: According to the manufacturer’s recommended intervals and when dropped or damaged; affix calibration tags or keep certificates readily available for inspection.

B. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

C. Dataloggers: Independent equipment and software for monitoring flows, currents, status, pressures, etc. of equipment.
   1. Dataloggers required to for Functional Tests will be provided by the Commissioning Authority and will not become the property of Owner.

PART 3 EXECUTION

3.01 COMMISSIONING PLAN

A. Commissioning Authority will prepare the Commissioning Plan including- but not limited to the following:
   1. Responsibilities of all parties regarding commissioing activities.
   2. Commissioning team conact information.
   3. List of equipment to be Commissioned and testing procedures to be used.
   4. Anticipated Schedule of Commissioning activities.
   5. Commissioning Status Check Sheet.

B. The General Contractor, Mechanical Contractor, and Electrical Contractor are responsible for compliance with the Commissioning Plan and coordination of construction schedule with the Commissioning Authority.

3.02 PREFUNCTIONAL CHECKLISTS

A. A Prefunctional Checklist is required to be filled out for each item of equipment or other assembly specified to be commissioned.
   1. No sampling of identical or near-identical items is allowed.
   2. These checklists do not replace manufacturers' recommended startup checklists, regardless of apparent redundancy.
   3. Prefunctional Checklist forms will not be complete until after award of the contract; the following types of information will be gathered via the completed Checklist forms:
      a. Certification by installing contractor that the unit is properly installed, started up, and operating and ready for Functional Testing.
      b. Confirmation of receipt of each shop drawing and commissioning submittal specified, itemized by unit.
      c. Manufacturer, model number, and relevant capacity information; list information "as specified," "as submitted," and "as installed."
      d. Serial number of installed unit.
      e. List of inspections to be conducted to document proper installation prior to startup and Functional Testing; these will be primarily static inspections and procedures; for equipment and systems may include normal manufacturer’s start-up checklist items and minor testing.
      f. Sensor and actuator calibration information.

B. The Commissioning Authority is responsible for filling out Prefunctional Checklists, after completion of installation and before startup.
   1. Each line item without deficiency is to be witnessed, initialed, and dated by the actual witness; checklists are not complete until all line items are initialed and dated complete without deficiencies.
   2. Checklists with incomplete items may be submitted for approval provided the Contractor attests that incomplete items do not preclude the performance of safe and reliable Functional Testing; re-submission of the Checklist is required upon completion of remaining items.
   3. Individual Checklists may contain line items that are the responsibility of more than one installer; Contractor shall assign responsibility to appropriate installers or subcontractors, with identification recorded on the form.
   4. If any Checklist line item is not relevant, record reasons on the form.
   5. Regardless of these reporting requirements, Contractor is responsible for correct startup and operation.

C. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.
   1. If difficulty in correction would delay progress, report deficiency to the owner immediately.

3.03 FUNCTIONAL PERFORMANCE TESTS

A. A Functional Performance Test is required for each item of equipment, system, or other assembly specified to be commissioned.

B. The General Contractor, Mechanical Contractor, Electrical Contractor, Plumbing Contractor and Commissioning Authority are responsible for execution of required Functional Tests, after completion of Prefunctional Checklist and before closeout.

C. Commissioning Authority is responsible for witnessing and reporting results of Functional Performance Tests, including preparation and completion of forms for that purpose.

D. The General Contractor, Mechanical Contractor, Plumbing Contractor,and Electrical Contractor are are responsible for correction of deficiencies and re-testing at no extra cost to Owner; if a deficiency is not corrected and re-tested immediately, the Commissioning Authority will document the deficiency and the Contractor's stated intentions regarding correction.
   1. Deficiencies are any condition in the installation or function of a component, piece of equipment or system that is not in compliance with Contract Documents or does not perform properly.

E. Functional Performance Test Procedures:
   1. Test procedures will be determined by the Commissioning Authority with input by and coordination with each Contractor.
   2. Examples of Functional Testing:
      a. Test the dynamic function and operation of equipment and systems (rather than just components) using manual (direct observation) or monitoring methods under full operation (e.g., the motor operated damper is tested interactively with the boiler functions to see if the dampers open upon a call from the respective boiler).
      b. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc.
      c. Systems are run through all the HVAC control system's sequences of operation and components are verified to be responding as the sequence's state.
      d. Traditional air or water test and balancing (TAB) is not Functional Testing; checking of TAB by demonstration to the Commissioning Authority is Functional Testing.

F. Deferred Functional Tests: Some tests may need to be performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions; performance of these tests remains the all the Commissioning Authority and respective Contractor's responsibility regardless of timing.

3.04 TEST PROCEDURES - GENERAL

A. The General Contractor, Mechanical Contractor, and Electrical Contractor will provide skilled technicians to execute starting of equipment and to execute the Functional Tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

B. Provide all necessary materials and system modifications required to produce the flows, pressures, temperatures, and conditions necessary to execute the test according to the specified conditions. At completion of the test, return all affected equipment and systems to their pre-test condition.

C. Manual Testing: Use hand-held instruments, immediate control system readouts, or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").

D. Simulating Conditions: Artificially create the necessary condition for the purpose of testing the response of a system; for example apply hot air to a space sensor using a hair dryer to see the response in an exhaust fan.

E. Simulating Signals: Disconnect the sensor and use a signal generator to send an amperage, resistance or pressure to the transducer and control system to simulate the sensor value.

F. Over-Writing Values: Change the sensor value known to the control system in the control system to see the response of the system; for example, change the outside air temperature value from 50 degrees F to 75 degrees F to verify economizer operation.

G. Indirect Indicators: Remote indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100 percent closed, are considered indirect indicators.

H. Monitoring: Record parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of the relevant control systems; where monitoring of specific points is called for in Functional Test Procedures:

END OF SECTION

SECTION 02 4100
DEMOLITION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Selective demolition of building elements for alteration purposes.

1.02 REFERENCE STANDARDS

A. 29 CFR 1926 - Safety and Health Regulations for Construction.

B. NFPA 241 - Standard for Safeguarding Construction, Alteration, and Demolition Operations.

PART 2 PRODUCTS -- NOT USED

PART 3 EXECUTION

3.01 SCOPE

A. Refer to Demolition Drawings.

B. Remove other items indicated, for salvage and relocation.

3.02 GENERAL PROCEDURES AND PROJECT CONDITIONS

A. Comply with applicable codes and regulations for demolition operations and safety of adjacent structures and the public.
   1. Obtain required permits.
   2. Comply with applicable requirements of NFPA 241.
   3. Take precautions to prevent catastrophic or uncontrolled collapse of structures to be removed; do not allow worker or public access within range of potential collapse of unstable structures.
   4. Provide, erect, and maintain temporary barriers and security devices.
   5. Use physical barriers to prevent access to areas that could be hazardous to workers or the public.
   6. Conduct operations to minimize effects on and interference with adjacent structures and occupants.
   7. Do not close or obstruct roadways or sidewalks without permit.
   8. Conduct operations to minimize obstruction of public and private entrances and exits; do not obstruct required exits at any time; protect persons using entrances and exits from removal operations.
   9. Obtain written permission from owners of adjacent properties when demolition equipment will traverse, infringe upon or limit access to their property.

B. Do not begin removal until receipt of notification to proceed from Owner.

C. Do not begin removal until built elements to be salvaged or relocated have been removed.

D. Protect existing structures and other elements that are not to be removed.
   1. Provide bracing and shoring.
   2. Prevent movement or settlement of adjacent structures.
   3. Stop work immediately if adjacent structures appear to be in danger.

E. Minimize production of dust due to demolition operations; do not use water if that will result in ice, flooding, sedimentation of public waterways or storm sewers, or other pollution.

F. If hazardous materials are discovered during removal operations, stop work and notify Design Professional and Owner; hazardous materials include regulated asbestos containing materials, lead, PCB's, and mercury.

G. Perform demolition in a manner that maximizes salvage and recycling of materials.
   1. Dismantle existing construction and separate materials.
   2. Set aside reusable, recyclable, and salvageable materials; store and deliver to collection point or point of reuse.

3.03 EXISTING UTILITIES

A. Coordinate work with utility companies; notify before starting work and comply with their requirements; obtain required permits.

B. Protect existing utilities to remain from damage.

C. Do not disrupt public utilities without permit from authority having jurisdiction.

D. Do not close, shut off, or disrupt existing life safety systems that are in use without at least 7 days prior written notification to Owner.

E. Do not close, shut off, or disrupt existing utility branches or take-offs that are in use without at least 3 days prior written notification to Owner.

F. Locate and mark utilities to remain; mark using highly visible tags or flags, with identification of utility type; protect from damage due to subsequent construction, using substantial barricades if necessary.

G. Remove exposed piping, valves, meters, equipment, supports, and foundations of disconnected and abandoned utilities.

3.04 SELECTIVE DEMOLITION FOR ALTERATIONS

A. Drawings showing existing construction and utilities are based on casual field observation and existing record documents only.
   1. Verify that construction and utility arrangements are as indicated.
   2. Report discrepancies to Design Professional before disturbing existing installation.
   3. Beginning of demolition work constitutes acceptance of existing conditions that would be apparent upon examination prior to starting demolition.

B. Separate areas in which demolition is being conducted from other areas that are still occupied.
   1. Provide, erect, and maintain temporary dustproof partitions of construction as required.

C. Maintain weatherproof exterior building enclosure except for interruptions required for replacement or modifications; take care to prevent water and humidity damage.

D. Remove existing work as indicated and as required to accomplish new work.
   1. Remove rotted wood, corroded metals, and deteriorated masonry and concrete; replace with new construction specified.
   2. Remove items indicated on drawings.

E. Services (Including but not limited to HVAC, Plumbing, and Electrical): Remove existing systems and equipment as indicated.
   1. Maintain existing active systems that are to remain in operation; maintain access to equipment and operational components.
   2. Where existing active systems serve occupied facilities but are to be replaced with new services, maintain existing systems in service until new systems are complete and ready for service.
   3. Verify that abandoned services serve only abandoned facilities before removal.
   4. Remove abandoned pipe, ducts, conduits, and equipment, including those above accessible ceilings; remove back to source of supply where possible, otherwise cap stub and tag with identification.

F. Protect existing work to remain.
   1. Prevent movement of structure; provide shoring and bracing if necessary.
   2. Perform cutting to accomplish removals neatly and as specified for cutting new work.
   3. Repair adjacent construction and finishes damaged during removal work.
   4. Patch as specified for patching new work.

3.05 DEBRIS AND WASTE REMOVAL

A. Remove debris, junk, and trash from site.

B. Leave site in clean condition, ready for subsequent work.

C. Clean up spillage and wind-blown debris from public and private lands.

END OF SECTION

SECTION 02 4119

SELECTIVE ELECTRICAL DEMOLITION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of material for demolition and salvaging existing electrical systems, wiring, raceways, supports, equipment, and minor repair of underlying structure.

B. Related Sections:
   1. Division 01 – General Requirements

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)

1.03 SUBMITTALS

A. Submit demolition plan.

1.04 COORDINATION AND SEQUENCING

A. Coordinate all power outages with Owner.

B. Perform demolition in a manner not to delay or interfere with other operations of work in the Project and operations of the Owner.

1.05 SCHEDULING

A. Schedule all work with the Owner through the Owner’s designated representative. Start no work in an area until a schedule has been prepared, submitted and approved.

B. Coordinate the work schedule with the Owner, Engineer, and other Contractors. Coordinate the work so not to interfere or conflict with the performance of work by the Owner and the Owner’s tenants.

1.06 PROJECT/SITE CONDITIONS

A. Care shall be used so as not to impede the ongoing operations of the Owner.

B. Demolition work, as specified herein, is not intended to be performed as a wrecking operation but as work relative to the performance of the various construction operations of the Project.

C. Existing Conditions:
   1. Demolition information shown or otherwise indicated on the Drawings is based on visual field examination and existing record documents. While the information provided is believed to be correct, no assurance is implied relative to its total completeness or accuracy. Report discrepancies to Construction Manager for disposition of the Engineer before disturbing existing installations.

2. The Contractor hereby distinctly agrees that neither the Construction Manager, the Engineer nor the Owner is responsible for the correctness or sufficiency of the information given and after his own Site Investigation:
   a. That he must have no claim for delay or extra compensation or damage on account of the information given; and
   b. That he must have no claim for relief from any obligation or responsibility under the Contract with respect to the above stated stipulations.

D. Protection: Exercise care during demolition work to confine demolition operations to the areas as indicated on the Drawings. The physical means and methods used for protection are at the Contractor's option. However, the Contractor will be completely responsible for replacement and restitution work, of whatever nature, at no expense to the Owner.
   1. Additionally, if public safety is endangered during the progress of the demolition work, provide adequate protective measures to protect the public and/or Owner personnel.
   2. Conform signs, signals and barricades to requirements of Federal, State and local laws, rules, regulations, precautions, orders and decrees.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Basic Electrical Materials: Those products such as conduit, raceway, wire and cable, support devices, fasteners, and control devices as required for work of this Section are specified in other Sections.

B. Equipment along with machinery and apparatus, motorized or otherwise, used to perform the demolition may be chosen at the Contractor's discretion. However, the chosen equipment shall perform the work within the limits of the Contract requirements.

C. Patching Materials: Patching materials shall match, as nearly as practical, the existing material for each surface being patched.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify that measurements and existing circuiting arrangements are as shown on Drawings.

B. Equipment, machinery and apparatus, motorized or otherwise, used to perform the demolition work may be used as chosen at the Contractor's discretion, but which will perform the work within the limits of the Contract requirements.

C. Verify that abandoned wiring and electrical equipment serve only the abandoned facility.

3.02 DEMOLITION

A. General: The means and methods of performing electrical demolition and removal operations are the sole responsibility of the Contractor, except as otherwise specified. However, equipment used, and methods of demolition and removal will be subject to approval of the Construction Manager and the Engineer.
   1. Remove, relocate and extend existing installations to accommodate new construction as indicated and/or as required.

2. Remove exposed abandoned conduit systems, including abandoned conduit systems above accessible ceiling systems.
3. Remove wiring in abandoned conduit systems to source of power supply.
4. Maintain access to existing electrical installations, which remain active. Modify installations and provide access panels or plates as appropriate.
5. Extend existing installations using materials and methods compatible with existing electrical installations, and as specified in other Sections of these Specifications.

B. System De-activation: Prior to demolition and removal work, de-activate existing electrical systems as indicated.

C. Use means and methods for permanent disconnection, which render the remaining electrical systems and apparatus in conformity with NFPA 70.

D. Provide temporary wiring and connections as required to maintain existing systems in service during construction. Remove same when no longer required.
1. Conform temporary wiring to the requirements of NEC Article 305, General Requirements.

E. Remove all wiring from disconnected circuits, feeders, and equipment unless otherwise specified or indicated. Remove all exposed raceways and related supports. Cut all exposed raceways flush with floor and plug.

F. Coordinate electrical power outages with requirements in Section 26 0500.

G. General: The means and methods of performing electrical demolition and removal operations are the sole responsibility of the Contractor except as otherwise specified. Use equipment and methods that do not damage items to remain or salvaged and areas adjacent to demolition operations. Use methods that do not interfere with Owner's operations and which do not cause excessive dust. Remove debris as it accumulates.

H. Cutting: Perform cutting work of existing structure materials by such methods as will prevent extensive damage beyond the immediate area of cutting.

I. Debris Removal: Dispose of demolition debris off site in a lawful manner. Containerize or otherwise store debris as work is in progress.

J. Patching: After demolition and removal work is performed patch the existing structure as required to match surrounding finish and appearance including the appropriate surface decoration.

K. Salvage: The Owner shall have the right to claim as salvage any items and materials removed under the work of this Section. Should such right of salvage be exercised by the Owner, move and neatly store removed items on the site in a location agreeable to the Owner and in a manner approved by the Engineer.

END OF SECTION 02 4119

SECTION 23 0519
METERS AND GAUGES FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pressure gauges and pressure gauge taps.

B. Thermometers and thermometer wells.

1.02 REFERENCE STANDARDS

A. ASME B40.100 - Pressure Gauges and Gauge Attachments.

B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers.

C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers.

D. UL 393 - Indicating Pressure Gauges for Fire-Protection Service.

1.03 SUBMITTALS

A. See General Conditions for submittal procedures.

B. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components.

C. Project Record Documents: Record actual locations of components and instrumentation.

D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Extra Pressure and Temperature Gages: One of each type and size.

1.04 FIELD CONDITIONS

A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 PRODUCTS

2.01 PRESSURE GAUGES

A. Manufacturers:
   1. Dwyer Instruments, Inc: www.dwyer-inst.com.
   2. Moeller Instrument Company, Inc: www.moellerinstrument.com.
   3. Omega Engineering, Inc: www.omega.com.
   4. H.O. Trerice Co.: www.trerice.com
   5. Or Equal

B. Pressure Gauges: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
   1. Case: Steel with brass bourdon tube.
   2. Size: 4-1/2 inch diameter.
   3. window: glass
   4. Mid-Scale Accuracy: One percent.
   5. Scale: Psi and KPa.

2.02 PRESSURE GAUGE TAPPINGS

A. Gauge Cock: Tee or lever handle, brass for maximum 150 psi.

B. Needle Valve: Brass, 1/4 inch NPT for minimum 150 psi.

C. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections.

2.03 STEM TYPE THERMOMETERS

A. Manufacturers:
   1. Dwyer Instruments, Inc: www.dwyer-inst.com.
   2. Omega Engineering, Inc: www.omega.com.
   3. Weksler Glass Thermometer Corp: www.wekslerglass.com.

4. H.O. Trerice Co.: www.trerice.com
5. Or Equal

B. Thermometers - Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
   1. Size: 9 inch scale.
   2. Window: Clear glass.
   3. Stem: 3/4 inch NPT brass.
   4. Accuracy: 2 percent, per ASTM E77.
   5. Calibration: Degrees F.

2.04 THERMOMETER SUPPORTS

A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.

2.05 TEST PLUGS

A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with Viton core for temperatures up to 400 degrees F.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge with isolation valves for each tap point.

C. Install pressure gauges with pulsation dampers. Provide gage cock to isolate each gauge. Extend nipples to allow clearance from insulation.

D. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.

E. Provide instruments with scale ranges selected according to service with largest appropriate scale.

F. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

G. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.

H. Locate test plugs adjacent thermometers and thermometer sockets and as indicated on drawings.

END OF SECTION

SECTION 23 0523
GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Applications.

B. General requirements.

C. Globe valves.

D. Ball valves.

E. Check valves.

1.02 REFERENCE STANDARDS

A. ASME B1.20.1 - Pipe Threads, General Purpose, Inch.

B. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

C. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.

D. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

E. ASME B31.9 - Building Services Piping.

F. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.

G. ASTM A48/A48M - Standard Specification for Gray Iron Castings.

H. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

I. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.

J. ASTM A536 - Standard Specification for Ductile Iron Castings.

K. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.

L. AWWA C606 - Grooved and Shouldered Joints.

M. MSS SP-67 - Butterfly Valves.

N. MSS SP-68 - High Pressure Butterfly Valves with Offset Design.

O. MSS SP-70 - Gray Iron Gate Valves, Flanged and Threaded Ends.

P. MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends.

Q. MSS SP-72 - Ball Valves with Flanged or Butt-Welding Ends for General Service.

R. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves.

S. MSS SP-85 - Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.

T. MSS SP-108 - Resilient-Seated Cast Iron Eccentric Plug Valves.

U. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

1.03 SUBMITTALS

A. General Conditions for submittal procedures

B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.

C. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

D. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

E. Maintenance Materials: Furnish Owner with one wrench for every five plug valves, in each size of square plug valve head.

1.04 QUALITY ASSURANCE

A. Manufacturer:
   1. Obtain valves for each valve type from single manufacturer.
   2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.

B. Welding Materials and Procedures: Comply with ASME BPVC-IX.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Minimize exposure of operable surfaces by setting plug and ball valves to open position.
   2. Protect valve parts exposed to piped medium against rust and corrosion.
   3. Protect valve piping connections such as grooves, weld ends, threads, and flange faces.
   4. Adjust globe, gate, and angle valves to the closed position to avoid clattering.
   5. Secure check valves in either the closed position or open position.
   6. Adjust butterfly valves to closed or partially closed position.

B. Use the following precautions during storage:
   1. Maintain valve end protection and protect flanges and specialties from dirt.
      a. Provide temporary inlet and outlet caps.
      b. Maintain caps in place until installation.
   2. Store valves in shipping containers and maintain in place until installation.
      a. Store valves indoors in dry environment.
      b. Store valves off the ground in watertight enclosures when indoor storage is not an option.

PART 2 PRODUCTS

2.01 APPLICATIONS

A. Provide the following valves for the applications if not indicated on drawings:
   1. Throttling (Hydronic): Ball and Globe.
   2. Throttling (Steam): Butterfly and Plug.
   3. Isolation (Shutoff): Butterfly, Gate, and Ball.
   4. Swing Check (Pump Outlet):
      a. 2 NPS and Smaller: Bronze with bronze disc.
      b. 2-1/2 NPS and Larger: Iron with lever and weight, lever and spring, center-guided metal, or center-guided with resilient seat.
   5. Dead-End: Butterfly, single-flange (lug) type.

B. Substitutions of valves with higher CWP classes or SWP ratings for same valve types are permitted when specified CWP ratings or SWP classes are not available.

C. Required Valve End Connections for Non-Wafer Types:
   1. Steel Pipe:
      a. 2 NPS and Smaller: Threaded ends.
      b. 2-1/2 NPS and Larger: Grooved ends.
   2. Copper Tube:
      a. 2 NPS and Smaller: Threaded ends (Exception: Solder-joint valve-ends).
      b. 2-1/2 NPS and Larger: Grooved ends.

D. Heating Hot Water Valves:
   1. 2 NPS and Smaller, Brass and Bronze Valves:
      a. Threaded ends.
      b. Angle: Bronze disc, Class 125.
      c. Ball: Full port, one piece, brass trim.
      d. Swing Check: Bronze disc, Class 125.

e. Globe: Bronze disc, Class 125.

2. 2-1/2 NPS and Larger, Iron Valves:
   a. 2-1/2 NPS to 4 NPS: Threaded ends.
   b. Ball: 2-1/2 NPS to 10 NPS, Class 150.
   c. Swing Check: Metal seats, Class 125.
   d. Swing Check: 2-1/2 NPS to 12 NPS, lever and spring closure control, Class 125.
   e. Grooved-End Swing Check: 3 NPS to 12 NPS, 300 CWP.
   f. Center-Guided Check: Compact-wafer, metal seat, Class 125.
   g. Plate-Type Check: Single plate, metal seat, Class 125 .

2.02 GENERAL REQUIREMENTS

A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.

B. Valve Sizes: Match upstream piping unless otherwise indicated.

C. Valve Actuator Types:
   1. Gear Actuator: Quarter-turn valves 8 NPS and larger.
   2. Handwheel: Valves other than quarter-turn types.
   3. Hand Lever: Quarter-turn valves 6 NPS and smaller.

D. Valves in Insulated Piping: Provide 2 NPS stem extensions and the following features:
   1. Gate Valves: Rising stem.
   2. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
   3. Butterfly Valves: Extended neck.
   4. Memory Stops: Fully adjustable after insulation is installed.

E. Memory Stops: Fully adjustable after insulation is installed.

F. Valve-End Connections:
   1. Threaded End Valves: ASME B1.20.1.
   2. Flanges on Iron Valves: ASME B16.1 for flanges on iron valves.
   3. Pipe Flanges and Flanged Fittings 1/2 NPS through 24 NPS: ASME B16.5.
   4. Solder Joint Connections: ASME B16.18.
   5. Grooved End Connections: AWWA C606.

G. General ASME Compliance:
   1. Building Services Piping Valves: ASME B31.9.

H. Bronze Valves:
   1. Fabricate from dezincification resistant material.
   2. Copper alloys containing more than 15 percent zinc are not permitted.

2.03 MANUFACTURERS

A. Apollo

B. Crane Company

C. Nibco

D. Or Equal

2.04 BRONZE GLOBE VALVES

A. Class 125: CWP Rating: 200 psig:.
   1. Comply with MSS SP-80, Type 1.
   2. Body: Bronze; ASTM B62, with integral seat and screw in bonnet.
   3. Ends: Threaded or solder joint.
   4. Stem and Disc: Bronze or PTFE.
   5. Packing: Asbestos free.
      a. Handwheel: Malleable iron.

2.05 IRON GLOBE VALVES

A. Class 125: CWP Rating: 200 psig:.
   1. Comply with MSS SP-85, Type I.
   2. Body: Gray iron; ASTM A126, with bolted bonnet.
   3. Ends: Flanged.
   4. Trim: Bronze.
   5. Packing and Gasket: Asbestos free.
   6. Operator: Handwheel or chainwheel.

2.06 BRASS BALL VALVES

A. Two Piece, Full Port and Standard Port with Brass Trim:
   1. Comply with MSS SP-110.
   2. CWP Rating: 600 psig.
   3. Body: Forged brass.
   4. Ends: Threaded.
   5. Seats: PTFE or TFE.
   6. Ball: Chrome-plated brass.

2.07 BRONZE BALL VALVES

A. Two Piece, Standard Port and Full Port with Bronze or Brass Trim:
   1. CWP Rating: 600 psig.
   2. Body: Bronze.
   3. Ends: Threaded.
   4. Seats: PTFE .
   5. Stem: Bronze or brass.
   6. Ball: Chrome plated brass.

2.08 IRON BALL VALVES

A. Split Body, Full Port:
   1. Comply with MSS SP-72.
   2. CWP Rating: 200 psig.
   3. Body: ASTM A126, gray iron.
   4. Ends: Flanged.
   5. Seats: PTFE.
   6. Stem: Stainless steel.
   7. Ball: Stainless steel.

2.09 BRONZE SWING CHECK VALVES

A. Class 125: CWP Rating: 200 psig (1380 kPa).
   1. Comply with MSS SP-80, Type 3.
   2. Body Design: Horizontal flow.
   3. Body Material: Bronze, ASTM B62.
   4. Ends: Threaded.
   5. Disc: Bronze.

PART 3 EXECUTION

3.01 EXAMINATION

A. Discard all packing materials and verify that valve interior, including threads and flanges, are completely clean without signs of damage or degradation that could result in leakage.

B. Verify valve parts to be fully operational in all positions from closed to fully open.

C. Confirm gasket material to be suitable for the service, to be of correct size, and without defects that could compromise effectiveness.

D. Should valve is determined to be defective, replace with new valve.

3.02 INSTALLATION

A. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.

B. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.

C. Where valve support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welds.

D. Install check valves where necessary to maintain direction of flow as follows:
   1. Swing Check: Install horizontal maintaining hinge pin level.
   2. Orient plate-type and center-guided into horizontal or vertical position, between flanges.

E. Provide chainwheels on operators for valves 4 NPS and larger where located 96 NPS or more above finished floor, terminating 60 NPS above finished floor.

END OF SECTION

SECTION 23 0529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Support and attachment components for equipment, piping, and other HVAC/hydronic work.

1.02 RELATED REQUIREMENTS

A. Section 03 3000 - Cast-in-Place Concrete: Concrete equipment pads.

B. Section 05 5000 - Metal Fabrications: Materials and requirements for fabricated metal supports.

1.03 REFERENCE STANDARDS

A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

C. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.

D. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings.

E. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.

F. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

G. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.

H. MFMA-4 - Metal Framing Standards Publication.

I. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

J. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
   2. Coordinate the work with other trades to provide additional framing and materials required for installation.
   3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
   4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
   5. Notify Design Professional of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

A. See General Conditions for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, nonpenetrating rooftop supports, post-installed concrete and masonry anchors, and thermal insulated pipe supports.

C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.
   1. Application of protective inserts, saddles, and shields at pipe hangers for each type of insulation and hanger.

D. Evaluation Reports: For products specified as requiring evaluation and recognition by ICC Evaluation Service, LLC (ICC-ES), provide current ICC-ES evaluation reports upon request.

E. Installer's Qualifications: Include evidence of compliance with specified requirements.

F. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.06 QUALITY ASSURANCE

A. Comply with applicable building code.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Installer Qualifications for Powder-Actuated Fasteners (when specified): Certified by fastener system manufacturer with current operator's license.

D. Installer Qualifications for Field-Welding: As specified in Section 05 5000.

E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:
   1. Comply with MSS SP-58.
   2. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
   3. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
   4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
   5. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
   6. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
      a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
      b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
      c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
      d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
   1. Manufacturers:
      a. Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com/#sle.
      b. Thomas & Betts Corporation: www.tnb.com/#sle.
      c. Unistrut, a brand of Atkore International Inc: www.unistrut.com/#sle.
      d. Or Equal
      e. Source Limitations: Furnish channels (struts) and associated fittings, accessories, and hardware produced by a single manufacturer.
   2. Provide factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.

3. Comply with MFMA-4.
4. Channel Material:
   a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
   b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
5. Minimum Channel Thickness: Steel sheet, 12 gage, 0.1046 inch.
6. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.

C. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
   1. Minimum Size, Unless Otherwise Indicated or Required:
      a. Equipment Supports: 1/2 inch diameter.
      b. Piping up to 1 inch (27 mm) nominal: 1/4 inch diameter.
      c. Piping larger than 1 inch (27 mm) nominal: 3/8 inch diameter.
      d. Trapeze Support for Multiple Pipes: 3/8 inch diameter.

D. Thermal Insulated Pipe Supports:
   1. General Construction and Requirements:
      a. Insulated pipe supports to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
      b. Surface Burning Characteristics: Flame spread index/smoke developed index of 5/30, maximum, when tested in accordance with ASTM E84 or UL 723.
      c. Pipe supports to be provided for nominally sized, 1/2 inch to 30 inch iron pipes.
      d. Insulation inserts to consist of rigid polyisocyanurate (urethane) insulation surrounded by a 360 degree, PVC jacketing.
   2. PVC Jacket:
      a. Pipe insulation protection shields to be provided with a ball bearing hinge and locking seam.
      b. Moisture Vapor Transmission: 0.0071 perm inch, when tested in accordance with ASTM E96/E96M.
      c. Thickness: 60 mil.
   3. Pipe insulation protection shields to be provided at the hanger points and guide locations on pipes requiring insulation as indicated on drawings.

E. Pipe Supports:
   1. Liquid Temperatures Up To 122 degrees F:
      a. Overhead Support: MSS SP-58 Types 1, 3 through 12.
      b. Support From Below: MSS SP-58 Types 35 through 38.
   2. Operating Temperatures from 122 to 446 degrees F:
      a. Overhead Support: MSS SP-58 Type 1 or 3 through 12, with appropriate saddle of MSS SP-58 Type 40 for insulated pipe.
      b. Roller Support: MSS SP-58 Types 41 or 43 through 46, with appropriate saddle of MSS SP-58 Type 39 for insulated pipe.

F. Pipe Stanchions: For pipe runs, use stanchions of same type and material where vertical adjustment is required for stationary pipe.
   1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
   2. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.

G. Pipe Alignment Guides: Galvanized steel.
   1. Pipe Diameter 8 inches and Smaller: Spider or sleeve type.
   2. Pipe Diameter 10 inches and Larger: Roller type.

H. Pipe Shields for Insulated Piping:
   1. General Construction and Requirements:
      a. Surface Burning Characteristics: Comply with ASTM E84 or UL 723.
      b. Shields Material: UV-resistant polypropylene with glass fill.
      c. Maximum Insulated Pipe Outer Diameter: 12-5/8 inch.
      d. Minimum Service Temperature: Minus 40 degrees F.
      e. Maximum Service Temperature: 178 degrees F.

f. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.

I. Anchors and Fasteners:
1. Manufacturers - Mechanical Anchors:
a. Hilti, Inc: www.us.hilti.com/#sle.
b. ITW Red Head, a division of Illinois Tool Works, Inc: www.itwredhead.com/#sle.
c. Powers Fasteners, Inc: www.powers.com/#sle.
d. Simpson Strong-Tie Company Inc: www.strongtie.com/#sle.
2. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
3. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
4. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
5. Hollow Masonry: Use toggle bolts.
6. Hollow Stud Walls: Use toggle bolts.
7. Steel: Use beam clamps, machine bolts, or welded threaded studs.
8. Sheet Metal: Use sheet metal screws.
9. Wood: Use wood screws.
10. Plastic and lead anchors are not permitted.
11. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
a. Comply with MFMA-4.
b. Channel Material: Use galvanized steel.
c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive support and attachment components.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

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

B. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.

C. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.

D. Unless specifically indicated or approved by Design Professional, do not provide support from suspended ceiling support system or ceiling grid.

E. Unless specifically indicated or approved by Design Professional, do not provide support from roof deck.

F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.

G. Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.

H. Equipment Support and Attachment:
1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.

4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 4 inch high concrete pad constructed in accordance with Section 03 3000.
5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.

I. Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.

J. Secure fasteners according to manufacturer's recommended torque settings.

K. Remove temporary supports.

3.03 FIELD QUALITY CONTROL

A. Inspect support and attachment components for damage and defects.

B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

C. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 23 0553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Adhesive-backed duct markers.

D. Pipe markers.

E. Ceiling tacks.

1.02 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems.

B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials.

1.03 SUBMITTALS

A. See General Conditions for submittal procedures.

B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.

C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

D. Product Data: Provide manufacturers catalog literature for each product required.

E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

F. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

A. Air Handling Units: Nameplates.

B. Automatic Controls: Tags. Key to control schematic.

C. Control Panels: Nameplates.

D. Ductwork: Adhesive Duct Markers.

E. Heat Transfer Equipment: Nameplates.

F. Instrumentation: Tags.

G. Major Control Components: Nameplates.

H. Piping: Pipe markers.

I. Pumps: Nameplates.

J. Relays: Tags.

K. Small-sized Equipment: Tags.

L. Tanks: Nameplates.

M. Thermostats: Nameplates.

N. Valves: Tags.

O. Water Treatment Devices: Nameplates.

2.02 NAMEPLATES

A. Manufacturers:
   1. Advanced Graphic Engraving, LLC: www.advancedgraphicengraving.com.
   2. Brimar Industries, Inc: www.pipemarker.com/#sle.
   3. Craftmark Pipe Markers: www.craftmarkid.com/#sle.
   4. Kolbi Pipe Marker Co: www.kolbipipemarkers.com.

5. Seton Identification Products, a Tricor Direct Company: www.seton.com.
6. Or Equal

B. Letter Color: White.

C. Letter Height: 1/4 inch.

D. Background Color: Black.

E. Plastic: Comply with ASTM D709.

2.03 TAGS

A. Manufacturers:
1. Advanced Graphic Engraving: www.advancedgraphicengraving.com.
2. Brady Corporation: www.bradycorp.com.
3. Brimar Industries, Inc: www.pipemarker.com/#sle.
4. Kolbi Pipe Marker Co: www.kolbipipemarkers.com.
5. Seton Identification Products, a Tricor Company: www.seton.com.
6. Or Equal

B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.

C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

D. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.04 ADHESIVE-BACKED DUCT MARKERS

A. Manufacturers:
1. Brimar Industries, Inc: www.pipemarker.com/#sle.
2. Craftmark Pipe Markers: www.craftmarkid.com/#sle.
3. Kolbi Pipe Marker Co: www.kolbipipemarkers.com.
4. Seton Identification Products, a Tricor Company: www.seton.com.
5. Or Equal

B. Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch; printed with UV and chemical resistant inks.

C. Style: Individual Label.

D. Color: Yellow/Black.

2.05 PIPE MARKERS

A. Manufacturers:
1. Brady Corporation: www.bradycorp.com.
2. Brimar Industries, Inc: www.pipemarker.com/#sle.
3. Craftmark Pipe Markers: www.craftmarkid.com/#sle.
4. Kolbi Pipe Marker Co: www.kolbipipemarkers.com.
5. MIFAB, Inc: www.mifab.com.
6. Seton Identification Products, a Tricor Company: www.seton.com.
7. Or Equal

B. Color: Comply with ASME A13.1.

C. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

E. Color code as follows:
1. Heating and Cooling,r: Green with white letters.

2.06 CEILING TACKS

A. Description: Steel with 3/4 inch diameter color coded head.

PART 3 EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.02 INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Install plastic pipe markers in accordance with manufacturer's instructions.

D. Use tags on piping 3/4 inch diameter and smaller.
   1. Identify service, flow direction, and pressure.
   2. Install in clear view and align with axis of piping.
   3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

E. Install ductwork with plastic nameplates. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

F. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

SECTION 23 0593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.

B. Testing, adjustment, and balancing of hydronic and refrigerating systems.

C. Commissioning activities.

1.02 RELATED REQUIREMENTS

A. Section 01 9113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.

B. Section 23 0800 - Commissioning of HVAC.

1.03 REFERENCE STANDARDS

A. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.

B. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing.

1.04 SUBMITTALS

A. See General Conditions for submittal procedures.

B. Installer Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.

C. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
   1. Submit to Design Professional.
   2. Submit to the Commissioning Authority.
   3. Submit six weeks prior to starting the testing, adjusting, and balancing work.
   4. Include certification that the plan developer has reviewed Contract Documents, the equipment and systems, and the control system with the Design Professional and other installers to sufficiently understand the design intent for each system.
   5. Include at least the following in the plan:
      a. Preface: An explanation of the intended use of the control system.
      b. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
      c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
      d. Identification and types of measurement instruments to be used and their most recent calibration date.
      e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
      f. Final test report forms to be used.
      g. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.
      h. Procedures for formal deficiency reports, including scope, frequency and distribution.

D. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.

E. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
   1. Submit to the the Commissioning Authority within two weeks after completion of testing, adjusting, and balancing.
   2. Revise TAB plan to reflect actual procedures and submit as part of final report.

3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Design Professional and for inclusion in operating and maintenance manuals.
4. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
5. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
6. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
7. Units of Measure: Report data in I-P (inch-pound) units only.
8. Include the following on the title page of each report:
    a. Name of Testing, Adjusting, and Balancing Agency.
    b. Address of Testing, Adjusting, and Balancing Agency.
    c. Telephone number of Testing, Adjusting, and Balancing Agency.
    d. Project name.
    e. Project location.
    f. Project Engineer.
    g. Project Contractor.
    h. Report date.

F. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

G. All submittals shall include but is not limited to the following:
1. All balancing, commissioning and/or start up reports must include the actual room number.
2. All new ventilation equipment must be started up as soon as possible after it is installed.
3. A balancing report is required as soon as a new piece of ventilation equipment is installed and start up completed.
4. All balancing reports shall show the design outside air in CFMs and the actual outside air in CFMs as measured by the balancing sub-contractor. If the actual does not meet the design, the unit needs to be adjusted and a revised report issued.
5. Provide the owner a copy of the balancing report as soon as possible when it is available.
6. All final balancing, commissioning and start-up reports still need to be submitted to the AOR/EOR for review for each project. Copies of the final reports shall be included in the close out documents for each project.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:
1. SMACNA (TAB).

B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

C. TAB Agency Qualifications:
1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
2. Having minimum of three years documented experience.
3. Certified by one of the following:
    a. AABC, Associated Air Balance Council: www.aabc.com/#sle; upon completion submit AABC National Performance Guaranty.
    b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
    c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org/#sle.

D. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.02 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   1. Systems are started and operating in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Proper thermal overload protection is in place for electrical equipment.
   4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
   5. Duct systems are clean of debris.
   6. Fans are rotating correctly.
   7. Fire and volume dampers are in place and open.
   8. Air coil fins are cleaned and combed.
   9. Access doors are closed and duct end caps are in place.
   10. Air outlets are installed and connected.
   11. Duct system leakage is minimized.
   12. Hydronic systems are flushed, filled, and vented.
   13. Pumps are rotating correctly.
   14. Proper strainer baskets are clean and in place.
   15. Service and balance valves are open.
   16. Record Nameplate Data of Systems withing scope

B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.

C. Beginning of work means acceptance of existing conditions.

3.03 PREPARATION

A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
   1. Require attendance by all installers whose work will be tested, adjusted, or balanced.

B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Design Professional to facilitate spot checks during testing.

C. Provide additional balancing devices as required.

3.04 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Adjust to within zero to plus 10 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

C. Hydronic Systems: Adjust to within plus or minus 5 percent of design.

3.05 RECORDING AND ADJUSTING

A. Field Logs: Maintain written logs including:
   1. Running log of events and issues.
   2. Discrepancies, deficient or uncompleted work by others.
   3. Contract interpretation requests.
   4. Lists of completed tests.

B. Ensure recorded data represents actual measured or observed conditions.

C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

H. Check and adjust systems approximately six months after final acceptance and submit report.

3.06 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities.

B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

L. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

M. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

3.07 WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or design quantities.

B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.

C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

D. Effect system balance with automatic control valves fully open to heat transfer elements.

E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.08 COMMISSIONING

A. See Sections 01 9113 - General Commissioning Requirements and 23 0800 for additional requirements.

B. Perform prerequisites prior to starting commissioning activities.

C. Fill out Prefunctional Checklists for:
   1. Air side systems.
   2. Water side systems.

D. Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.

E. Re-check a random sample equivalent up to 10 percent of the final TAB report data as directed by Commissioning Authority.
   1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
   2. Use the same test instruments as used in the original TAB work.
   3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
   4. For purposes of re-check, failure is defined as follows:
      a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
      b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
      c. Temperatures: Deviation of more than one degree F.
      d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
      e. Sound Pressures: Deviation of more than 3 decibels, with consideration for variations in background noise.
   5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.

F. In the presence of the Commissioning Authority, verify that:
   1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
   2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.
   3. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.

3.09 SCOPE

A. Test, adjust, and balance the following: all mechanical equipment shown on the contract documents including but not limited to
   1. Unit Heaters.
   2. Cabinet Unit Heaters.
   3. Unit Ventilators.
   4. Air Handling Units.

5. Boiler Pumps.
6. Hot Water Boilers
7. Fans.
8. Air Terminal Units.
9. Air Inlets and Outlets.

3.10 MINIMUM DATA TO BE REPORTED

A. Electric Motors:
1. Manufacturer.
2. Model/Frame.
3. HP/BHP.
4. Phase, voltage, amperage; nameplate, actual, no load.
5. RPM.
6. Service factor.
7. Starter size, rating, heater elements.
8. Sheave Make/Size/Bore.

B. V-Belt Drives:
1. Identification/location.
2. Required driven RPM.
3. Driven sheave, diameter and RPM.
4. Belt, size and quantity.
5. Motor sheave diameter and RPM.
6. Center to center distance, maximum, minimum, and actual.

C. Pumps (e.g. HVAC):
1. Identification/number.
2. Manufacturer.
3. Size/model.
4. Impeller.
5. Service.
6. Design flow rate, pressure drop, BHP.
7. Actual flow rate, pressure drop, BHP.
8. Discharge pressure.
9. Suction pressure.
10. Total operating head pressure.
11. Shut off, discharge and suction pressures.
12. Shut off, total head pressure.

D. Cooling Coils:
1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Air flow, design and actual.
6. Entering air DB temperature, design and actual.
7. Entering air WB temperature, design and actual.
8. Leaving air DB temperature, design and actual.
9. Leaving air WB temperature, design and actual.
10. Water flow, design and actual.
11. Water pressure drop, design and actual.
12. Entering water temperature, design and actual.
13. Leaving water temperature, design and actual.
14. Saturated suction temperature, design and actual.
15. Air pressure drop, design and actual.

E. Heating Coils:

1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Air flow, design and actual.
6. Water flow, design and actual.
7. Water pressure drop, design and actual.
8. Entering water temperature, design and actual.
9. Leaving water temperature, design and actual.
10. Entering air temperature, design and actual.
11. Leaving air temperature, design and actual.
12. Air pressure drop, design and actual.

F. Air Moving Equipment:
1. Location.
2. Manufacturer.
3. Model number.
4. Serial number.
5. Arrangement/Class/Discharge.
6. Air flow, specified and actual.
7. Return air flow, specified and actual.
8. Outside air flow, specified and actual.
9. Total static pressure (total external), specified and actual.
10. Inlet pressure.
11. Discharge pressure.
12. Sheave Make/Size/Bore.
13. Number of Belts/Make/Size.
14. Fan RPM.

G. Return Air/Outside Air:
1. Identification/location.
2. Design air flow.
3. Actual air flow.
4. Design return air flow.
5. Actual return air flow.
6. Design outside air flow.
7. Actual outside air flow.
8. Return air temperature.
9. Outside air temperature.
10. Required mixed air temperature.
11. Actual mixed air temperature.
12. Design outside/return air ratio.
13. Actual outside/return air ratio.

H. Exhaust Fans:
1. Location.
2. Manufacturer.
3. Model number.
4. Serial number.
5. Air flow, specified and actual.
6. Total static pressure (total external), specified and actual.
7. Inlet pressure.
8. Discharge pressure.
9. Sheave Make/Size/Bore.
10. Number of Belts/Make/Size.
11. Fan RPM.

I. Duct Traverses:
   1. System zone/branch.
   2. Duct size.
   3. Area.
   4. Design velocity.
   5. Design air flow.
   6. Test velocity.
   7. Test air flow.
   8. Duct static pressure.
   9. Air temperature.
   10. Air correction factor.

END OF SECTION

SECTION 23 0713
DUCT INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Duct insulation.

1.02 REFERENCE STANDARDS

A. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

B. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

D. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.

E. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.03 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

C. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.05 FIELD CONDITIONS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER, FLEXIBLE

A. Manufacturer:
   1. Johns Manville: www.jm.com/#sle.
   2. JP Lamborn Co; Thermal Sleeve MT: www.jpflex.com/#sle.
   3. Knauf Insulation; Atmosphere Duct Wrap: www.knaufinsulation.com/#sle.
   4. Owens Corning Corporation: www.ocbuildingspec.com/#sle.
   5. CertainTeed Corporation: www.certainteed.com/#sle.

B. Insulation: ASTM C553; flexible, noncombustible blanket.
   1. K value: 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
   2. Maximum Service Temperature: 1200 degrees F.
   3. Maximum Water Vapor Absorption: 5.0 percent by weight.
   4. minimum installed R value: 8

C. Vapor Barrier Jacket:

1. Kraft paper with glass fiber yarn and bonded to aluminized film.
2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
3. Secure with pressure sensitive tape.

D. Vapor Barrier Tape:
1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

E. Indoor Vapor Barrier Mastic:
1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.03 SCHEDULES

A. insulate supply and return ducts with 2" thick foil faced fiberglass insulation

B. insulate the first 20' of exhaust ductwork with 2" thick foil faced fiberglass insulation

END OF SECTION

SECTION 23 0719
HVAC PIPING INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Piping insulation.

B. Flexible removable and reusable blanket insulation.

C. Jackets and accessories.

1.02 REFERENCE STANDARDS

A. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

B. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).

C. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

D. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.

E. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.

F. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.

G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

H. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.

I. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.03 SUBMITTALS

A. See General Conditions for submittal procedures.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.06 FIELD CONDITIONS

A. Maintain ambient conditions required by manufacturers of each product.

B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER, RIGID

A. Manufacturers:
   1. CertainTeed Corporation: www.certainteed.com/#sle.
   2. Johns Manville Corporation: www.jm.com/#sle.
   3. Knauf Insulation; Earthwool 1000 Degree Pipe Insulation: www.knaufinsulation.com/#sle.

4. Owens Corning Corporation; Fiberglas Pipe Insulation ASJ: www.ocbuildingspec.com/#sle.
5. Owens Corning Corporation; VaporWick Pipe Insulation: www.ocbuildingspec.com/#sle.

B. Insulation: ASTM C547 and ASTM C795; semi-rigid, noncombustible, end grain adhered to jacket.
1. K Value: ASTM C177, 0.24 at 75 degrees F.
2. Maximum Service Temperature: 650 degrees F.
3. Maximum Moisture Absorption: 0.2 percent by volume.

C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.

D. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.

E. Vapor Barrier Lap Adhesive: Compatible with insulation.

F. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

G. Fibrous Glass Fabric:
1. Cloth: Untreated; 9 oz/sq yd weight.
2. Blanket: 1.0 lb/cu ft density.
3. Weave: 5 by 5.

2.03 JACKETS

A. PVC Plastic.
1. Manufacturers:
a. Johns Manville Corporation: www.jm.com.
b. Proto.
c. Speedline PVC.
d. Or Equal.
2. Jacket: One piece molded type fitting covers and sheet material, off-white color.
a. Minimum Service Temperature: 0 degrees F.
b. Maximum Service Temperature: 150 degrees F.
c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
d. Thickness: 10 mil.
e. Connections: Brush on welding adhesive.
3. Covering Adhesive Mastic: Compatible with insulation.

PART 3 EXECUTION

3.01 EXAMINATION

A. Test piping for design pressure, liquid tightness, and continuity prior to applying insulation materials.

B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Exposed Piping: Locate insulation and cover seams in least visible locations.

C. Insulated Pipes Conveying Fluids Below Ambient Temperature:
1. Insulate entire system, including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

D. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

E. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.

F. Glass Fiber Insulated Pipes Conveying Fluids Above Ambient Temperature:

1. Provide standard jackets, with or without vapor barrier, factory-applied, or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples.
2. provide aluminum jackets where installed less than 10' below finished floor.
3. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.

G. Inserts and Shields:
1. Application: Piping 1-1/2 inches diameter or larger.
2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
3. Insert location: Between support shield and piping and under the finish jacket.
4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

H. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with aluminum jacket.

END OF SECTION

SECTION 23 0800
COMMISSIONING OF HVAC

PART 1 GENERAL

1.01 SUMMARY

A. This section covers the Contractors' responsibilities for HVAC commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.

B. The Commissioning Authority (CA) directs and coordinates all commissioning activities and provides Prefunctional Checklists and Functional Test Procedures for Contractor's use.

C. The mechanical equipment and instruments installed within the scope of this project are to be commissioned. Refer to Division 01 for the Commissioning Authority's Responsibilities.

D. The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

1.02 REFERENCE STANDARDS

A. ASHRAE Guideline 1.1 - HVAC&R Technical Requirements for the Commissioning Process.

1.03 SUBMITTALS

A. Refer to General Conditions and Supplementary Conditions for Submittal Requirements.

B. Updated Submittals: Keep the Commissioning Authority informed of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.

C. DRAFT Prefunctional Checklists and Functional Test Procedures for Control System: Detailed written plan indicating the procedures to be followed to test, checkout and adjust the control system prior to full system Functional Testing; include at least the following for each type of equipment controlled:
   1. System name.
   2. List of devices.
   3. Step-by-step procedures for testing each controller after installation, including:
      a. Process of verifying proper hardware and wiring installation.
      b. Process of downloading programs to local controllers and verifying that they are addressed correctly.
      c. Process of performing operational checks of each controlled component.
      d. Plan and process for calibrating valve and damper actuators and all sensors.
      e. Description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
   4. Copy of proposed log and field checkout sheets to be used to document the process; include space for initial and final read values during calibration of each point and space to specifically indicate when a sensor or controller has “passed” and is operating within the contract parameters.
   5. Description of the instrumentation required for testing.
   6. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the Commissioning Authority and TAB contractor for this determination.

D. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Authority.

E. HVAC Control System O&M Manual Requirements. In addition to documentation specified elsewhere, compile and organize at minimum the following data on the control system:
   1. Specific step-by-step instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. Provide an index and clear table of contents. Include the detailed technical manual for programming and customizing control loops and algorithms.

2. Full as-built set of control drawings.
3. Full as-built sequence of operations for each piece of equipment.
4. Full points list; in addition to the information on the original points list submittal, include a listing of all rooms with the following information for each room:
    a. Floor.
    b. Room number.
    c. Room name.
    d. Air handler unit ID.
    e. Reference drawing number.
    f. Air terminal unit tag ID.
    g. Heating and/or cooling valve tag ID.
    h. Minimum air flow rate.
    i. Maximum air flow rate.
5. Full print out of all schedules and set points after testing and acceptance of the system.
6. Full as-built print out of software program.
7. Electronic copy on disk of the entire program for this facility.
8. Marking of all system sensors and thermostats on the as-built floor plan and HVAC drawings with their control system designations.
9. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
10. Control equipment component submittals, parts lists, etc.
11. Warranty requirements.
12. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
13. Organize and subdivide the manual with permanently labeled tabs for each of the following data in the given order:
    a. Sequences of operation.
    b. Control drawings.
    c. Points lists.
    d. Controller and/or module data.
    e. Thermostats and timers.
    f. Sensors and DP switches.
    g. Valves and valve actuators.
    h. Dampers and damper actuators.
    i. Program setups (software program printouts).

F. Project Record Documents:
1. Submit updated version of control system documentation, for inclusion with operation and maintenance data.
2. Show actual locations of all static and differential pressure sensors (air, water and building pressure) and air-flow stations on project record drawings.

G. Draft Training Plan:
1. Follow the recommendations of ASHRAE Guideline 1.1.
2. Control system manufacturer's recommended training.
3. Demonstration and instruction on function and overrides of any local packaged controls not controlled by the HVAC control system.

H. Training Manuals:
1. Provide three extra copies of the controls training manuals in a separate manual from the O&M manuals.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

A. Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing; unless otherwise noted such testing equipment will NOT become the property of Owner.

B. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

PART 3 EXECUTION

3.01 PREPARATION

A. Cooperate with the Commissioning Authority in development of the Prefunctional Checklists and Functional Test Procedures.

B. Furnish additional information requested by the Commissioning Authority.

C. Prepare a preliminary schedule for HVAC pipe and duct system testing, flushing and cleaning, equipment start-up and testing, adjusting, and balancing start and completion for use by the Commissioning Authority; update the schedule as appropriate.

D. Notify the Commissioning Authority when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and testing, adjusting, and balancing will occur; when commissioning activities not yet performed or not yet scheduled will delay construction notify ahead of time and be proactive in seeing that the Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.

E. Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning, as required.

F. Provide test holes in ducts and plenums where directed to allow air measurements and air balancing; close with an approved plug.

G. Provide temperature and pressure taps in accordance with Contract Documents.

3.02 INSPECTING AND TESTING - GENERAL

A. Submit startup plans, startup reports, and Prefunctional Checklists for each item of equipment or other assembly to be commissioned.

B. Perform the Functional Tests directed by the Commissioning Authority for each item of equipment or other assembly to be commissioned.

C. Provide two-way radios for use during the testing.

D. Valve/Damper Stroke Setup and Check:
   1. For all valve/damper actuator positions checked, verify the actual position against the control system readout.
   2. Set pump/fan to normal operating mode.
   3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.
   4. Command valve/damper to a few intermediate positions.

E. Isolation Valve or System Valve Leak Check: For valves not by coils.
   1. With full pressure in the system, command valve closed.
   2. Use an ultra-sonic flow meter to detect flow or leakage.

F. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

3.03 TAB COORDINATION

A. TAB: Testing, adjusting, and balancing of HVAC.

B. Coordinate commissioning schedule with TAB schedule.

C. Review the TAB plan to determine the capabilities of the control system toward completing TAB.

D. Provide all necessary unique instruments and instruct the TAB technicians in their use; such as handheld control system interface for setting terminal unit boxes, etc.

E. Have all required Prefunctional Checklists, calibrations, startup and component Functional Tests of the system completed and approved by the Commissioning Authority prior to starting TAB.

F. Provide a qualified control system technician to operate the controls to assist the TAB technicians or provide sufficient training for the TAB technicians to operate the system without assistance.

3.04 CONTROL SYSTEM FUNCTIONAL TESTING

A. Prefunctional Checklists for control system components will require a signed and dated certification that all system programming is complete as required to accomplish the requirements of Contract Documents and the detailed Sequences of Operation documentation submittal.

B. Do not start Functional Testing until all controlled components have themselves been successfully Functionally Tested in accordance with Contract Documents.

C. Using a skilled technician who is familiar with this building, execute the Functional Testing of the control system as required by the Commissioning Authority.

D. Functional Testing of the control system constitutes demonstration and trend logging of control points monitored by the control system.
   1. The scope of trend logging is partially specified; trend log up to 50 percent more points than specified at no extra cost to Owner.
   2. Perform all trend logging specified in Prefunctional Checklists and Functional Test procedures.

E. Functionally Test integral or stand-alone controls in conjunction with the Functional Tests of the equipment they are attached to, including any interlocks with other equipment or systems; further testing during control system Functional Test is not required unless specifically indicated below.

F. Demonstrate the following to the Commissioning Authority during testing of controlled equipment; coordinate with commissioning of equipment.
   1. Setpoint changing features and functions.
   2. Sensor calibrations.

G. Demonstrate to the Commissioning Authority:
   1. That all specified functions and features are set up, debugged and fully operable.
   2. That scheduling features are fully functional and setup, including holidays.
   3. That all graphic screens and value readouts are completed.
   4. Correct date and time setting in central computer.
   5. That field panels read the same time as the central computer; sample 10 percent of field panels; if any of those fail, sample another 10 percent; if any of those fail test all remaining units at no extra cost to Owner.
   6. Functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad; demonstrate 100 percent of panels and 10 percent of ports; if any ports fail, sample another 10 percent; if any of those fail, test all remaining units at no extra cost to Owner.
   7. Power failure and battery backup and power-up restart functions.
   8. Global commands features.
   9. Security and access codes.
   10. Occupant over-rides (manual, telephone, key, keypad, etc.).
   11. O&M schedules and alarms.
   12. Occupancy sensors and controls.
   13. All control strategies and sequences not tested during controlled equipment testing.

H. If the control system, integral control components, or related equipment do not respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice, under any of the conditions, sequences, or modes tested, correct all systems, equipment, components, and software required at no additional cost to

Owner.

3.05 OPERATION AND MAINTENANCE MANUALS

A. See General Conditions and Supplementary Conditions for additional requirements.

B. Add design intent documentation furnished by Design Professional to manuals prior to submission to Owner.

C. Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.

D. Commissioning Authority will add commissioning records to manuals after submission to Owner.

3.06 DEMONSTRATION AND TRAINING

A. See General Conditions and Supplementary Conditions for additional requirements.

B. Demonstrate operation and maintenance of HVAC system to Owner' personnel; if during any demonstration, the system fails to perform in accordance with the information included in the O&M manual, stop demonstration, repair or adjust, and repeat demonstration. Demonstrations may be combined with training sessions if appropriate.

C. These demonstrations are in addition to, and not a substitute for, Prefunctional Checklists and demonstrations to the Commissioning Authority during Functional Testing.

D. Provide classroom and hands-on training of Owner's designated personnel on operation and maintenance of the HVAC system, control system, and all equipment items indicated to be commissioned. Provide the following minimum durations of training:

E. TAB Review: Instruct Owner's personnel for minimum 4 hours, after completion of TAB, on the following:
   1. Review final TAB report, explaining the layout and meanings of each data type.
   2. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
   3. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
   4. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
   5. Other salient information that may be useful for facility operations, relative to TAB.

F. HVAC Control System Training: Perform training in at least three phases:
   1. Phase 1 - Basic Control System: Provide minimum of 8 hours of actual training on the control system itself. Upon completion of training, each attendee, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
      a. This training may be held on-site or at the manufacturer's facility.
      b. If held off-site, the training may occur prior to final completion of the system installation.
      c. For off-site training, Contractor shall pay expenses of up to two attendees.
   2. Phase 2 - Integrating with HVAC Systems: Provide minimum of 8 hours of on-site, hands-on training after completion of Functional Testing. Include instruction on:
      a. The specific hardware configuration of installed systems in this facility and specific instruction for operating the installed system, including interfaces with other systems, if any.
      b. Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
      c. Trend logging and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically

and printing trends; provide practice in setting up trend logging and monitoring during training session.

d. Every display screen, allowing time for questions.
e. Point database entry and modifications.

3. Phase 3 - Post-Occupancy: Six months after occupancy conduct minimum of 8 hours of training. Tailor training session to questions and topics solicited beforehand from Owner. Also be prepared to address topics brought up and answer questions concerning operation of the system.

G. Provide the services of manufacturer representatives to assist instructors where necessary.

H. Provide the services of the HVAC controls instructor at other training sessions, when requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

END OF SECTION

SECTION 23 0913
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Control panels.

B. Control Valves:
   1. Globe pattern.
   2. Electronic operators.

C. Dampers.

D. Damper Operators:
   1. Electric operators.

E. Thermostats:
   1. Electric room thermostats.
   2. Low-limit temperature cutout switch (freezestat)
   3. Line voltage thermostats.
   4. Room thermostat accessories.
   5. Outdoor reset thermostats.
   6. Immersion thermostats.

1.02 REFERENCE STANDARDS

A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating.

B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

C. NEMA DC 3 - Residential Controls - Electrical Wall-Mounted Room Thermostats.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week before starting work of this section; require attendance by all affected installers.

B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.04 SUBMITTALS

A. Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.

B. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.

C. Design Data: Provide design data for sizing and selection of compressor.

D. Manufacturer's Instructions: Provide for all manufactured components.

E. Designer's Qualification Statement.

F. Manufacturer's Qualification Statement.

G. Installer's Qualification Statement.

H. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.

I. Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.

J. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

K. Proof of Niagra 4 Certification of three (3) Controls Contractor Employees.

1.05 QUALITY ASSURANCE

A. Designer Qualifications: Design system under direct supervision of a Professional Engineer experienced in design of this work and licensed in the State in which the Project is located.

B. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

C. Installer Qualifications: Company specializing in performing the work of this section with minimum three years experience approved by manufacturer.
   1. At least three (3) Employees are to be Niagra 4 Certified.

D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.06 WARRANTY

A. Correct defective work within a five year period after Substantial Completion.

PART 2 PRODUCTS

2.01 EQUIPMENT - GENERAL

A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

2.02 CONTROL PANELS

A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face.

B. NEMA 250, general purpose utility enclosures with enameled finished face panel.

C. Provide common keying for all panels.

2.03 CONTROL VALVES

A. Manufacturers
   1. Belimo.
   2. Siemens
   3. Honeywell.
   4. Or Equal.

B. Control Valves shall be sized by the control manufacturer to produce the required capacity at a pressure loss not exceeding the allowable pressure drop indicated on the drawing. Nominal body rating shall be not less than 125 PSI. However, the valve body and packing selected shall be sized to withstand the system static head plus the maximum pump head and the maximum temperature of the control medium, steam, and/or hot water. Two-way modulating valves shall have close-off ratings exceeding the maximum pressure difference, at any load condition, between the outlet and inlet. Each valve shall be equipped with proper packing to assure there will be no leakage at the valve stem.

C. Operators: All damper and valve operators shall be 0 to 10vdc electric and be provided for each automatic damper or valve and shall be of sufficient capacity to operate the damper or valve under all conditions and to guarantee tight close-off of valves, as specified, against system pressure encountered. Damper operators shall be provided with spring-return for normally closed or normally open position for fail safe operation to account for fire, low temperatures, or power interruption as indicated. Valve operators shall be spring return or DDC failsafe operated to fail to safe position if the associated fan system is off. Damper and valve operators are to be made out of die cast metal; no plastic or sheet metal bodies will be allowed. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow

conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.

D. Hot water control valves shall be modulating ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (r 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.

E. Ball valves shall be used for hot water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.

F. Globe Pattern:
   1. Up to 2 inches: Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.
   2. Over 2 inches: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.
   3. Hydronic Systems:
      a. Rate for service pressure of 125 psig at 250 degrees F.
      b. Replaceable plugs and seats of stainless steel.
      c. Size for 3 psig maximum pressure drop at design flow rate.
      d. Two-way valves shall have equal percentage characteristics, three way valves linear characteristics. Size two-way valve operators to close valves against pump shut off head.

G. Electronic Operators:
   1. Select operator for full shut off at maximum pump differential pressure.

2.04 DAMPERS

A. Manufactuers:
   1. Ruskin
   2. Honeywell
   3. Pottorff
   4. Or Equal.

B. Performance: Test in accordance with AMCA 500-D.

C. Frames: Galvanized steel, welded or riveted with corner reinforcement, minimum 12 gage, 0.1046 inch.

D. Blades: Insulated Galvanized steel, maximum blade size 8 inches wide, 48 inches long, minimum 22 gage, 0.0299 inch, attached to minimum 1/2 inch shafts with set screws.

E. Blade Seals: Synthetic elastomeric, inflatable, mechanically attached, field replaceable.

F. Jamb Seals: Spring stainless steel.

G. Shaft Bearings: Oil impregnated sintered bronze.

H. Linkage Bearings: Oil impregnated sintered bronze.

I. Leakage: Less than one percent based on approach velocity of 2000 ft per min and 4 inches wg.

J. Maximum Pressure Differential: 6 inches wg.

K. Temperature Limits: Minus 40 to 200 degrees F.

2.05 DAMPER OPERATORS

A. Manufacturers:

1. Belimo
2. Honeywell
3. Siemens
4. Or Equal

B. General: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.
   1. Provide sufficient number of operators to achieve unrestricted movement throughout damper range.

C. Electric Operators:
   1. Spring return, adjustable stroke motor having oil immersed gear train, with auxiliary end switch.

D. Electronic damper actuators shall be of adequate size and quantity to properly position the automatic controlled dampers. Actuator capacity and torque shall be required to meet 125 % of the damper manufacturer's torque requirements.

E. Electronic direct Coupled actuation shall be provided.

F. The actuator shall be direct Coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of "V" bolt design with associated "V" shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a "V" clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up 1.05 inches when damper is constructed in this manner. Single bolt or setscrew type fasteners are not acceptable.

G. The actuator shall have electronic overload or digital sensing circuitry to prevent damage to the actuator throughout the entire rotation of actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.

H. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non mechanical forms of fail-safe operations are not acceptable.

I. All spring returns actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.

J. Proportional actuators shall accept A 0 to 10 VDC or 4 to 20 MA control input and provide A 2 to 10 VDC or 4 to 20 MA operating range. Actuators using pulse width modulating control signal are not acceptable. All actuators shall provide A 2 to 10 VDC position feedback signal.

K. All 24 VAC/DC actuators shall operate on class 2 wiring and shall not require more than 10 VA for AC or more than 8 Watts for DC applications. Actuators operating on 120 VAC power shall not require more than 11 VA.

L. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in LB torque capacity shall have a manual crank for this purpose.

M. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.

N. Actuators shall be provided with a conduit fittings and a minimum three foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

O. Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Associates Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.

P. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rayed torque and shall have a 2 year manufacturer's warranty, starting from the date of installation. Manufacturer shall be ISO 9001 certified. Actuators shall be as manufactured by Belimo or as approved.

1.

2.06 THERMOSTATS

A. Manufacturers:
   1. Honeywell
   2. Johnson Controls
   3. Siemens
   4. Or Equal

B. Electric Room Thermostats:
   1. Type: Surface-Mount Room Sensor, 1000Ω Nickel-Iron, Balco Sensor, Stainless Steel Plate; no local adjustment available. All adjustment via the Building Management System
   2. Covers: Stainless Steel cover Plate

C. Line Voltage Thermostats:
   1. Integral manual On/Off/Auto selector switch, single or two pole as required.
   2. Dead Band: Maximum 2 degrees F.
   3. Rating: Motor load.

D. Room Thermostat Accessories:
   1. Insulating Bases: For thermostats located on exterior walls.
   2. Thermostat Guards: Metal mounted on separate base.
   3. Type: Surface-Mount Room Sensor, 1000Ω Nickel-Iron, Balco Sensor, Stainless Steel Plate; no local adjustment available. All adjustment via the Building Management System

E. Outdoor Reset Thermostats:
   1. Remote bulb or bimetal rod and tube type, proportioning action with adjustable throttling range, adjustable setpoint.
   2. Scale range: Minus 10 to 70 degrees F.

F. Immersion Thermostats:
   1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint and adjustable throttling range.

G. Transmitters shall be of an integral two wire 4-20 MA device with 100 OHM platinum RTD sensor. The transmitter shall be provided with non-Interacting zero and span adjustments. The transmitters shall be protected against damage from reverse polarity and line transients. Thermistors, IC type or non-transmitting devices will not be acceptable. Transmitters shall meet or exceed the following:

1.	Calibrated:	+/ - 0.4% of Span
2.	Linearity:	+/ - 0.05% of Span
3.	Stability:	+/ - 0.01% of Span / Deg. C
4.	Response Time:	100 MS
5.	Temperature Range	-58 to 160 Deg.F
6.	Output Signal	4 to 20 MA
7.	Input Power	24 VDC

H. End-to-end minimum accuracy of RTD's and transmitters shall be as follows:
   1. Return and Exhaust Air Duct Telemetering Temperatures: +0.1 deg C over the full range of -1.0°C to 55°C.
   2. Outside Air Temperatures: +0.25 deg. C between -10°C and 40°C.
   3. Discharge Air Duct Temperatures: +0.25 deg. C over the full range of 4°C to 60°C.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify existing conditions before starting work. Examine conditions under which products are to be installed in coordination with Installer of materials and components specified in this Section and notify General Contractor in writing, with copies to the Owner's Representative, Owner, and Architect, of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to

Installer.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

3.02 FIELD QUALITY CONTROL

A. After completion of installation, test and adjust control equipment. Submit data showing set points and final adjustments of controls.

3.03 DEMONSTRATION AND TRAINING

A. Demonstrate complete operation of systems, including sequence of operation prior to Date of Substantial Completion.

B. Demonstrate complete and operating system to Owner.

3.04 INSTALLATION

A. All control cabling within mechanical and electrical rooms shall be in rigid metal conduit. All control cabling external to these rooms to be within EMT. No control cabling is acceptable that is not within the conduit noted.

B. Install in accordance with manufacturer's instructions.

C. Check and verify location of thermostats with plans and room details before installation. Locate 60 inches above floor. Align with lighting switches and humidistats. Refer to Section 26 2726.

D. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.

E. Provide separate steam valves for each bank of coils. Provide two valves in parallel where steam load exceeds 1500 lb per hr with 1/3 to 2/3 load capacities sequenced with smaller valve opening first.

F. Do not install damper motors in cold locations at outdoor temperatures.

G. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

H. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.

I. Provide conduit and electrical wiring in accordance with Division 26. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

J. Labeling: All instruments and control devices are to be labeled with the associated equipment it serves.

END OF SECTION

SECTION 23 0934
VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Variable-frequency motor controllers for low-voltage (600 V and less) AC motor applications.

B. Overcurrent protective devices for motor controllers, including overload relays.

1.02 RELATED REQUIREMENTS

A. Section 23 0529 - Hangers and Supports for HVAC Piping and Equipment.

B. Section 26 0526 - Grounding and Bonding for Electrical Systems.

1.03 REFERENCE STANDARDS

A. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code).

B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

C. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts.

D. NEMA ICS 6 - Industrial Control and Systems: Enclosures.

E. NEMA ICS 7 - Industrial Control and Systems: Adjustable-Speed Drives.

F. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems.

G. NEMA ICS 7.2 - Application Guide for AC Adjustable Speed Drive Systems.

H. NEMA ICS 61800-2 - Adjustable Speed Electrical Power Drive Systems, Part 2: General Requirements-Rating Specifications for Low Voltage Adjustable Frequency AC Power Drive Systems.

I. NEMA MG 1 - Motors and Generators.

J. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.

K. NFPA 70 - National Electrical Code.

L. UL 508A - Industrial Control Panels.

M. UL 61800-5-1 - Standard for Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements – Electrical, Thermal, and Energy.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate work to provide motor controllers suitable for use with actual motors to be installed.
   2. Coordinate work to provide controllers and associated wiring suitable for interface with control devices to be installed.
   3. Coordinate arrangement with dimensions and clearance requirements of actual equipment to be installed.
   4. Verify with manufacturer that conductor terminations are suitable for use with conductors to be installed.
   5. Notify Design Professional of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for motor controllers, enclosures, overcurrent protective devices, and other installed components and accessories.

B. Shop Drawings: Indicate dimensions, voltage, controller sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.

1. Include dimensioned plan and elevation views of controllers and adjacent equipment with required clearances indicated.
2. Include wiring diagrams showing factory and field connections.
3. Identify mounting conditions required for equipment seismic qualification.

C. Field quality control test reports.

D. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.

E. Project Record Documents: Record actual installed locations of controllers and final equipment settings.
1. Include nameplate data of actual installed motors and associated overload relay selections and settings.

1.06 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to internal components, enclosure, and finish.

1.08 FIELD CONDITIONS

A. Maintain field conditions within required service conditions during and after installation.

1.09 WARRANTY

A. Provide minimum 18 month manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.01 VARIABLE-FREQUENCY MOTOR CONTROLLERS

A. Provide variable-frequency motor control system consisting of required controller assemblies, operator interfaces, control power transformers, instrumentation and control wiring, sensors, accessories, system programming, etc. as necessary for complete operating system.

B. Provide products listed, classified, and labeled as suitable for purpose intended.

C. Variable-Frequency Motor Controller:
1. Filtering: Provide input/line reactor and output/load reactor.

D. Controller Assemblies: Comply with NEMA ICS 7, NEMA ICS 7.1, and NEMA ICS 61800-2; list and label as complying with UL 61800-5-1 or UL 508A as applicable.

E. Provide controllers selected for actual installed motors and coupled mechanical loads in accordance with NEMA ICS 7.2, NEMA MG 1 Part 30, and recommendations of manufacturers of both controller and load, where not in conflict with specified requirements; considerations include, but are not limited to:
1. Motor type (e.g., induction, reluctance, and permanent magnet); consider NEMA MG 1 design letter or inverter duty rating for induction motors.
2. Motor load type (e.g., constant torque, variable torque, and constant horsepower); consider duty cycle, impact loads, and high inertia loads.
3. Motor nameplate data.
4. Requirements for speed control range, speed regulation, and braking.
5. Motor suitability for bypass starting method, where applicable.

F. Devices on Load Side of Controller: Suitable for application across full controller output frequency range.

G. Operating Requirements:
1. Input Voltage Tolerance: Plus/minus 10 percent of nominal.

2. Input Frequency Tolerance: Plus/minus 5 percent of nominal.
3. Efficiency: Minimum of 96 percent at full speed and load.
4. Input Displacement Power Factor: Minimum of 0.96 throughout speed and load range.
5. Overload Rating:
   a. Variable Torque Loads: Minimum of 110 percent of nominal for 60 seconds.
   b. Constant Torque Loads: Minimum of 150 percent of nominal for 60 seconds.

H. Power Conversion System: Microprocessor-based, pulse width modulation type consisting of rectifier/converter, DC bus/link, and inverter.
   1. Rectifier/Converter: Diode-based, 6-pulse type unless otherwise indicated.

I. Control System:
   1. Provide microprocessor-based control system for automatic control, monitoring, and protection of motors. Include sensors, wiring, and connections necessary for functions and status/alarm indications specified.
   2. Provide integral operator interface for controller programming, display of status/alarm indications, fault reset, and local control functions including motor run/stop, motor forward/reverse selection, motor speed increase/decrease, and local/remote control selection.
   3. Control Functions:
      a. Control Method: Selectable vector and scalar/volts per hertz unless otherwise indicated.
         1) Scalar/Volts per Hertz Control: Provide IR compensation for improved low-speed torque.
         2) Vector Control: Provide selectable autotuning function.
      b. Adjustable acceleration and deceleration time; linear and S-curve ramps; selectable coast to stop.
      c. Selectable braking control; DC injection or flux braking.
      d. Adjustable minimum/maximum speed limits.
      e. Adjustable pulse width modulation switching carrier frequency.
      f. Adjustable motor slip compensation.
      g. Selectable autorestart after noncritical fault; programmable number of time delay between restart attempts.
   4. Status Indications:
      a. Motor run/stop status.
      b. Motor forward/reverse status.
      c. Local/remote control status.
      d. Output voltage.
      e. Output current.
      f. Output frequency.
      g. DC bus voltage.
      h. Motor speed.
   5. Protective Functions/Alarm Indications:
      a. Overcurrent.
      b. Motor overload.
      c. Undervoltage.
      d. Overvoltage.
      e. Controller overtemperature.
      f. Input/output phase loss.
      g. Output short circuit protection.
      h. Output ground fault protection.
   6. Inputs:
      a. Digital Input(s): Three.
      b. Analog Input(s): Two.
   7. Outputs:
   8. Features:

a. Password-protected security access.
b. Event log.

J. Power Conditioning/Filtering:
1. Provide DC link choke or input/line reactor for each controller unless otherwise indicated or required.
2. Reactor Impedance: 3 percent, unless otherwise indicated or required.

K. Packaged Controllers: Controllers factory-mounted in separate enclosure with externally operable disconnect and specified accessories.
1. Disconnects: Circuit breaker or disconnect switch type.
a. Disconnect Switches: Fusible type or nonfusible type with separate input fuses.
b. Provide externally operable handle with means for locking in OFF position. Provide safety interlock to prevent opening cover with disconnect in ON position with capability of overriding interlock for testing purposes.
c. Provide auxiliary interlock for disconnection of external control power sources where applicable.
2. Provide door-mounted remote operator interface.

L. Service Conditions:
1. Provide controllers and associated components suitable for operation under following service conditions without derating:
a. Altitude: Less than 3,300 feet.
b. Ambient Temperature: Between 32 degrees F and 104 degrees F.
2. Provide controllers and associated components suitable for operation at indicated ratings under service conditions at installed location.

M. Short Circuit Current Rating:
1. Provide line/input reactors where specified by manufacturer for required short circuit current rating.

N. Conductor Terminations: Suitable for use with conductors to be installed.

O. Enclosures:
1. Comply with NEMA ICS 6.
2. NEMA 250 Environment Type or Equivalent IEC 60529 Rating: Unless otherwise indicated, as specified for following installation locations:
3. Finish: Manufacturer's standard unless otherwise indicated.
4. Cooling: Forced air or natural convection as determined by manufacturer.

2.02 OVERCURRENT PROTECTIVE DEVICES

A. Overload Relays:
1. Provide overload relays and, where applicable, associated current elements/heaters selected for actual installed motor nameplate data, in accordance with manufacturer's recommendations and NFPA 70; include consideration for motor service factor and ambient temperature correction, where applicable.
2. Comply with NEMA ICS 2.
3. Inverse-Time Trip Class Rating: Class 20 unless otherwise indicated or required.
4. Trip-free operation.
5. Visible trip indication.
6. Resettable:
a. Employ manual reset unless otherwise indicated.
b. Do not employ automatic reset with two-wire control.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that ratings of controllers are consistent with indicated requirements.

C. Verify that mounting surfaces are ready to accept controllers.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

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

B. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.

C. Do not exceed manufacturer's recommended maximum cable length between controller and motor.

D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

E. Provide required support and attachment in accordance with Section 23 0529.

F. Install controllers plumb and level.

G. Provide grounding and bonding in accordance with Section 26 0526.

H. Install field-installed devices, components, and accessories.

I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

J. Set field-adjustable settings of controllers and associated components according to installed motor requirements, in accordance with recommendations of manufacturers of controller and load.

3.03 FIELD QUALITY CONTROL

A. Provide services of manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's reports with submittals.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.17. Insulation-resistance test on control wiring listed as optional is not required.

D. Correct deficiencies and replace damaged or defective controllers or associated components.

3.04 CLOSEOUT ACTIVITIES

A. Training: Train Owner's personnel on operation, adjustment, and maintenance of controllers and associated devices.
   1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
   2. Provide minimum of two hours of training.
   3. Instructor: Manufacturer's authorized representative.

3.05 PROTECTION

A. Protect installed controllers from subsequent construction operations.

END OF SECTION

SECTION 23 2113
HYDRONIC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Hydronic system requirements.

B. Heating water piping, above grade.

C. Equipment drains and overflows.

D. Pipe hangers and supports.

E. Unions, flanges, mechanical couplings, and dielectric connections.

F. Flow controls.

1.02 RELATED REQUIREMENTS

A. Section 08 3100 - Access Doors and Panels.

B. Section 09 9123 - Interior Painting.

C. Section 23 2114 - Hydronic Specialties.

D. Section 23 2500 - HVAC Water Treatment: Pipe cleaning.

E. Section 23 0529 - Hanger and Supports for HVAC Piping and Equipment

1.03 REFERENCE STANDARDS

A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.

B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.

D. ASME B31.9 - Building Services Piping.

E. ASTM B32 - Standard Specification for Solder Metal.

F. ASTM B88 - Standard Specification for Seamless Copper Water Tube.

G. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric).

H. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.

I. ASTM F876 - Standard Specification for Crosslinked Polyethylene (PEX) Tubing.

J. ASTM F877 - Standard Specification for Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems.

K. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.

L. AWWA C606 - Grooved and Shouldered Joints.

M. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.04 SUBMITTALS

A. Welders Certificate: Include welders certification of compliance with ASME BPVC-IX.

B. Product Data:
   1. Include data on pipe materials, pipe fittings, valves, and accessories.
   2. Provide manufacturers catalog information.
   3. Indicate valve data and ratings.

C. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

D. Project Record Documents: Record actual locations of valves.

E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Valve Repacking Kits: One for each type and size of valve.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.

B. Installer Qualifications: Company specializing in performing work of the type specified in this section, with minimum three years of experience.

C. Additional Installer Qualifications: Certified Pex-A piping installer, with attendance of minimum 2-day class from manufacturer.

D. Install and test per manufacturer's recccomendation.

E. Date stamp all castings used for coupling housings, fittings, valve bodies, etc. for quality assurance and traceability.

F. Coupling Manufacturer:
   1. Perform on-site training by factory-trained representative to the Contractor's field personnel in the proper use of grooving tools and installation of grooved joint products.
   2. Periodic job site visits by factory-trained representative to ensure best practices in grooved joint installation.
   3. A distributor's representative is not considered qualified to perform the training.

G. Welder Qualifications: Certify in accordance with ASME BPVC-IX.
   1. Provide certificate of compliance from authority having jurisdiction, indicating approval of welders.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

B. Provide temporary protective coating on cast iron and steel valves.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 HYDRONIC SYSTEM REQUIREMENTS

A. Comply with ASME B31.9 and applicable federal, state, and local regulations.

B. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.

C. Valves: Provide valves where indicated:
   1. Provide drain valves where indicated, and if not indicated, provide at least at main shut-off, low points of piping, bases of vertical risers, and at equipment. Use 3/4 inch gate valves with cap; pipe to nearest floor drain.
   2. Isolate equipment using butterfly valves with lug end flanges or grooved mechanical couplings.
   3. For throttling, bypass, or manual flow control services, use globe, ball, or butterfly valves.
   4. For throttling and isolation service in chilled and condenser water systems, use only butterfly valves.
   5. In heating water, chilled water, or condenser water systems, butterfly valves may be used interchangeably with gate and globe valves.
   6. For shut-off and to isolate parts of systems or vertical risers, use gate, ball, or butterfly valves.
   7. For throttling service, use plug cocks. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.

D. Welding Materials and Procedures: Comply with ASME BPVC-IX.

2.02 EQUIPMENT DRAINS AND OVERFLOWS

A. Copper Tube: ASTM B88 (ASTM B88M), Type M (C), drawn; using one of the following joint types:
   1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.

2.03 PIPE HANGERS AND SUPPORTS

A. Refer to Specification Section 23 0529 Hangers and Supports for HVAC Piping and Equipment.

B. Provide hangers and supports that comply with MSS SP-58.
   1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.

C. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge-shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.

2.04 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe 2 Inches and Less:
   1. Ferrous Piping: 150 psig malleable iron, threaded.
   2. Copper Pipe: Bronze, soldered joints.

B. Flanges for Pipe 2 Inches and Greater:
   1. Ferrous Piping: 150 psig forged steel, slip-on.
   2. Copper Piping: Bronze.

C. Dielectric Connections:
   1. Waterways:
      a. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
      b. Dry insulation barrier able to withstand 600-volt breakdown test.
      c. Construct of galvanized steel with threaded end connections to match connecting piping.
      d. Suitable for the required operating pressures and temperatures.
   2. Flanges:
      a. Dielectric flanges with same pressure ratings as standard flanges.
      b. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
      c. Dry insulation barrier able to withstand 600-volt breakdown test.
      d. Construct of galvanized steel with threaded end connections to match connecting piping.
      e. Suitable for the required operating pressures and temperatures.

PART 3 EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.

C. Remove scale and dirt on inside and outside before assembly.

D. Prepare piping connections to equipment using jointing system specified.

E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

F. After completion, fill, clean, and treat systems. Refer to Section 23 2500 for additional requirements.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Route piping in orderly manner, parallel to building structure, and maintain gradient.

C. Install piping to conserve building space and to avoid interference with use of space.

D. Group piping whenever practical at common elevations.

E. Sleeve pipe passing through partitions, walls, and floors.

F. Slope piping and arrange to drain at low points.

G. Grooved Joints and press seal joints:
   1. Install in accordance with the manufacturer's latest published installation instructions.
   2. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.
   3. permissible in mechanical rooms only

H. Inserts:
   1. Provide inserts for placement in concrete formwork.
   2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
   3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
   4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
   5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

I. Pipe Hangers and Supports:
   1. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58.
   2. Support horizontal piping as scheduled.
   3. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.
   4. Place hangers within 12 inches of each horizontal elbow.
   5. Use hangers with 1-1/2 inches minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
   6. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
   7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
   8. Provide copper plated hangers and supports for copper piping.
   9. Prime coat exposed steel hangers and supports. Refer to Section 09 9123. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

J. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 3100.

K. Use eccentric reducers to maintain top of pipe level.

L. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welds.

M. Install valves with stems upright or horizontal, not inverted.

END OF SECTION

SECTION 23 2114
HYDRONIC SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Air vents.

B. Strainers.

C. Pressure-temperature test plugs.

D. Balancing valves.

1.02 REFERENCE STANDARDS

A. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels.

1.03 SUBMITTALS

A. See General Conditions for submittal procedures.

B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description and model.

C. Certificates: Inspection certificates for pressure vessels from authority having jurisdiction.

D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

E. Project Record Documents: Record actual locations of flow controls.

F. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

B. Provide temporary protective coating on cast iron and steel valves.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.06 SPARE PARTS

A. Provide a full stock (box of 50) #2, 25 micron bag filters

PART 2 PRODUCTS

2.01 AIR VENTS

A. Manufacturers:
   1. Armstrong International, Inc: www.armstronginternational.com.
   2. ITT Bell & Gossett: www.bellgossett.com.
   3. Taco, Inc: www.taco-hvac.com.

B. Manual Type: Short vertical sections of 2-inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.

C. Float Type:
   1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

2. Cast iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.

2.02 STRAINERS

A. Manufacturers:
   1. Armstrong International, Inc: www.armstronginternational.com.
   2. Flexicraft Industries: www.flexicraft.com.
   3. Grinnell Products, a Tyco Business: www.grinnell.com.
   4. The Metraflex Company: www.metraflex.com/#sle.

B. Size 2 inch and Under:
   1. Screwed brass or iron body for 175 psi working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

C. Size 2-1/2 inch to 4 inch:
   1. Provide flanged iron body for 175 psi working pressure, Y pattern with 1/16 inch or 3/64 inch stainless steel perforated screen.

D. Size 5 inch and Larger:
   1. Provide flanged iron body for 175 psi working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.03 PRESSURE-TEMPERATURE TEST PLUGS

A. Manufacturers:
   1. Ferguson Enterprises Inc: www.fnw.com.
   2. Peterson Equipment Company Inc: www.petesplug.com.
   3. Sisco Manufacturing Company Inc: www.siscomfg.com.

B. Construction: Brass body designed to receive temperature or pressure probe with removable protective cap, and Neoprene rated for minimum 200 degrees F.

C. Application: Use extended length plugs to clear insulated piping.

2.04 BALANCING VALVES

A. Manufacturers:
   1. Armstrong International, Inc: www.armstronginternational.com.
   2. ITT Bell & Gossett: www.bellgossett.com.
   3. Taco, Inc: www.taco-hvac.com.

B. Size 2 inch and Smaller:
   1. Provide ball or globe style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and dNPT threaded connections.
   2. Metal construction materials consist of bronze or brass.
   3. Non-metal construction materials consist of Teflon or EPDM.

C. Size 2.5 inch and Larger:
   1. Provide ball, globe, or butterfly style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and flanged connections.
   2. Valve body construction materials consist of cast iron, carbon steel, or ductile iron.
   3. Internal components construction materials consist of brass, aluminum bronze, bronze, Teflon, EPDM, NORYL, or engineered resin.

2.05 RELIEF VALVES

A. Manufacturers:
   1. Armstrong International, Inc: www.armstronginternational.com.
   2. ITT Bell & Gossett: www.bellgossett.com.
   3. Conbraco Industries: www.apollovalves.com.

B. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install specialties in accordance with manufacturer's instructions.

B. Where large air quantities can accumulate, provide enlarged air collection standpipes.

C. Provide manual air vents at system high points and as indicated.

D. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

E. Provide valved drain and hose connection on strainer blowdown connection.

F. Provide relief valves on pressure tanks, low-pressure side of reducing valves, heat exchangers, and expansion tanks.

G. Pipe relief valve outlet to nearest floor drain.

END OF SECTION

SECTION 23 2300
REFRIGERANT PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Piping.
B. Refrigerant.
C. Moisture and liquid indicators.
D. Valves.
E. Strainers.
F. Check valves.
G. Pressure relief valves.
H. Solenoid valves.
I. Expansion valves.
J. Flexible connections.

1.02 RELATED REQUIREMENTS

A. Section 23 0716 - HVAC Equipment Insulation.
B. Section 23 0719 - HVAC Piping Insulation.
C. Section 23 6313 - Air Cooled Refrigerant Condensers.
D. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

A. AHRI 750 - Thermostatic Refrigerant Expansion Valves.
B. AHRI 760 - Performance Rating of Solenoid Valves for Use With Volatile Refrigerants.
C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems.
D. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.
E. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
F. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.
G. ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
H. ASME B31.9 - Building Services Piping.
I. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
J. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
K. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding.
L. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.04 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
B. Provide pipe hangers and supports in accordance with ASME B31.5 unless indicated otherwise.
C. Valves:

1. Use service valves on suction and discharge of compressors.

D. Refrigerant Charging (Packed Angle) Valve: Use in liquid line between receiver shut-off valve and expansion valve.

E. Pressure Relief Valves: Use on ASME receivers and pipe to outdoors.

F. Filter-Driers:
1. Use a filter-drier immediately ahead of liquid-line controls, such as thermostatic expansion valves, solenoid valves, and moisture indicators.
2. Use a filter-drier on suction line just ahead of compressor.

1.05 SUBMITTALS

A. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.

B. Design Data: Submit design data indicating pipe sizing. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.

C. Test Reports: Indicate results of leak test, acid test.

D. Submit welders certification of compliance with ASME BPVC-IX.

E. Project Record Documents: Record exact locations of equipment and refrigeration accessories on record drawings.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra Filter-Dryer Cartridges: One of each type and size.
2. Refrigeration Oil Test Kits: One, each containing everything required to conduct one test.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties in shipping containers with labeling in place.

B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

A. Comply with ASME B31.9 for installation of piping system.

B. Welders Certification: In accordance with ASME BPVC-IX.

2.02 PIPING

A. Copper Tube: ASTM B280, H58 hard drawn or O60 soft annealed.
1. Fittings: ASME B16.22 wrought copper.
2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.

B. Copper Tube to 7/8 inch OD: ASTM B88 (ASTM B88M), Type K (A), annealed or drawn-temp.
1. Fittings: ASME B16.26 cast copper.
2. Joints: Flared and soldered.

C. Pipe Supports and Anchors:
1. Provide hangers and supports that comply with MSS SP-58.
a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
2. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
4. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
5. Vertical Support: Steel riser clamp.
6. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
7. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

8. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.03 REFRIGERANT

A. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.

2.04 MOISTURE AND LIQUID INDICATORS

A. Indicators: Single port type, UL listed, with copper or brass body, flared or solder ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum temperature of 200 degrees F and maximum working pressure of 500 psi.

2.05 VALVES

A. Diaphragm Packless Valves:
   1. UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, solder or flared ends, with positive backseating; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.

B. Packed Angle Valves:
   1. Forged brass or nickel plated forged steel, forged brass seal caps with copper gasket, rising stem and seat with backseating, molded stem packing, solder or flared ends; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.

C. Ball Valves:
   1. Two piece bolted forged brass body with teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of 500 psi and maximum temperature of 300 degrees F.

D. Service Valves:
   1. Forged brass body with copper stubs, brass caps, removable valve core, integral ball check valve, flared or solder ends, for maximum pressure of 500 psi.

2.06 STRAINERS

A. Straight Line or Angle Line Type:
   1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi.

2.07 CHECK VALVES

A. Straight Through Type:
   1. Brass body and disc, phosphor-bronze or stainless steel spring, neoprene seat; for maximum working pressure of 500 psi and maximum temperature of 200 degrees F.

2.08 PRESSURE RELIEF VALVES

A. Straight Through or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB, selected to ASHRAE Std 15, with standard setting of 235 psi.

2.09 SOLENOID VALVES

A. Valve: AHRI 760 I-P, pilot operated, copper, brass or steel body and internal parts, synthetic seat, stainless steel stem and plunger assembly (permitting manual operation in case of coil failure), integral strainer, with flared, solder, or threaded ends; for maximum working pressure of 500 psi.

2.10 EXPANSION VALVES

A. Angle or Straight Through Type: AHRI 750; design suitable for refrigerant, brass body, internal or external equalizer, bleed hole, adjustable superheat setting, replaceable inlet strainer, with non-replaceable capillary tube and remote sensing bulb and remote bulb well.

B. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 degrees F superheat. Select to avoid being undersized at full load and excessively oversized at part load.

2.11 FLEXIBLE CONNECTORS

A. Corrugated stainless steel hose with single layer of stainless steel exterior braiding, minimum 9 inches long with copper tube ends; for maximum working pressure of 500 psi.

PART 3 EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.02 INSTALLATION

A. Install refrigeration specialties in accordance with manufacturer's instructions.

B. use fittings to make changes in direction in hard drawn and steel piping.

C. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.

D. install piping in concealed locations unless indicated otherwise. piping above accessible ceilings shall be installed high enough to remove ceiling tiles.

E. Install piping to conserve building space and avoid interference with use of space.

F. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.

G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

H. install piping in conduit where exposed to damage.

I. Solder piping in accordance with ASTM B828.

J. Braze piping in accordance with the AWS brazing handbook.

K. Construct welded joints in accordance with AWS D10.12.

L. Slope hot gas piping downward away from the compressor.

M. Slope suction lines downward towards the compressor.

N. clean interior of steel piping for suction, liquid, or hot gas using shot blasting methods followed by wiping with trichloroethylene followed by compressor oil. perform visual inspection for dirt.

O. Inserts:
   1. Provide inserts for placement in concrete formwork.
   2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
   3. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

P. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required by manufacturer of cooling equipment.

Q. install sleeves and escutcheons where piping passes thru walls and floors.

R. Install piping at equipment to allow for regular maintenance access.

S. Provide clearance for installation of insulation and access to valves and fittings.

T. Flood piping system with nitrogen when brazing.

U. Insulate piping; see Section 23 0716.

V. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.

W. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.

X. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.

Y. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.

Z. Fully charge completed system with refrigerant after testing.

AA. Provide electrical connection to solenoid valves. See Section 26 0583.

BB. install refrigerant piping in accordance with ASHRAE 15 and chapter 11 of the mechanical code

3.03 FIELD QUALITY CONTROL

A. Test refrigeration system in accordance with ASME B31.5.

B. Pressure test R-134a system with dry nitrogen to 225 psi. Perform final tests at 27 inches vacuum and 225 psi using halide torch. Test to no leakage.

3.04 SCHEDULES

A. Refrigerant Piping
   1. Suction lines
      a. 1-1/2" and smaller: Type ACR copper with soldered connections.
      b. 1-1/2" and smaller: Type ACR copper with brazed connections.
      c. 1-1/2" and smaller: Type copper with soldered connections.
      d. 1-1/2" and smaller: Type ACR copper with brazed connections.
      e. 4" and smaller: Type ACR or type K drawn temper copper with brazed connections.
   2. Hot Gas and Liquid lines
      a. 1-1/2" and smaller: Type ACR copper with soldered connections.
      b. 1-1/2" and smaller: Type ACR copper with brazed connections.
      c. 4" and smaller: Type ACR or type K drawn temper copper with brazed connections.
      d. 2" and greater": schedule 40 black steel with wrought fittings and welded joints
   3. Safety relief valve piping
      a. 1-1/2" and smaller: Type ACR copper with soldered connections.
      b. 1-1/2" and smaller: Type ACR copper with brazed connections.
      c. 4" and smaller: Type ACR or type K drawn temper copper with brazed connections.
      d. 2" and greater": schedule 40 black steel with wrought fittings and welded joints

B. Hanger Spacing for Copper Tubing.

END OF SECTION

SECTION 23 3100
HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Metal ductwork.

B. Nonmetal ductwork.

1.02 REFERENCE STANDARDS

A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.

B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

D. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements.

E. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements.

F. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

G. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

I. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.

1.03 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data for duct materials.

C. Shop Drawings: Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work for all systems.

D. 1/4":1'-0" scale coordination plans indicating duct size, elevation, fittings, accessories.

E. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

PART 2 PRODUCTS

2.01 DUCT ASSEMBLIES

A. Regulatory Requirements: Construct ductwork to comply with NFPA 90A standards.

B. Ducts: Galvanized steel, unless otherwise indicated.

C. Low Pressure Supply (Heating Systems): 2 inch w.g. pressure class or the fan system external static pressure, whichever is greater, galvanized steel.

D. Low Pressure Supply (System with Cooling Coils): 2 inch w.g. pressure class or the fan system external static pressure, whichever is greater, galvanized steel.

E. ductwork between terminal units and air outlets: 1/2" pressure class, galvanized steel.

F. Return and Relief: 1 inch w.g. pressure class or the fan system external static pressure, whichever is greater, galvanized steel.

G. General Exhaust: 1 inch w.g. pressure class or the fan system external static pressure, whichever is greater, galvanized steel.

H. Outside Air Intake: 1/2 inch w.g. pressure class, galvanized steel.

I. Transfer Air and Sound Boots: 1/2 inch w.g. pressure class, internally lined galvanized steel.

2.02 MATERIALS

A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G60/Z180 coating.

B. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
   1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
   2. VOC Content: Not more than 250 g/L, excluding water.
   3. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
   4. For Use With Flexible Ducts: UL labeled.
   5. Manufacturers:
      a. Carlisle HVAC Products; Hardcast Iron-Grip 601 Water Based Duct Sealant: www.carlislehvac.com/#sle.
      b. Ductmate Industries, Inc, a DMI Company: www.ductmate.com/#sle.
      c. Or equal as approved.

C. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

D. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
   1. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
   2. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
   3. Concrete Screw Type Anchors: Complying with ICC-ES AC193.
   4. Masonry Screw Type Anchors: Complying with ICC-ES AC106.
   5. Other Types: As required.

2.03 DUCTWORK FABRICATION

A. Fabricate and support in accordance with SMACNA (DCS) and as indicated.

B. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation.

D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

E. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).

F. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, providea full sized 6" deep plenum and tap duct into plenum. Use same material as duct.

2.04 MANUFACTURED DUCTWORK AND FITTINGS

A. Spiral Ducts: Round spiral lockseam duct with galvanized steel outer wall.
   1. Manufacture in accordance with SMACNA (DCS).

B. Round Ducts: Round lockseam duct with galvanized steel outer wall.
   1. Manufacture in accordance with SMACNA (DCS).

C. Flexible Ducts: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound spring steel wire.
   1. Insulation: Fiberglass insulation with polyethylene vapor barrier film.
   2. Pressure Rating: 10 inches WG positive and 1.0 inches WG negative.
   3. Maximum Velocity: 4000 fpm.
   4. Temperature Range: Minus 20 degrees F to 210 degrees F.
   5. maximum length: 5 feet

D. Flexible Ducts: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound spring steel wire.
   1. Insulation: None.
   2. Pressure Rating: 10 inches WG positive and 1.0 inches WG negative.
   3. Maximum Velocity: 4000 fpm.

4. Temperature Range: Minus 20 degrees F to 210 degrees F.

E. Specialty Coatings for Metal Ductwork: Factory or field-applied per manufacturers instructions.
1. Application: Antimicrobial.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install, support, and seal ducts in accordance with SMACNA (DCS).

B. Install in accordance with manufacturer's instructions.

C. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

D. Flexible Ducts: Connect a maximum of 5' section to metal ducts with liquid adhesive plus tape.

E. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.

F. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

H. Use double nuts and lock washers on threaded rod supports.

I. paint inside of plenums and ductwork visible from outside with flat black paint. ref

J. Connect diffusers or light troffer boots to low pressure ducts directly or with 5 feet maximum length of flexible duct held in place with strap or clamp.

K. At exterior wall louvers, seal duct to louver frame and install blank-out panels.

L. Paint inside of plenums, diffuser boots, and ductwork visible from outside flat black.

END OF SECTION

SECTION 23 3300
AIR DUCT ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Backdraft dampers - metal.

B. Duct access doors.

C. Duct test holes.

D. Flexible duct connectors.

E. Volume control dampers.

F. Miscellaneous products:
   1. Damper operators.
   2. Duct opening closure film.

1.02 REFERENCE STANDARDS

A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

B. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

C. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

D. UL 33 - Safety Heat Responsive Links for Fire-Protection Service.

E. UL 555 - Standard for Fire Dampers.

1.03 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide for shop fabricated assemblies including volume control dampers and duct access doors. Include electrical characteristics and connection requirements.

C. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers and duct access doors.

D. Manufacturer's Installation Instructions: Provide instructions for fire dampers.

E. Project Record Drawings: Record actual locations of access doors.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 6000 - Product Requirements, for additional provisions.
   2. Extra Fusible Links: One of each type and size.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect dampers from damage to operating linkages and blades.

PART 2 PRODUCTS

2.01 BACKDRAFT DAMPERS - METAL

A. Manufacturers:
   1. Louvers & Dampers, Inc, a brand of Mestek, Inc: www.louvers-dampers.com/#sle.
   2. Nailor Industries, Inc: www.nailor.com/#sle.
   3. Ruskin Company: www.ruskin.com/#sle.
   4. Or Equal.

B. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Extruded aluminum, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.02 DUCT ACCESS DOORS

A. Manufacturers:

1. Acudor Products Inc, a Division of Nelson Industrial Inc: www.acudor.com/#sle.
2. Ductmate Industries, Inc, a DMI Company: www.ductmate.com/#sle.
3. Elgen Manufacturing, Inc: www.elgenmfg.com/#sle.
4. Lloyd Industries, Inc: www.firedamper.com/#sle.
5. MKT Metal Manufacturing: www.mktduct.com/#sle.
6. Nailor Industries, Inc: www.nailor.com/#sle.
7. Ruskin Company: www.ruskin.com/#sle.
8. SEMCO LLC: www.semcohvac.com/#sle.
9. Ward Industries, a brand of Hart and Cooley, Inc: www.wardind.com/#sle.
10. Or Equal.

B. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, install minimum 1 inch thick insulation with sheet metal cover.
   1. Up to 18 inches Square: Provide two hinges and two sash locks.
   2. Up to 24 by 48 inches: Three hinges and two compression latches with outside and inside handles.
   3. Larger Sizes: Provide an additional hinge.

2.03 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

2.04 FIRE DAMPERS

A. Manufacturers:
   1. AireTechnologies, Inc, a DMI Company: www.airetechnologies.com/#sle.
   2. Lloyd Industries, Inc: www.firedamper.com/#sle.
   3. Louvers & Dampers, Inc, a brand of Mestek, Inc: www.louvers-dampers.com/#sle.
   4. Nailor Industries, Inc: www.nailor.com/#sle.
   5. NCA, a brand of Metal Industries Inc: www.ncamfg.com/#sle.
   6. Pottorff: www.pottorff.com/#sle.
   7. Ruskin Company: www.ruskin.com/#sle.
   8. Ward Industries, a brand of Hart and Cooley, Inc: www.wardind.com/#sle.
   9. or approved equal.

B. Fabricate and install in accordance with NFPA 90A and UL 555, and as indicated.

C. Horizontal Dampers: Galvanized steel, 22 gage, 0.0299 inch frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket.

D. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations or closure under air flow conditions. Configure with blades out of air stream except for 1.0 inch pressure class ducts up to 12 inches in height.

E. Fusible Links: UL 33, separate at 165 degrees F with adjustable link straps for combination fire/balancing dampers.

2.05 FLEXIBLE DUCT CONNECTORS

A. Manufacturers:
   1. Carlisle HVAC Products; Dynair Connector Plus G90 Steel Offset Seam Neoprene Fabric: www.carlislehvac.com/#sle.
   2. Ductmate Industries, Inc, a DMI Company: www.ductmate.com/#sle.
   3. Elgen Manufacturing, Inc: www.elgenmfg.com/#sle.
   4. Or Equal.

B. Fabricate in accordance with SMACNA (DCS) and as indicated.

C. Flexible Duct Connections: Fabric crimped into metal edging strip.
   1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd.

a. Net Fabric Width: Approximately 3 inches wide.

2. Metal: 3 inches wide, 24 gage, 0.0239 inch thick galvanized steel.

D. Maximum Installed Length: 14 inch.

2.06 VOLUME CONTROL DAMPERS

A. Manufacturers:
1. AireTechnologies, Inc, a DMI Company: www.airetechnologies.com/#sle.
2. Louvers & Dampers, Inc, a brand of Mestek, Inc: www.louvers-dampers.com/#sle.
3. MKT Metal Manufacturing: www.mktduct.com/#sle.
4. Nailor Industries, Inc: www.nailor.com/#sle.
5. NCA, a brand of Metal Industries Inc: www.ncamfg.com/#sle.
6. Ruskin Company: www.ruskin.com/#sle.
7. Or Equal.

B. Fabricate in accordance with SMACNA (DCS) and as indicated.

C. Single Blade Dampers:
1. Fabricate for duct sizes up to 12 by 48 inch.
2. Blade: 24 gage, 0.0239 inch, minimum.

D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 by 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

E. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.

F. Quadrants:
1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
3. Where rod lengths exceed 30 inches provide regulator at both ends.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 3100 for duct construction and pressure class.

B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

C. Provide dampers in the mains, branches, returns, exhaust, and outdoor air intakes for balancing of each duct system.

D. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96 Provide minimum 8 by 8 inch size for hand access, size for shoulder access, and as indicated. Provide 4 by 4 inch for balancing dampers only. Review locations prior to fabrication.

E. Provide duct test holes where indicated and required for testing and balancing purposes.

F. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.

G. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.

H. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.

I. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

END OF SECTION

SECTION 23 3423
HVAC POWER VENTILATORS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Roof exhausters.

B. Wall exhausters.

C. Inline centrifugal fans.

D. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.

1.02 REFERENCE STANDARDS

A. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program.

B. AMCA 99 - Standards Handbook.

C. AMCA 204 - Balance Quality and Vibration Levels for Fans.

D. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

E. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.

F. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.03 ADMINISTRATIVE REQUIREMENTS

A. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.04 SUBMITTALS

A. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.

B. Manufacturer's Instructions: Indicate installation instructions.

C. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Extra Fan Belts: One set for each individual fan.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.06 FIELD CONDITIONS

A. Permanent ventilators may not be used for ventilation during construction.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Greenheck Fan Corporation: www.greenheck.com/#sle.

B. Loren Cook Company: www.lorencook.com/#sle.

C. PennBarry, Division of Air System Components: www.pennbarry.com/#sle.

D. Or Equal.

2.02 POWER VENTILATORS - GENERAL

A. Static and Dynamically Balanced: AMCA 204 - Balance Quality and Vibration Levels for Fans.

B. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.

C. Sound Ratings: AMCA 301, tested to AMCA 300 and bearing AMCA Certified Sound Rating Seal.

D. Fabrication: Comply with AMCA 99.

E. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

F. Enclosed Safety Switches: Comply with NEMA 250.

2.03 ROOF EXHAUSTERS

A. Fan Unit: Belt driven or direct drive electronically commutated motor with speed control via 0-10VDC as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.

B. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.

C. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

D. Belt tensioner: Provide belt tensioner on all belt driven units.

2.04 WALL EXHAUSTERS

A. Fan Unit: Direct electronically commutated motor with speed control via 0-10VDC with aluminum housing; resiliently mounted motor; 1/2 inch mesh, 0.062 inch thick aluminum wire bird screen.

B. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor, and wall mounted solid state speed controller.

C. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked.

D. Sheaves: For V-belt drives, provide cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.05 INLINE CENTRIFUGAL FANS

A. Centrifugal Fan Unit: Direct electronically commutated motor with speed control via 0-10VDC with galvanized steel housing, resilient mounted motor, gravity backdraft damper in discharge.

B. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof exhausters with cadmium plated steel lag screws to roof curb.

C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.

D. Hung Inline Fans:
1. Install fans with resilient mountings and flexible electrical leads. Refer to Section 22 0548.
2. Install flexible connections specified in Section 23 3300 between fan and ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

E. Provide sheaves required for final air balance.

F. Install backdraft dampers on inlet to roof and wall exhausters.

G. Provide backdraft dampers on outlet from cabinet and ceiling exhauster fans and as indicated.

END OF SECTION

SECTION 23 3600
AIR TERMINAL UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Single-duct terminal units.
   1. Single-duct, constant-volume units.
   2. Single-duct, variable-volume units.

1.02 REFERENCE STANDARDS

A. AHRI 880 (I-P) - Performance Rating of Air Terminals.

B. ASHRAE Std 130 - Laboratory Methods of Testing Air Terminal Units.

1.03 SUBMITTALS

A. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.

B. Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.

C. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant-volume regulators.

D. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.04 WARRANTY

A. Provide five year manufacturer warranty for air terminal units.

PART 2 PRODUCTS

2.01 SINGLE-DUCT, VARIABLE-VOLUME AND CONSTANT-VOLUME UNITS

A. Manufacturers:
   1. Trane, a brand of Ingersoll Rand: www.trane.com/#sle.
   2. Carrier.
   3. Johnson Controls.
   4. Price.
   5. Or Equal.

B. General:
   1. Factory-assembled, AHRI 880 (I-P) rated and bearing the AHRI seal, air volume control terminal with damper assembly, flow sensor, externally mounted volume controller, duct collars, and all required features.
   2. Control box bearing identification, including but not necessarily limited to nominal cfm, maximum and minimum factory-set airflow limits, coil type and coil (right or left hand) connection, where applicable.

C. Unit Casing:
   1. Minimum 22 gage, 0.0299 inch galvanized steel.
      a. Casing leakage to meet ASHRAE Std 130.
   2. Air Inlet Collar: Provide round, suitable for standard flexible duct sizes.
   3. Unit Discharge: Rectangular, with slip-and-drive connections.
   4. Acceptable Liners:
      a. Liner not to contain pentabrominated diphenyl ether (CAS #32534-81-9) or octabrominated diphenyl ether.

D. Damper Assembly:
   1. Provide integral position indicator or alternative method for indicating damper position over full range of 90 degrees.

2. Incorporate low leak damper blades for tight airflow shutoff.
    a. Air Leakage Past Closed Damper: Maximum two percent of unit maximum airflow at 3 inch wg inlet static pressure, tested in accordance with ASHRAE Std 130.

E. Controls:
1. DDC (Direct-Digital Controls):
    a. Bi-directional Damper Actuator: 24 volt, powered closed, spring return open.
    b. Microprocessor-Based Controller: Air volume controller, pressure-independent with electronic airflow transducers, factory-calibrated maximum and minimum CFM's.
        1) Occupied and unoccupied operating mode.
        2) Remote reset of temperature or CFM set points.
        3) Proportional, plus integral control of room temperature.
        4) Monitoring and adjusting with portable terminal.
    c. Room Sensor:
        1) Compatible with temperature controls specified.
        2) Wall-mounted, system powered, with temperature set-point adjustment including connection access for portable operator terminal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that conditions are suitable for installation.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install the inlets of air terminal units and air flow sensors a minimum of four duct diameters from elbows, transitions, and duct takeoffs.

C. Provide ceiling access doors or locate units above easily removable ceiling components.

D. Do not support from ductwork.

E. Connect to ductwork in accordance with Section 23 3100.

F. Install heating coils in accordance with Section 23 8200.

END OF SECTION

SECTION 23 3700
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Diffusers:

B. Rectangular ceiling diffusers.

C. Registers/grilles:
   1. Ceiling-mounted, exhaust and return register/grilles.

D. Gravity ventilators.

1.02 REFERENCE STANDARDS

A. AMCA 511 - Certified Ratings Program Product Rating Manual for Air Control Devices.

B. AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers.

C. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.

D. ASTM B221M - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric).

E. SMACNA (ASMM) - Architectural Sheet Metal Manual.

1.03 SUBMITTALS

A. See General Conditions and Supplementary Conditions.

B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

PART 2 PRODUCTS

2.01 RECTANGULAR CEILING DIFFUSERS

A. Manufacturers:
   1. Krueger-HVAC: www.krueger-hvac.com/#sle.
   2. Metalaire, a brand of Metal Industries Inc: www.metalaire.com/#sle.
   3. Tustin.
   4. Or Equal.

B. Type: Provide square and rectangular, multi-louvered diffuser to discharge air in four way pattern with sectorizing baffles where indicated.

C. Connections: Round.

D. Frame: Provide surface mount and inverted T-bar type. In plaster ceilings, provide plaster frame and ceiling frame.

E. Fabrication: Steel with baked enamel finish.

F. Color: white.

G. Accessories: Provide butterfly volume control damper; gaskets for surface mounted diffusers with damper adjustable from diffuser face.

2.02 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

A. Manufacturers:
   1. Krueger-HVAC: www.krueger-hvac.com/#sle.
   2. Metalaire, a brand of Metal Industries Inc: www.metalaire.com/#sle.
   3. Tustin.
   4. Or Equal.

B. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, vertical face.

C. Frame: 1-1/4 inch margin with countersunk screw mounting.

D. Fabrication: Steel with 20 gage, 0.0359 inch minimum frames and 22 gage, 0.0299 inch minimum blades, steel and aluminum with 20 gage, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.

E. Fabrication: Stainless steel with 20 gage, 0.0359 inch minimum frames and 22 gage, 0.0299 inch minimum blades, steel and aluminum with 20 gage, 0.0359 inch minimum frame.

F. Color: White.

G. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

2.03 GRAVITY VENTILATORS

A. Hood Intake and Relief Gravity Ventilator:
   1. Manufacturers:
      a. Greenheck Fan Corporation
      b. Loren Cook Company
      c. Twin City Fan and Blower Company
      d. Or Equal.
   2. General:
      a. Low silhouette for intake applications with natural gravity or negative pressure system(s).
      b. Performance ratings and factory testing to be in accordance with AMCA 511 and AMCA 550.
      c. Equipment to bear permanently affixed manufacturer's nameplate listing model and serial number.
   3. Hood and Base:
      a. Material: Aluminum.
      b. Hood Construction: Precision formed, arched panels with interlocking seams.
      c. Vertical End Panels: Fully locked into hood end panels.
      d. Curb Cap: Pre-punched mounting holes for installation.
   4. Birdscreen:
      a. Fabricate in accordance with ASTM B221 (ASTM B221M).
      b. Construction: 1/2 inch Galvanized mesh.
      c. Horizontally mounted across hood intake area.
   5. Hood Support: Galvanized steel construction and fastened so hood can be removed completely from the base or hinged open.
   6. Options/Accessories:
      a. Roof Curbs:
         1) Mounted on the roof with fan.
         2) Material: Aluminum.
         3) Insulation Thickness: 1 inch.
      b. Provide extended base minimum 7 inch extension to base height making overall base 12 inches in height to prevent snow or moisture intake.
      c. Curb Seal: Rubber seal between fan and roof curb.
      d. Dampers:
         1) Type: Gravity or Motorized as indicated.
         2) Factory designed to prevent outside air from entering back into building when fan is off.
         3) Balanced for minimal resistance to flow.
         4) Galvanized frames with pre-punched mounting holes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.

C. Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement.

END OF SECTION

SECTION 23 4000
HVAC AIR CLEANING DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Bipolar Ionization System

B. Disposable panel filters.

C. Filter gauges.

1.02 REFERENCE STANDARDS

A. UL 867 - Electrostatic Air Cleaners Current Edition, Including All Revisions

B. UL 900 - Standard for Air Filter Units.

1.03 SUBMITTALS

A. See General Conditions and Supplementary Conditions

B. Product Data: Provide data on filter media, filter performance data, filter assembly and filter frames, dimensions, motor locations and electrical characteristics and connection requirements.

C. Operation and Maintenance Data: Include instructions for operation, changing, and periodic cleaning.

PART 2 PRODUCTS

2.01 BIPOLAR IONIZATION SYSTEM

A. Manufacturers:
   1. AtmosAir
   2. PlasmaAir.
   3. Global Plasma Solutions
   4. Or Equal.

B. A qualified representative from the manufacturer shall be available to inspect the installation of the air purification system to ensure installation in accordance with manufacturer's recommendation.

C. The complete Air Purification System including the Bi-polar ionization unit as assembled, complete with power and control wiring, and housing The units shall posses the following classifications:
   1. Underwriters Laboratories UL 1995 classification
   2. Underwriters Laboratories UL 867 classification
   3. Underwriters Laboratories UL 2043 classification
   4. USEPA Energy Star Certification
   5. OPA 2807-10
   6. OPA 2808-10

D. The bi-polar system shall have been 3rd party independently tested to ANSI / AHAM AC-1 2002 and provide a minimum performance of 125 Dust CADR (Clean Air Delivery Rate). The manufacturer of the equipment shall furnish proof of testing. Equipment that does not have independent testing to the above protocol shall not be accepted.

E. The bi-polar system shall have been independently tested to show a 99% reduction effectiveness on gram negative and gram positive bacteria and MS2 virus. The manufacturer of the equipment shall furnish proof of testing

F. The bi-polar system shall be tested to and comply with UL 867 Standard 40 Revision 2013 with respect to ozone emission. Proof of compliance by a certified independent laboratory test result shall be furnished.

G. Each Bi-Polar Ionization system shall be capable of effectively killing microorganisms throughout the ductwork and interior spaces served by the bi-polar system. (including mold, bacteria, and viruses), controlling gas phase contaminants generated from human occupants,

building structure and furnishings, and reducing static space charges.

H. The Bi-Polar ionization system shall be designed to increase ionization levels in the areas served by the air handling system the units are installed in. The acceptable ionization level increase is between 500 and 1,500 ions cm3. System commissioning shall include ion level measurements to ensure these design increase levels has been achieved.

I. The bi-polar ionization system shall operate in such a manner so that agglomeration or precipitation of airborne particulate shall not be permitted to collect on occupants, walls, or furnishings by virtue of its operation.

J. Air Exchange Rate: Air exchange rates may vary through the full operating range of a constant volume or VAV system. The quantity of air exchange shall not be increased due to requirements of the air purification system.

K. Velocity Profile: The air velocity through the plenum approaching the air purification system shall not exceed 2,500 fpm in the Bi-polar Ionization Section.

L. Humidity: Ion tubes shall not require preheat protection when the relative humidity of the entering air exceeds 85%. Relative humidity from 0 - 99% shall not cause damage, deterioration or dangerous conditions within the air purification system. The ion tubes shall be rated at 200° F. Tubes not rated to this temperature range shall not be accepted.

M. Equipment Requirements: A schematic representation of the ionization system is indicated on the drawings. Each unit shall include mounting plate, ion tube(s), ion generator, differential pressure switch and on/off switch with green LED power indicator. Each ion generator shall be capable of providing an adjustable voltage output to the electrodes of between 2,000 and 3,000 VAC by means of an internal transformer rated at 135 VA. Systems that do not provide a variable voltage output or transformer capacity as described above, shall not be accepted.

N. Electrode Specifications (Bi-Polar Ion Tubes) Each unit shall include the required number of electrodes and power generators sized to the air handling unit capacity and contaminant conditions. Electrodes shall be installed with insulators to create the required dielectric. Glass Ion Tubes shall not be accepted. The dielectric shall consist of suitable inorganic non-corrosive insulation material so that the presence of water vapor, gasses or airborne particles will not affect the dielectric value. Electrodes of ferrous or copper composition with or without plating are not acceptable due to uncontrolled corrosion. Each electrode shall be capable of 100 cfm of airflow per inch of electrode. Electrodes that do not conform to this specification shall not be accepted. Electrodes shall also be rated to 200°F. Electrodes that are rated for less that 200°F shall not be accepted.

O. Mounting: Electrodes and power generators shall be installed on the duct with a single point wiring connection. It shall include one quick disconnect electrical connector for removal from the power source without the use of hand tools.

P. The Bi-polar ionization system shall consist of ionization tubes, power generators, airflow switches, and other accessories required for safe and efficient operation. Needlepoint ion generators and glass ion tubes shall not be accepted.

2.02 DISPOSABLE PANEL FILTERS

A. Media: UL 900 Class 2, fiber blanket, factory sprayed with flameproof, non-drip, non-volatile adhesive.

B. Casing: Cardboard frame.

2.03 FILTER GAUGES

A. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range 0-0.5 inch WG, 2 percent of full scale accuracy.

B. Accessories: Static pressure tips with integral compression fittings, 1/4 inch aluminum tubing, 2-way or 3-way vent valves.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install air cleaning devices in accordance with manufacturer's instructions.

B. A manufacturer's authorized representative shall provide startup supervision and training of owner's personnel in the proper operation and maintenance of all equipment.

END OF SECTION

SECTION 23 7313
MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Casing construction.
B. Fan section.
C. Coil section.
D. Integral face and bypass coil section.
E. Filter and air cleaner section.
F. Damper section.
G. Ultraviolet lights.
H. Access section.
I. Controls.

1.02 RELATED REQUIREMENTS

A. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
B. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.
C. Section 23 0719 - HVAC Piping Insulation.
D. Section 23 3300 - Air Duct Accessories: Flexible duct connections.

1.03 REFERENCE STANDARDS

A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings.
B. ABMA STD 11 - Load Ratings and Fatigue Life for Roller Bearings.
C. ACGIH - Ultraviolet Radiation: TLV(R) Physical Agents 7th Edition Documentation.
D. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
E. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program.
F. AMCA 99 - Standards Handbook.
G. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
H. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
I. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
J. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating.
K. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating.
L. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
M. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality.
N. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
O. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
P. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
Q. UL (DIR) - Online Certifications Directory.

1.04 SUBMITTALS

A. Product Data:
   1. Published Literature: Indicate dimensions, weights, capacities, ratings, gauges and finishes of materials, and electrical characteristics and connection requirements.

2. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
3. Fans: Performance and fan curves with specified operating point clearly plotted, power, RPM.
4. Sound Power Level Data: Fan outlet and casing radiation at rated capacity.
5. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

B. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

C. Specimen Warranty: Submit sample of manufacturer's warranty.

D. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.

E. Manufacturer's Instructions: Include installation instructions.

F. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

G. Maintenance Materials: Furnish 3 sets of the following for startup, final balancing, and owner stock for first replacement:
1. Extra Fan Belts (one spare set for owner stock)
2. Extra Filters.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.06 REGULATORY REQUIREMENTS

A. Products Requiring Electrical Connection: Listed and classified by {\rs\#1} as suitable for the purpose specified and indicated.

1.07 WARRANTY

A. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Trane Inc: www.trane.com.

B. Carrier Corporation: www.carrier.com.

C. York International Corporation / Johnson Controls Inc: www.york.com.

D. Or Equal.

2.02 CASING CONSTRUCTION

A. Full Perimeter Base Rail:
1. Construct of galvanized steel.
2. Provide base rail of sufficient height to raise unit for external trapping of condensate drain pans.

B. Casing:
1. Construct of one piece, insulated, double wall panels.
2. Provide mid-span, no through metal, internal thermal break.
3. Construct outer panels of galvanized steel and inner panels of galvanized steel.
4. Casing Air Pressure Performance Requirements:
   a. Able to withstand up to 8 inches w.g. positive or negative static pressure.
   b. Not to exceed 0.0042 inches per inch deflection at 1.5 times design static pressure up to a maximum of plus 8 inches w.g. in positive pressure sections and minus 8 inches w.g. in negative pressure sections.

C. Access Doors:
   1. Construction, thermal and air pressure performance same as casing.
   2. Provide surface mounted handles on hinged, swing doors.

D. Outside Air and Exhaust Air Weather Hood:
   1. Fabricate from same material as casing outer panel.
   2. Extend hood past perimeter of unit casing opening so as not to instruct airflow path.
   3. Paint hoods with same finish as external surface of outdoor units.
   4. Provide inlet hood for each fresh air damper with a sine wave moisture eliminator to prevent entrainment of water into the unit from outside air.
   5. Provide exhaust hoods for each exhaust air opening.
   6. Size each hood for 100 percent of nominal fresh air damper capacities.
   7. Protect each hood with bird screen to prevent nesting at intake or exhaust air flow paths.

E. Unit Flooring: Construct with sufficient strength to support expected people and equipment loads associated with maintenance activities.

F. Casing Leakage: Seal joints and provide airtight access doors so that air leakage does not exceed one percent of design flow at the specified casing pressure.

G. Insulation:
   1. Provide minimum thermal thickness of 12 R throughout.
   2. Completely fill panel cavities in each direction to prevent voids and settling.
   3. Comply with NFPA 90A.

H. Drain Pan Construction:
   1. Provide cooling coil and humidifier sections with an insulated, double wall, galvanized steel drain pan complying with ASHRAE Std 62.1 for indoor air quality and sufficiently sized to collect all condensate.
   2. Slope in two planes to promote positive drainage and eliminate stagnate water conditions.
   3. Locate outlet of sufficient diameter at lowest point of pan to prevent overflow at normal operating conditions.
   4. Provide threaded drain connections constructed of drain pan material, extended sufficient distance beyond the base to accommodate field installed, condensate drain trapping.

I. Louvers: Stationary, of galvanized steel, 4 inch deep with plenum, nylon bearings, 1/2 inch mesh, 0.04 inch galvanized wire bird screen in aluminum frame, and bearing AMCA Certified Ratings Seal in accordance with AMCA 500-L. Furnish adjustable louvers with hollow vinyl bulb edging on blades and foam side stops to limit leakage to maximum 2 percent at 4 inch wg differential pressure when sized for 2000 fpm face velocity.

J. Finish:
   1. Indoor Units:
      a. Provide exterior, galvanized steel panels without paint.
      b. Color: Manufacturer's standard color.

2.03 FAN SECTION

A. Type: Forward curved, single width, single inlet, centrifugal plug type fan, in compliance with AMCA 99. Refer to Section 23 3413.

B. Performance Ratings: Determined in accordance with AMCA 210 and labeled with AMCA Certified Rating Seal.

C. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.

D. Bearings: Self-aligning, grease lubricated, with lubrication fittings extended to exterior of casing with plastic tube and grease fitting rigidly attached to casing.

E. External Motor Junction Box: Factory mount NEMA 4 external junction box and connect to extended motor leads from internally mounted motors.

F. Motor Wiring Conduit: Factory wire fan motor wiring to the unit mounted starter-disconnect, variable frequency drive, and external motor junction box.

G. Fan Accessories:
   1. Damper operator.

H. Flexible Duct Connections:
   1. For separating fan, coil, and adjacent sections.
   2. Refer to Section 23 3300.

I. Drives:
   1. Comply with AMCA 99.
   2. Bearings: Heavy duty pillow block type, ball bearings, with ABMA STD 9 L-10 life at 50,000 hours.
   3. Shafts: Solid, hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.
   4. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.
   5. Belt Guard: Fabricate to SMACNA (DCS); 0.106 inch thick, 3/4 inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.04 COIL SECTION

A. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends exposed outside casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.

B. Drain Pans: 24 inch downstream of coil and down spouts for cooling coil banks more than one coil high.

C. Eliminators: Three break of galvanized steel, mounted over drain pan.

D. Air Coils:
   1. Certify capacities, pressure drops, and selection procedures in accordance with AHRI 410.

E. Fabrication:
   1. Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
   2. Fins: Aluminum.
   3. Casing: Die formed channel frame of galvanized steel.

F. Water Heating Coils:
   1. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
   2. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.

G. Water Cooling Coils:
   1. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
   2. Configuration: Drainable, with threaded plugs for drain and vent; threaded plugs in return bends and in headers opposite each tube.

2.05 FILTER AND AIR CLEANER SECTION

A. General: Provide filter sections with filter racks, minimum of one access door for filter removal, and filter block-offs to prevent air bypass.

B. Hi-Efficiency Filters:
   1. Media: 2 inch prefilter and 4 inch closely spaced, pleated, fine fiber, hi-efficiency filter, sealed into a rigid frame, and capable of operating up to a maximum of 625 fpm without loss of efficiency and holding capacity.

2. Filter Rack: Side-access designed to hold rigid frames.
3. Minimum Efficiency Reporting Value: 13 MERV when tested in accordance with ASHRAE Std 52.2.

C. Differential Pressure Gauge:
1. Provide factory installed dial type differential pressure gauge, flush mounted with casing outer wall, and fully piped to both sides of each filter to indicate status.
2. Maintain plus/minus 5 percent accuracy within operating limits of 20 degrees F to 120 degrees F.

2.06 DAMPER SECTION

A. Mixing Section: Provide a functional section to support the damper assembly for modulating the volume of outdoor, return, and exhaust air.

B. Damper Blades:
1. Double-skin airfoil design with metal, compressible jamb seals and extruded-vinyl blade-edge seals on each blade.
2. Self-lubricating stainless steel or synthetic sleeve bearings.
3. Comply with ASHRAE Std 90.1 I-P for rated maximum leakage rate.
4. Provide leakage testing and pressure ratings in compliance with AMCA 500-D test methods.
5. Arrange in parallel or opposed-blade configuration.

C. Barometric Relief Dampers:
1. Frame: Roll formed galvanized steel.
2. Blades: Roll formed galvanized steel.
3. Blade Seals: Extruded vinyl, mechanically attached to the blade edge.

2.07 CONTROLS

A. Combination VFD - Disconnects:
1. Provide factory mounted, combination VFD - disconnect for each fan motor.
2. Factory mount in full metal enclosure and wire to fan motor.

B. Factory Installed Direct Digital Control (DDC) System:
1. Factory engineer and test each component.
2. Provide fully functional control system to operate in either stand-alone mode or as part of the building automation system (BAS) via single pair of twisted wires tie-in.
3. DDC Controller:
a. Dedicated, field programmable DDC controller with appropriate point capabilities.

C. Factory Provided Controls for Field Installation:
1. Control valves.
2. Space and outdoor air temperature sensors.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Bolt sections together with gaskets.

C. Install flexible duct connections between fan inlet and discharge ductwork and air handling unit sections. Ensure that metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

D. Install assembled unit on vibration isolators. Install isolated fans with resilient mountings and flexible electrical leads. Install restraining snubbers as indicated. Refer to Section 22 0548. Adjust snubbers to prevent tension in flexible connectors when fan is operating.

E. Provide fixed sheaves required for final air balance.

F. Make connections to coils with unions or flanges.

G. Hydronic Coils:

1. Hydronic Coils: Connect water supply to leaving air side of coil (counterflow arrangement).
2. Provide shut-off valve on supply line and lockshield balancing valve with memory stop on return line.
3. Locate water supply at bottom of supply header and return water connection at top.
4. Provide manual air vents at high points complete with stop valve.
5. Ensure water coils are drainable and provide drain connection at low points.

3.02 SYSTEM STARTUP

A. Provide manufacturer's field representative to perform systems startup.

B. Prepare and start equipment and systems in accordance with manufacturers' instructions and recommendations.

C. Adjust for proper operation within manufacturer's published tolerances.

3.03 CLOSEOUT ACTIVITIES

A. Demonstrate proper operation of equipment to Owner's designated representative.

B. Demonstration: Demonstrate operation of system to Owner's personnel.
   1. Use operation and maintenance data as reference during demonstration.
   2. Briefly describe function, operation, and maintenance of each component.

C. Training: Train Owner's personnel on operation and maintenance of system.
   1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
   2. Provide minimum of two hours of training.
   3. Instructor: Manufacturer's training personnel.
   4. Location: At project site.

END OF SECTION

SECTION 23 8101
TERMINAL HEAT TRANSFER UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Unit heaters.

B. Cabinet unit heaters.

C. Unit ventilators.

1.02 SUBMITTALS

A. Product Data: Provide typical catalog of information including arrangements.

B. Shop Drawings:
   1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
   2. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
   3. Indicate mechanical and electrical service locations and requirements.,

C. Manufacturer's Instructions: Indicate installation instructions and recommendations.

D. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.

E. Operation and Maintenance Data: Include manufacturers descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.

F. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.03 WARRANTY

A. Provide five year manufacturers warranty for unit ventilators and heaters.

1.04 SPARE PARTS

A. furnish 3 sets of filters, one set for startup, one set for final balance, and one set to be delivered to the owner as a spare stock.

PART 2 PRODUCTS

2.01 UNIT HEATERS

A. Manufacturers:
   1. Trane Inc: www.trane.com/#sle.
   2. Carrier Corporation: www.carrier.com/#sle.
   3. York International Corporation / Johnson Controls Inc: www.york.com.
   4. Or Equal.

B. Coils: Seamless copper tubing, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.

C. Casing: 0.0478 inch steel with threaded pipe connections for hanger rods.

D. Finish: Factory applied baked enamel of color.

E. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.

F. Air Outlet: Adjustable pattern diffuser on projection models and two way louvers on horizontal throw models.

G. Motor: Permanently lubricated sleeve bearings on horizontal models, grease lubricated ball bearings on vertical models.

H. Provide with factory-installed disconnect switch.

2.02 CABINET UNIT HEATERS

A. Manufacturers:
   1. Trane Inc: www.trane.com/#sle.
   2. Carrier Corporation: www.carrier.com/#sle.
   3. York International Corporation / Johnson Controls Inc: www.york.com.
   4. Or Equal.

B. Coils: Evenly spaced aluminum fins mechanically bonded to copper tubes, designed for 100 psi and 220 degrees F.

C. Cabinet: 0.0598 inch steel with exposed corners and edges rounded, easily removed panels, glass fiber insulation and integral air outlet and inlet grilles.

D. Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.

E. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.

F. Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted.

G. Control: Multiple speed switch, factory wired, located in cabinet.

H. Filter: Easily removed 1 inch thick glass fiber throw-away type, located to filter air before coil.

I. Provide with factory-installed disc

2.03 UNIT VENTILATORS

A. Manufacturers:
   1. Trane Inc: www.trane.com/#sle.
   2. Carrier Corporation: www.carrier.com/#sle.
   3. York International Corporation / Johnson Controls Inc: www.york.com.
   4. Or Equal.

B. Coils: Copper tubes mechanically expanded into evenly spaced aluminum fins tested to operate at 150 psi. Provide drain pan under cooling coil, easily removable for cleaning, with drain connection.

C. Cabinet: 0.0747 inch steel on solid base pan with exposed edges rounded. Provide removable front panels with quick-acting, key-operated cam locks. Provide removable die-cast or fabricated steel discharge grilles. For units having cooling coils, insulate internal parts and surfaces exposed to conditioned air stream with moisture resistant insulation.

D. Cabinet Accessories: Matching steel construction, matching finish, reinforced, full adapter back along the entire length and height of the back of the unit.

E. Finish: Factory apply baked enamel of color on visible surfaces of enclosure or cabinet.

F. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven, arranged to draw air through coil.

G. Wall Louvers: Anodized aluminum wall intake box and louvers removable from frame with 1/2 inch square mesh galvanized screen in back of louver.

H. Motor: Electronically commutated direct drive to provide variable air volume operation.

I. Control: Factory mounted controls, manufacturer provided standalone direct digital controller (DDC).

J. Filter: Easily removed 1 inch thick glass fiber throw-away MERV-8 type, located to filter air before coil.

K. Mixing Dampers: Multi-blade with compressible seal, capable of varying proportion of mixed air from 100 percent room air to 100 percent outside air.

L. Freeze Protection: Provide face and bypass dampers for freeze protection and temperature control.

M. Provide with factory-installed disconnect swtich.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install equipment exposed to finished areas after walls and ceiling are finished and painted. Do not damage equipment or finishes.

C. Protection: Provide finished cabinet units with protective covers during balance of construction.

D. Unit Heaters: Hang from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

E. Cabinet Unit Heaters: Install as indicated. Coordinate to assure correct recess size for recessed units.

F. Unit Ventilators: Locate as indicated, level and shim units, and anchor to structure. Coordinate exact location of wall louvers.

G. Hydronic Units: Provide with shut-off valve on supply and lockshield balancing valve on return piping. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing. For cabinet unit heaters, fan coil units, and unit heaters, provide float operated automatic air vents with stop valve.

H. Units with Cooling Coils: Connect drain pan to condensate drain.

3.02 CLEANING

A. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. Install new filters.

END OF SECTION

SECTION 23 8126.13
SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

PART 2 PRODUCTS

1.01 MANUFACTURERS

A. Carrier Corporation: www.carrier.com/#sle.

B. Trane Inc: www.trane.com/#sle.

C. York International Corporation / Johnson Controls: www.york.com/#sle.

D. Or Equal.

1.02 SYSTEM DESIGN

A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
   1. Heating: Hot Water.
   2. Cooling: Outdoor electric condensing unit with evaporator coil in central ducted indoor unit.
   3. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.

B. Performance Requirements: See Drawings for additional requirements.

1.03 INDOOR AIR HANDLING UNITS FOR DUCTED SYSTEMS

A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating and cooling element(s), controls, and accessories; wired for single power connection with control transformer.
   1. Air Flow Configuration: Upflow.
   2. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.

B. Supply Fan: Centrifugal type rubber mounted with direct or belt drive with adjustable variable pitch motor pulley.
   1. Motor: NEMA MG 1; 1750 rpm single speed, permanently lubricated, hinge mounted.
   2. Motor Electrical Characteristics:

C. Air Filters: 1 inch thick urethane, washable type arranged for easy replacement.

D. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
   1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
   2. Manufacturers: System manufacturer.

E. Provide with factory-installed disconnect switch.

1.04 OUTDOOR UNITS

A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
   1. Comply with AHRI 210/240.
   2. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
   3. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23.1 and UL 207.

B. Compressor: Hermetic, two speed 1800 and 3600 rpm, AHRI 520 resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.

C. Air Cooled Condenser: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.

1. Condenser Fans: Direct-drive propeller type.

D. Coil: Air-cooled, aluminum fins bonded to copper tubes.

E. Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).
   1. Provide thermostatic expansion valves.

F. Operating Controls:
   1. Provide with BACNET compatible controller for future integration.
   2. Provide with remote, programmable thermostat.
   3. Control by room thermostat to maintain room temperature setting.
   4. Low Ambient Kit: Provide refrigerant pressure switch to cycle condenser fan on when condenser refrigerant pressure is above 285 psig and off when pressure drops below 140 psig for operation to 0 degrees F.
   5. Provide with factory-installed disconnect switch.

END OF SECTION

SECTION 23 8200
CONVECTION HEATING AND COOLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Hydronic convectors.

1.02 REFERENCE STANDARDS

A. AHRI 350 - Sound Performance Rating of Non-Ducted Indoor Air-Conditioning and Heat Pump Equipment.

B. AHRI 840 - Unit Ventilators.

1.03 SUBMITTALS

A. Product Data: Provide typical catalog of information including arrangements.

B. Manufacturer's Instructions: Indicate installation instructions and recommendations.

C. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.

D. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

PART 2 PRODUCTS

2.01 HYDRONIC CONVECTORS

A. Manufacturers:
   1. Modine Manufacturing Company
   2. Sterling Hydronics, a Mestek Company
   3. Vulcan Radiator, a Mestek Company
   4. Or Equal.

B. Perform factory run test under normal operating conditions, and water flow rates.

C. Heating Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and cast iron headers, steel side plates and supports, factory air pressure tested at 100 psi under water, with means of adjusting pitch of element.

D. Cabinet: 16 gauge, 0.0598 inch sheet steel front and top, 18 gauge, 0.0478 inch sheet steel back and ends; exposed corners rounded; easily secured removable front panels, adequately braced and reinforced for stiffness.

E. Finish: Factory applied baked primer coat.

F. Damper: Where not thermostatically controlled, provide knob-operated internal damper at enclosure air outlet.

G. Access Doors: For otherwise inaccessible valves, provide factory-made permanently hinged access doors, 6 by 7 inch minimum size, integral with cabinet.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's recommendations.

B. Do not damage equipment or finishes.

C. Convectors:
   1. Install where indicated.
   2. Coordinate to ensure correct recess size for recessed convectors.

3.02 FIELD QUALITY CONTROL

A. Provide manufacturer's field representative to test, inspect, instruct, and observe.

3.03 CLEANING

A. After construction and painting is completed, clean exposed surfaces of units.

B. Vacuum clean coils and inside of units.

C. Touch-up marred or scratched surfaces of factory-finished cabinets using finish materials furnished by the manufacturer.

D. Install new filters.

3.04 PROTECTION

A. Provide finished cabinet units with protective covers during the balance of construction.

END OF SECTION

SECTION 26 0500

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:
1. Electrical equipment coordination and installation
2. Sleeves for raceways and cables
3. Sleeve seals
4. Common electrical installation requirements
5. Supporting devices for electrical components
6. Cutting and patching for electrical construction
7. Touchup painting

1.03 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. Provide: Furnish and install.

C. Directed: Directed by the A/E.

D. Indicated: Indicated in the Contract Documents.

E. Concealed: Hidden from normal sight. Includes items in shafts, pipe and duct spaces and above ceilings.

F. Exposed: Not concealed. Work within equipment rooms and all visible (normal sight) work shall be considered “exposed”.

1.04 SUBMITTALS

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

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

C. Electrical System Studies.

1.05 QUALITY ASSURANCE

A. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."

1.06 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So that connecting raceways, cables and wireways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
   1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

D. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

E. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent, are tested to demonstrate successful interoperability.

1.07 GENERAL REQUIREMENTS

A. Nothing contained in these "SPECIFICATIONS" or shown on the "DRAWINGS" shall be so constructed as to conflict with any local, municipal, or State laws or regulations governing the installation of electric or other work specified herein, and all such ordinances and regulations, including the National Electrical Code, are hereby incorporated and made a part of these specifications. All such requirements shall be satisfied by the Contractor and at no additional cost to the Owner.

B. Due to the small scale of drawings, it is not possible to indicate all conduits, conductors, boxes, fittings, switches, and similar parts which may be required. The contractor shall investigate the structural and finish conditions affecting the work and arrange all work accordingly furnishing such parts and equipment as may be required to meet building conditions.

C. Contractor shall lay out work from dimensions of architectural and structural drawings and actual dimensions of equipment being installed. Layouts in congested areas should not be scaled from mechanical or electrical drawings.

D. The Drawings are indicative of the character and scope of the work and are not intended to show all the details.

E. The actual location of all wiring, outlets, and equipment shall be determined at the site.

F. The Drawings shall be carefully checked, to ensure that all equipment, as shown, will operate satisfactorily in the space allotted to it.

G. Generally, major equipment of the system is located on the floor plans and the interconnecting conduit and wiring are indicated on the diagrams or called for in the Specifications.

1.08 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with all applicable requirements of NFPA 70, National Electrical Code.

C. Testing Agency: Use a NETA accredited electrical testing agency, or approved equal, that is accredited for the region in which the Contract work is performed. Refer to Section 26 0563.

1.10 REGULATIONS

D. All electrical work, equipment and material furnished or installed under this contract shall conform to the requirements of latest applicable codes and any other Governmental or Local Authorities having jurisdiction and all rules and regulations of the Utility Company involved. Nothing mentioned in the specifications or indicated on the drawings shall be construed to conflict with the mentioned codes, ordinances, and regulations.

E. All materials furnished, and all work installed, shall comply with the latest issue of the codes, rules, regulations, and recommendations of the following bodies, unless otherwise noted:
1. American National Standards Institute (ANSI)
2. American Society of Testing and Materials (ASTM)
3. International Building Code (IBC)
4. International Energy Conservation Code (IECC)
5. Insulated Power Cable Engineers Associate (IPCEA)
6. Insulated Cable Engineers Associate (ICEA), formerly IPCEA.
7. Illuminating Engineering Society (IES)
8. Institute of Electrical and Electronic Engineers (IEEE)
9. National Electrical Code (NEC)
10. National Electrical Manufacturers Association (NEMA)
11. National Fire Protection Association (NFPA)
12. National Electrical Safety Code (NESC)
13. National Electrical Contractors Association (NECA)
14. Occupational Safety and Health Agency (OSHA)
15. Underwriters Laboratories, Inc. (UL)
16. City or Local Code(s)
17. Pennsylvania Department of Labor and Industry (L&I)
18. Pennsylvania Department of Health (DoH)
19. National Board of Fire Underwriters
20. Americans with Disabilities Act (ADA)
21. City of Philadelphia Electrical Code
22. Other codes, as applicable

1.11 ELECTRICAL SYSTEM STUDIES

A. Prepare and submit a Short Circuit, Arc-Flash, and Protective Device Coordination Study as specified in this Article.
1. Immediately after award of the Contract, collect all data needed to perform calculations for the studies.

a. Obtain, in writing, electrical utility source information and any other information required from the utility to perform the necessary studies directly from the serving utility.
b. The Owner will provide, as available, information about the portions of the facility's existing electrical system affected by the work performed under this Contract.
    1) The Owner will provide copies of the latest revision of the existing facility record drawings to the Contractor for use in defining existing equipment load requirements.
    2) Base the contribution of motors on actual motor loads as indicated on the equipment list, system one-line diagrams, and panel schedules.
    3) If the information provided is insufficient to perform the studies or represents unknown ratings of existing equipment, investigate and obtain the information required.
        a) Employ qualified technicians to obtain the necessary data.
c. Obtain data for new equipment directly from suppliers and other contractors working on the project.

2. Once the data needed is obtained, perform a preliminary computerized Short Circuit, Arc-Flash, and Protective Device Coordination Study, complete with initial calculations.
    a. At least two full calendar weeks prior to submitting Shop Drawings for equipment included the respective studies, submit the preliminary studies and corresponding computer printouts and annotated one-line distribution diagram to the Engineer for review and comment.
    b. After the Engineer provides his comments, submit four copies of the revised and corrected preliminary studies.
3. Include the following types of information common to each study:
    a. Calculations and tabulations.
        1) Ensure that the calculations in the Short Circuit, Arc-Flash, and Protective Device Coordination Study are sufficient to ascertain interrupting and/or withstand ratings of the equipment.
            a) Identify items of distribution system equipment that are not rated for the available fault current and provide corrective recommendations for consideration.
    b. Data on the computer programs used to perform calculations and tabulations.
    c. An appendix to each report that includes the information obtained from outside entities, agencies, electrical manufacturers, the serving utility company, field inspections, and other field sources such as the following:
        1) Copies of letters.
        2) Photographic records.
        3) Nameplate tracings.
        4) Actual data sources from which the data and information was obtained.

B. Final Project Report:
1. After the Engineer accepts the revised and corrected preliminary studies, prepare a report summarizing the results of the individual studies; and submit this Final Project Report to the Engineer for acceptance and approval.
    a. Include the following sections in the Final Project Report:
        1) Description.
        2) Purpose.
        3) Basis and scope of the study.
        4) A single line diagram of that portion of the power system that is included within the scope of the study.
        5) Computerized time versus current coordination graphs and corresponding printouts for protective devices.
            a) Include the feeder cable damage curves associated with the items being coordinated in these graphs.

b) Include the ANSI/NEMA MG 1 damage points for the motors in the system and the ANSI/IEEE C57.12.00 mechanical and electrical damage points on the curves.

6) Tabulations of the relay and circuit breaker trip settings, fuse selection, and commentary regarding same.

7) Harmonic data at Points-of-Common-Coupling (PCC).

b. Submit ten bound copies of the Final Project Report for review and approval and two copies of record drawings showing the existing facility as it was before the work of this Contract was performed.

c. Once the Final Project Report has been approved, forward one additional bound final copy of the report to the Owner.

C. Short Circuit, Arc-Flash, and Protective Device Coordination Study:

1. Prepare the Short Circuit, Arc-Flash, and Protective Device Coordination Study under the supervision of a Professional Engineer, licensed in the Commonwealth of Pennsylvania, or have a NETA certified electrical testing laboratory employing technicians certified according to ANSI/NETA ETT prepare it.

a. Perform the short circuit portion of the Study in accordance with ANSI/IEEE C37.10, ANSI/IEEE C37.13, ANSI/IEEE 141, ANSI/IEEE 242, and ANSI/IEEE 399.

1) Calculate short circuit momentary duty values and interrupting duty values on the basis of the following short circuit conditions at every distribution transformer, secondary and primary terminal at every bus in every switchboard, motor control center, distribution panelboard, branch circuit panelboard and at terminals of utilization equipment whether it be Electrical, Process, HVAC, Plumbing or Instrumentation that is either 480V or 208V, 3-phase and rated 15 Amps or higher. Include:

a) Single line to ground fault.

b) Bolted three-phase line to ground fault.

c) Double line (line to line) to ground fault.

b. Perform the arc flash portion of the Study for the electrical distribution equipment in accordance with NFPA 70E and ANSI/IEEE 1584.

1) Perform the analysis under worst-case arc-flash conditions; and if applicable, describe in the final report how these conditions differ from worst-case bolted fault conditions.

2) Provide the following items for each circuit and arc location analyzed:

a) Printed hardcopy of calculations performed.

b) Arcing fault magnitude.

c) Device clearing time.

d) Duration of arc.

e) Arc flash boundary distances.

f) Working distance.

g) Arc flash incident energy.

h) Hazard risk category.

i) Personal-protective equipment classes.

j) Arc flash warning labels as specified in Section 26 05 23.

k) Recommendations and potential options for arc flash energy reduction to reduce the Incident Energy levels where they are calculated to be over the 40 cal/cm2.

l) Maintenance procedures/guidelines in accordance with the requirements of NFPA 70E for the Owner.

c. Coordinate protective devices with systems and equipment by providing the necessary calculations and logic decisions required to select or to check the selection of power fuse ratings, ratios and characteristics of associated current transformers, and breaker trip characteristics and settings and distribution system fuses.

1) Provide coordination plots for phase and ground protective devices on a system basis.
   a) Adhere to National Electrical Code restrictions and maintain proper coordination.
   b) Provide a sufficient number of separate curves to clearly indicate the coordination achieved.
2) Computer-generate time-current characteristics of the specified protective devices on log-log scale plots.
   a) Include complete titles, the respective one-line diagram and identifying legends, associated relays or fuse characteristics, significant motor starting characteristics, complete operating bands of low voltage circuit breaker trip curves and fuses.
   b) Indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing inrush, through-fault current duration per ANSI/IEEE C57.12.59, dry-type transformers withstand, cable thermal overcurrent withstand limits, symmetrical fault currents and motor full load current, locked-rotor current, and magnetizing inrush in the coordination plots.
3) Provide the selection and settings of the protective devices separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios and connection, manufacturer and type, range of adjustment, and recommended settings.
   a) Use the information from the Study to obtain optimum device protective and coordination performance.

2. In addition to the information common to the studies as listed in Subparagraph 1.11 A 3, include the following information specific to short circuit, arc-flash, and protective device coordination distortion only in the Short Circuit, Arc-Flash, and Protective Device Coordination Study:
   a. Complete short circuit and protective device coordination studies, including coordination plots, for the following electrical distribution systems serving the entire facility:
      1) Utility (primary) voltage service
      2) Low voltage service/distribution system.
      3) Low voltage 208Y/120 volts, 3 phase, 4 wire distribution systems.
   b. Power company supply and network characteristics, including the following:
      1) The base quantities selected.
      2) Source impedance data and impedance diagrams.
      3) One-line diagrams.
      4) Calculation methods and tabulations.
         a) Include short circuit tabulations of the fault impedance, X to R ratios, asymmetry factors, KVA, symmetrical and asymmetrical fault currents, and all multiplying factors.
      5) Conclusions and recommendations.
   c. Motor starting characteristics for motors 50 HP and above.
   d. Provide sufficient information in the study to ensure adequate protection of the cables, transformers, and other equipment; to indicate proper coordination between fuses and circuit breakers; and to determine areas of the system in which additional coordination may be required.
3. Submit Short Circuit, Arc-Flash, and Protective Device Coordination Study information with the equipment submittals for review by the Engineer.

1.12 PERMITS AND INSPECTIONS

A. Give all necessary notices and obtain all required permits. Pay all fees and other costs, including utility connections or extensions in connection with the work. File all necessary

plans, prepare all documents, and obtain all necessary approvals of all governmental agencies having jurisdiction. Obtain all required certifications of inspection and deliver same to the Architect.

1.13 RECORD DRAWINGS

A. The Contractor shall keep accurate records of all deviations in work as actually installed from work indicated. One complete set of Contract Documents shall be available at the construction site for indicating said deviations. The Contractor shall indicate routing of all feeders, junction boxes and the like.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

2.02 SLEEVES FOR RACEWAYS AND CABLES

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

B. Coordinate sleeve selection and application with selection and application of firestopping. Use UL listed materials as shown in a UL listed detail for the configuration of the penetration. Submit UL detail showing materials used.

2.03 MATERIALS AND EQUIPMENT

A. All materials and equipment furnished for the project shall be new and of first quality, produced by manufacturers of recognized reputation for each line of material or equipment. The fact that materials or equipment offered are recently developed and untried may be sufficient justification for their rejection. All materials, fittings, devices, and equipment shall be those approved by the Underwriters Laboratories, Inc., and if of the class for which the Underwriters Laboratories, Inc., provides label service, they shall bear such labels.

B. Where there is more than one item of equipment furnished under this Contract, the Contractor shall furnish equipment of the same type and from the same manufacturer. In no case shall the Contractor furnish similar types of equipment from different manufacturers. One manufacturer shall furnish all similar types of equipment.

2.04 TOUCHUP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give right of way to raceways and piping systems installed at a required slope.

F. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

3.02 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables or wireways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section, "Firestopping."

C. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

D. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both surfaces of walls.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require a different clearance.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.

K. Sleeves shall be provided by the Contractor for the installation of conduit, etc. The sleeves shall be carefully located in advance of the construction of walls and floors where new construction is involved. Provide all cutting and patching necessary to set sleeves which are not placed prior to construction. All cutting and patching necessary to set sleeves which are not placed prior to construction shall be the responsibility of the trade providing the sleeves.

L. Sleeves shall be provided for all conduit, etc. passing through concrete, masonry, plaster and gypsum wallboard construction

M. Fasten sleeves securely in the construction so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials being forced into space between conduits, etc., and sleeve during construction.

N. Sleeves required in existing concrete or masonry walls shall be set and secured with mortar grout and fast drying bitumastic sealant.

O. Where conduit motion due to expansion and contraction will occur, provide sleeves of sufficient diameter, or permit free movement of conduit. Check construction to determine proper length for various locations; make actual lengths to suit the following:
   1. Terminate sleeves flush with walls, partitions, and ceilings.
   2. Terminate sleeves 2 inches above finished floor in equipment rooms or Wet Locations.
   3. In all other areas, terminate sleeves 1/2-inch above finished floors.

3.03 SLEEVE-SEAL INSTALLATION

A. Install to seal underground, exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.04 FIELD QUALITY CONTROL

A. Inspect installed sleeve and sleeve-seal installations and associated firestopping for damage and faulty work.

3.05 WORKMANSHIP

A. Each subcontractor shall furnish the services of an experienced superintendent who shall be constantly in charge of the installation of the work.

B. The quality of the workmanship required for each trade in the execution of its work shall be the finest and highest obtainable in that trade working with the materials specified. Workmanship shall be satisfactory to the Architect and his decision as to the acceptable quality is final.

3.06 WATERPROOFING

A. Under no circumstances shall any waterproofing be damaged or penetrated. Should conditions arise which indicate such necessity, notify the Architect. Penetrations required by this Contract shall be made watertight.

3.07 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.08 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work, including the following:
1. Raceways
2. Supporting devices for electrical components
3. Electricity-metering components
4. Concrete bases
5. Cutting and patching for electrical construction
6. Touchup painting

3.09 REFINISHING AND TOUCHUP PAINTING

A. Refinish and touch up paint: Paint materials and application requirements are specified in Division 09 Section, "Painting."
1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.10 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

C. Conduit and Equipment to be painted: Clean all conduits exposed to view in completed structure by removing plaster and dirt. Remove grease, oil, and similar material from conduit and equipment by wiping with clean rags and suitable solvents in preparation for paint.

D. All Items with Factory Finish: Remove cement, plaster, grease and oil, and leave all surfaces, including cracks and corners, clean and polish. Touch up any scratched or bare spots to match finish. The Architect may approve factory finish as prime coat. See “Painting” Section.

E. Electrical equipment and materials exposed to public and in finished areas shall be finish-painted after installation to coordinate with surrounding walls. Surfaces shall be thoroughly cleaned for receiving paint. Paint color coordination shall be as directed, and on adjacent surfaces to insure proper matching of quality and color with surrounding areas.

F. All electrical apparatus and equipment in equipment rooms shall be provided with a factory finish coat. All panels in public spaces, corridors, etc. shall be provided with a factory prime coat and field finish painted to match surrounding finishes.

G. Site Cleaning: Remove from site all packing cartons, scrap materials, and other rubbish relating to electrical installation.

3.13 MECHANICAL EQUIPMENT WIRING

A. Furnish and install all conduit and power wiring to all safety switches, motor starters, start/stop switches, HOA switches, and thermal switches, and make final power connections to all mechanical equipment.

B. Provide all safety switches, motor starters, start/stop switches to mechanical equipment as indicated on the Contract Drawings.

C. All safety disconnect switches, shall be installed by the Electrical Contractor.

D. All control wiring shall be the responsibility of the respective Contractor supplying the equipment.

END OF SECTION 26 0500

SECTION 26 0519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for furnishing, installing, connecting, energizing, testing, cleaning, and protecting low voltage cable, shielded cable, and accessories.

B. Related Sections:
   1. Section 26 0500 – Common Work Results for Electrical
   2. Section 26 0526 – Grounding and Bonding for Electrical Systems
   3. Section 26 0553 – Identification for Electrical Systems
   4. Section 26 0533 – Raceways and Boxes for Electrical Systems
   5. Section 26 0563 – Acceptance Electrical Testing

1.02 REFERENCES

A. American Society for Testing Materials (ASTM):
   1. ASTM B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

B. Institute of Electrical and Electronic Engineers (IEEE):
   1. IEEE 1202 - Standard for Flame-Propagation Testing of Wire and Cables

C. National Electrical Manufacturer's Association (NEMA):
   1. NEMA WC 26/EEMAC 201 - Binational Wire and Cable Packaging Standard
   2. ANSI/NEMA WC 57 - Standard for Control, Thermocouple Extension, and Instrumentation Cables

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)

E. Underwriter's Laboratories, Inc. (UL):
   1. UL 13 - Standard for Power-Limited Circuit Cables
   2. UL 1581 - Reference Standard for Electrical Wires, Cables, and Flexible Cords
   3. UL 1685 - Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

F. Insulated Cable Engineers Association (ICEA):
   1. ICEA T-29-520 - Vertical Cable Tray Flame Test @ 210,000 BTU

1.03 DESIGN REQUIREMENTS

A. Conductors in Raceway and Conduit Systems:
   1. Provide conduit systems for installing wiring that is outside of equipment.
   2. Except for raceway or conduit for control wires or where otherwise indicated on the Contract Drawings, design raceway and conduit systems so that the maximum number of low-voltage current carrying conductors (per NFPA 70, Article 310) in each raceway or conduit does not exceed three, plus a ground.

B. Cable Tension Design Requirements:
   1. Design conduit runs so that the tension limits set by the wire and cable manufacturers will not be exceeded.
      a. Provide additional pulling points as required to limit the tension to acceptable levels.

C. Product Data and Catalog Cuts:
   1. Submit low-voltage ground, power, and control wiring product data as listed below for the products provided as the Work of this Section; and clearly indicate the usage of each product on the data submitted.
      a. Wires and cables.
      b. Lugs.
      c. Connectors.
      d. Tapes.
      e. Pulling lubricant.
      f. Tools used to crimp connectors.

D. Use of Trade Names:
   1. The use of trade names within the Contract Documents is intended to establish the basis of design and to illustrate the constructability and level of quality required.
      a. The use of trade names is not intended to exclude other manufacturers whose products are equivalent to those named, subject to compliance with Contract requirements.

1.04 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of General Conditions:
   1. Product Data:
      a. Wires and cables
      b. Lugs
      c. Connectors
      d. Tape
      e. Pulling lubricant
   2. Samples:
      a. Wire samples
   3. Quality Assurance/Control Submittals:
      a. Certificates:
         1) Testing agency/quality verification
      b. Manufacturer’s Instructions:
         1) Cable manufacturer’s recommendations
      c. Qualification Statements:
         1) Documented experience of the installing firm
         2) Qualifications of the licensed electricians supervising the Work

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Installer Qualifications:
      a. To install the Work of this Section, employ the services of a firm specializing in installing wire, cable, and accessories, and that has a minimum of 3 years experience doing so.
         1) Submit the documented experience of the firm installing the wire, cable, and accessories.
      b. To supervise installation of the Work of this Section, employ licensed electricians.

1) Submit the qualifications of the licensed electricians supervising the Work of this Section.

B. Regulatory Requirements:
1. Perform the Work of this Section in accordance with the requirements specified in NFPA 70, and to all other applicable state, local, and national governing codes and regulatory requirements.

C. Certifications:
1. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location installed in, and the application intended, unless products meeting the requirements of these testing laboratories are not available or unless standards do not exist for the products.
a. Provide copper conductors listed and labeled by UL for all wiring.
2. Submit evidence of testing agency/quality verification, listing, and labeling for each product with the submitted product data either by providing a printed mark on the data or by attaching a separate listing card.
a. For items without such evidence, submit a written statement from the product manufacturer that indicates why it does not have quality assurance verification.

1.06 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
1. Imprint insulated conductors with the date of manufacture, the wire type, and the manufacturer.
2. Package wire and cable in conformance with the requirements of NEMA WC 26/ EEMAC 201.
3. Protect items from damage during delivery, handling, and installation.
a. Comply with the cable manufacturer’s recommendations for inspection, handling, storage, temperature conditioning, bending and training limits, pulling limits, and calculation parameters for installing cable.
b. Submit the cable manufacturer’s recommendations for inspection, handling, storage, temperature conditioning, bending and training limits, pulling limits, and calculation parameters for installing cable

B. Acceptance at Site:
1. Wire and cable manufactured more than 12 months before delivery to the Site is unacceptable for use under this Contract, and will be rejected.

C. Storage and Protection:
1. Store products indoors on blocking or pallets.
2. Protect items from damage during storage.

PART 2 PRODUCTS

2.01 LOW VOLTAGE CONDUCTORS

A. Conductor Design Requirements:
1. Provide conductors of proper size and ampacity ratings based on Article 310 of NFPA 70.
a. Provide copper conductors that have 98 percent conductivity.
b. Unless otherwise indicated on the Contract Drawings, at a minimum provide conductors of the following American Wire Gauge (AWG) sizes:

1) For power and branch feeder circuits: 12 AWG.
   a) For power and branch feeders, provide solid copper low-voltage conductors for sizes up to and including 10 AWG; provide stranded copper low-voltage conductors for 8 AWG and larger sizes.
2) For control circuits: 14 AWG.
3) For alarm and status circuits: 14 AWG.

B. Insulation Design Requirements:
   1. Provide low voltage ground, power, and control wiring having the proper insulation types as follows:
      a. For wiring that is wholly in dry indoor locations: dual-rated Type THHN/THWN.
      b. For ground wires: THW may be used at the Contractor's option.

   2. Color Coding of Wires:
      a. Insulation shall be color coded in accordance with requirements of Section 26 05 53.

   3. Available Manufacturers:
      a. Continental Wire & Cable Company
      b. SouthWire
      c. General Cable
      a. CME Wire & Cable Inc.
      b. Or Approved Equal

2.02 ACCESSORIES

A. Cable Pulling Lubrication and Lubricant:
   1. Lubricant shall provide reduced tension on all types of cable jackets, dry to a thin lubricating film that retains its lubricity for an extended period and won't cement in the cables.
   2. The cable pulling lubricant shall produce a low coefficient of friction on a wide variety of cable jacket materials. The lubricant shall be UL listed. It shall be easy to handle and adhere well to the cable. Where appropriate, it shall also be tested and approved for use with CSPE (chlorosulfonated polyethylene) fire-retardant cable jackets where these materials are utilized.
   3. The lubricant shall be UL or CSA Listed and Labeled and shall pass the IEEE 1210, Standard Tests for Determining Compatibility of Cable-Pulling Lubricants with Wire and Cable. It shall pass physical compatibility tests on LLDPE, XLPE, CPE, and PVC cable jacket or sheath materials. It shall not stress crack polyethylene per ASTM Standard 1693. There shall be no significant changes in the conductive properties of XLPE and EPR semi-conducting compounds when the lubricant's effect on volume resistivity is tested according to IEEE Standard 1210.
   4. Lubricant to be specification-grade type that does not promote flame propagation when used with fire-retardant cables and systems, is harmless to humans, environmentally safe, and compatible with all common cable jacket materials
   5. The lubricant shall contain no waxes, greases, silicones, or polyalkylene glycol oils or waxes. The lubricant shall have less than a 6.0% solids residue after drying for 24 hours at 105°C.
   6. Where CPE insulated wire and/or cable is rated for Low Smoke / Zero Halogen type, only Polywater Type LZ shall be utilized.
   7. Specific lubricants for fiber-optic and other special cable installations shall be determined by the cable / lubricant manufaturers and the Contractor shall provide submittal information, including MSDS documentation and other information verifying suitability of products and general specification compliance as outlined herein.
   8. Available Manufacturers:

a. PolyWater - DynaBlue
b. 3M - Type WL
c. Greenlee - Type GEL

B. Grounding Braid:
1. Provide conformable, all-metal (tinned copper wires), corrosion resistant, woven grounding braid having a high current-carrying capacity approximately that of 6 AWG wire, such as.
2. Available Manufacturers:
a. 3M, Scotch, Scotch® 25 Electrical Grounding Braid,
b. Plymouth
c. Permacel
d. Or Approved equal

C. Tapes:
1. Vinyl Insulating Tape:
a. Provide UL-listed flexible polyvinyl chloride (PVC) backed insulating tape with a pressure sensitive adhesive, such as black Scotch® 33+ Vinyl Electrical Tape, that is resistant to abrasion, acids, alkalis, and copper corrosion; resistant to, hot, cold and wet weather; and resistant to damage from UV sunlight exposure.
2. Available Manufacturers:
a. 3M, Scotch
b. Plymouth
c. Permacel
d. Or Approved equal

D. Wire and Cable Connections:
1. Grounding Connectors:
a. Provide grounding connectors conforming to the requirements of Section 26 05 26 Grounding and Bonding for Electrical Systems.
2. Connectors for Service Wires and Cables, and for Wires and Cables Larger Than Number 6:
a. Split Bolt Connectors or Compression Type Connectors:
1) Provide UL-listed split bolt connectors or compression type connectors for making parallel or butt splices of stranded copper wire.
2) Use companion preformed plastic insulating covers or tape insulation conforming to NFPA 70 (NEC) requirements.
b. Mechanical compression connectors:
1) Provide mechanical compression connectors that are capable of connecting single or multiple conductors, and of being installed with one wrench.
a) Type: Compact, two-hole mechanical compression connectors having two clamping bolts.
(1) Connector Body: Provide a high copper bronze or brass alloy body.
(2) Bolts: Provide brass or bronze bolts; plated steel screws are unacceptable.
(3) Fasteners: Provide silicon-bronze fasteners for bolting connectors to connections.
c. Crimped Compression Connectors:
1) Provide two-hole crimped compression type connectors fabricated from high conductivity, seamless, electrolytic wrought copper, electrolytically tin-plated, and color coded to match the dies.
2) Provide crimped compression type connectors with adequate area to conduct the electrical current.

3) To crimp connectors, provide crimping tools from the same manufacturer that manufactured the connectors.

3. Control Wiring Connections:
   a. For control wiring connections at terminal boards, provide crimped nylon-insulated ring terminals.
   b. For control wiring splices, provide nylon insulated butt splices with insulation grips.
   c. For joining more than two control wires, provide junction boxes with terminal boards.
4. Connectors for Other Conductors:
   a. Any of the applicable types listed for larger wire may be provided.
   b. Screw Terminal Connections:
      1) For making terminal connections of stranded copper wire to screw terminals, provide nylon insulated crimped compression terminals with copper barrel on the wire.
      2) For making terminal connections of solid copper wire to screw terminals, provide screw lock connectors.
   c. Wire Nuts:
      1) For making splices of copper wire, provide pre-insulated, UL-listed, solderless connectors of the spring-lock or compression type that can be installed by hand or using tools.
      2) For site lighting, wire nuts used in underground or below grade locations is prohibited. There only permitted use for site lighting is within a pole base.
   d. Available Manufacturers:
      1) Thomas & Betts Corp.
      2) Tyco Electronics, AMP Inc.
      3) Ilsco Corp.
      4) FCI-Burndy® Products
      5) Or Approved equal

PART 3 EXECUTION

3.01 INSTALLERS

A. Install the work of this Section only under the supervision of licensed electricians.

3.02 EXAMINATION

A. Inspect all conduits, junction boxes, electrical vaults, and handholes to verify that they are clean, that they do not have burrs, that conduits are properly aligned, and that they are complete.
   1. Ensure that on all conduits without threaded hubs, two locknuts are installed.
   2. Ensure that in all conduits with wires larger than No. 10, bushings are installed.
   3. Ensure that grounding bushings and fittings are installed at all places specified in Section 26 0526, “Grounding and Bonding”.
   4. Verify that proper sized boxes are installed.

B. Verify that boxes and conduit fittings conform to the bending requirements specified in Article 314 of NFPA 70 (NEC).

3.03 PREPARATION

A. Verify that pulling calculations have been made and are available for long conduit runs and pulls as indicated in this Section.

B. Do not begin installing wiring until other work which might cause damage to the wires, cables, or conduits has been completed.
   1. Correct deficiencies in conduits, junction boxes, and raceways that have been discovered by the inspection required in Paragraph 3.02.A.

C. Prepare conduits to receive wire and cable.
   1. Swab the conduits with a nylon brush and steel mandrel.
   2. Pre-lubricate the conduits for which the pulling tension calculations are based on a coefficient of friction less than that of a dry conduit.

D. Verify that a means of controlling the pulling tension on the wire or cable is installed on the mechanical assist devices furnished for pulling cable.

E. Take the necessary precautions to prevent water, dirt, or other foreign material from accumulating in the conduits during the execution of wiring work.

3.04 INSTALLATION

A. Low Voltage Ground, Power, and Control Wiring:
   1. Install Type CL2P, FPLP, or CMP cable as required by the application in accordance with the requirements of NFPA 70 (NEC).
      a. For low voltage wiring concealed from view, only install wiring in the accessible locations permitted by the Contract Drawings.
   2. Neutral Conductors:
      a. For each single-phase and each multi-phase feeder, provide separate neutrals.
      b. For branch circuits, except at three-phase, wye-connected panelboards, provide separate neutral conductors.
         1) For three-phase, wye-connected panelboards, a common, or “shared”, neutral from three (3) adjacent single-pole circuit breakers, or from the poles of the same multi-pole circuit breaker, may be provided unless otherwise specified.
            a) Do not utilize shared neutrals for receptacle circuits.
            b) Do not utilize shared neutrals for control circuits or circuits serving electronic equipment.
            c) Do not utilize shared neutrals for circuits serving LED lighting fixtures.
      c. Size each neutral conductor the same as the largest phase conductor.
   3. Equipment Ground Conductors:
      a. Provide a green equipment ground conductor with all runs.
         1) Provide equipment ground conductor wire type as specified in Section 26 0526, Grounding and Bonding.

B. Pulling Cable:
   1. Establish a feed-in located at the highest elevation of the run, and pull cables down grade using flexible cable feeds to convey cables into raceways through the feed-in point opening.
      a. Furnish quadrant blocks located properly along the cable run.
      b. Limit cable pulling tensions to the maximum pulling tensions recommended by the cable manufacturer.
         1) Measure the cable pulling tension on all runs pulled with mechanical assistance and for all cable runs where calculations are required to be submitted by using a dynameter.
         2) Remove cables subjected to excessive bending and tension and that are cracked or have damaged or nicked outer jackets from the Site, and replace these cables with new undamaged cables.

a) If pulling tension is exceeding during pulling, remove the affected cables and mark them as not to be reused.

c. Lubricate cables with lubricants during pulling.

C. Terminating Cable:
1. Terminate cable using materials and methods indicated or specified herein, or in accordance with the written instructions of the cable manufacturer or termination kit manufacturer.
a. For equipment connections, provide split bolt or compression type connectors, mechanical compression connectors, or crimped compression type connectors as specified and approved by the equipment manufacturer; for all other types of connections provide connectors of one of the types specified:
2. Protect insulated power and lighting cable terminations from accidental contact, deterioration of coverings, and moisture by using proper terminating devices and materials.

D. Splicing Wire and Cable:
1. All new conductors shall be continuous from end to end without splices, except where indicated on the drawings or with the special written permission of the Engineer on a case-by-case basis where the Contractor can demonstrate that installation without splices is not practical.
2. If permitted as noted above, splice cables in accessible locations.
3. Within outlet or junction boxes, make wire and cable splices that conform to the requirements of NFPA 70 (NEC).
a. Install these outlet or junction boxes in accessible locations.

E. Wiring Identification:
1. Color code all wires and cables as indicated in Section 26 0553.
2. Identify all power wiring by circuit and panelboard numbers.
3. Identify all control wiring with wire numbers.
4. Provide additional electrical identification of cabling and wiring as specified in Section 26 0553, “Identification for Electrical Systems”.

F. Refer to Section 26 0500 for requirements for measuring and recording of conductor lengths.

3.05 FIELD QUALITY CONTROL

A. Site Tests:
1. Prior to energizing wire and cable, field test wires and cables as specified in Section 26 0563, “Acceptance Electrical Testing”.

B. Verify that control wiring wire numbers correspond to the numbers indicated in the record drawings.

END OF SECTION 26 0519

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 0526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.03 SUBMITTALS

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

B. Qualification Data: For testing agency and testing agencies field supervisor.

C. Field quality-control test reports.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 PRODUCTS

2.01 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
1. Solid Conductors: ASTM B 3
2. Stranded Conductors: ASTM B 8
3. Tinned Conductors: ASTM B 33
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor

6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick

2.02 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.

C. Clamps and Non-Welded Connectors:
1. Provide bronze or brass clamps and connectors that are UL Listed for use below grade
2. All bolts and other materials shall be bronze or brass; plated-steel screws or other hardware are unacceptable
3. Provide bolts, nuts, lock-washers, and similar hardware designed not to damage ground wire.

PART 3 EXECUTION

3.01 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
1. Feeders and branch circuits
2. Receptacle circuits
3. Single-phase motor and appliance branch circuits
4. Three-phase motor and appliance branch circuits
5. Flexible raceway runs

3.02 INSTALLATION

A. General:
1. Layout the electrical work to suit actual field conditions and in accordance with accepted industry standard practice
2. Verify existing conditions are as expected and ready for installation of grounding materials prior to commencement of the installation
   a. Perform field measurements to discover offsets and fitting requirements
   b. Locate on-site utilities and other obstructions in the area of work and verify that interferences will not occur.
3. Clean paint, grease, and other such insulating materials from contact points of grounds
4. After inspection by Owner’s Representative, and prior to backfilling the excavation, apply protective coating compound to all grounding connections located underground.
   a. Coatings shall be allowed to cure for the minimum required time period, as recommended by the coating manufacturer, prior to backfilling of the excavation.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.

3.03 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

B. Perform the following tests and inspections and prepare test reports:

   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

C. Report measured ground resistances that exceed the following values:

   1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.

D. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify the Engineer promptly, and include recommendations to reduce ground resistance.

END OF SECTION 26 0526

SECTION 26 0528

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for furnishing, installing, cleaning, and protecting hanger and support systems for electrical wiring, conduit boxes, and equipment.

B. Related Section:
   1. Section 26 0500 – Common Work Results for Electrical

1.02 REFERENCES

A. American Iron and Steel Institute (AISI):
   1. AISI Standard Steels (Handbook)

B. American Society for Testing Materials (ASTM):
   1. ASTM A 36/A 36M - Standard Specification for Carbon Structural Steel
   2. ASTM A 53/A 53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated - Welded and Seamless
   3. ASTM A 123/A 123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   4. ASTM A 153/A 153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   5. ASTM A 283/A 283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
   6. ASTM A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi, Minimum Tensile Strength
   7. ASTM A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
   8. ASTM A 563 - Standard Specification for Carbon and Alloy Steel Nuts
   9. ASTM A 575 - Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
   10. ASTM A 576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
   11. ASTM A 635/A 635M - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled
   12. ASTM A 1011/A 1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
   13. ASTM B 633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
   14. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials

C. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel

D. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts maximum)

E. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)
   2. NFPA 258 - Standard Research Test Method for Determining Smoke Generation of Solid Materials

F. Society of Automotive Engineers International (SAE):
   1. SAE J 429 - Mechanical and Material Requirements for Externally Threaded Fasteners

G. The Society for Protective Coatings (SSPC):
   1. SSPC Painting Manual:
      a. SSPC-SP 2 - Hand Tool Cleaning
      b. SSPC-Paint 15 - Paint Specification No. 15, Steel Joist Shop Paint, Type I, Red Oxide Paint, Type II, Asphalt Coating
      c. SSPC-Paint 20 - Paint Specification No. 20, Zinc-Rich Primers (Type I, “Inorganic,” and type II, “Organic”)

H. Underwriters Laboratory, Inc. (UL):
   1. UL 568 - Nonmetallic Cable Tray Systems
   2. UL 635 - Standard for Insulating Bushings
   3. UL 870 - Standard for Wireways, Auxilliary Gutters, and Associated Fittings
   4. UL 884 - Standard for Underfloor Raceways and Fittings
   5. UL 1479 - Standard for Fire Tests of Through-Penetration Firestops
   6. UL 2239 - Hardware for the Support of Conduit, Tubing, and Cable

I. U. S. General Services Administration (GSA)
   1. Federal Specifications:
      a. A-A-1922A - Shield, Expansion (Caulking Anchors, Single Lead)
      b. FF-S-107C (2) - Screws, Tapping and Drive

1.03 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of Supplementary Conditions SC-19 Shop Drawings/Samples, and Section 26 0500, Basic Electrical Materials and Methods:
   1. Product Data:
      a. Provide product data and catalog cuts for the products provided under this Section.
   2. Shop Drawings:
      a. Provide Shop Drawings for equipment backboards and support structures not directly fastened to walls.
      b. Provide Shop Drawings of hanging supports for conduit.
   3. Quality Assurance/Control Submittals:
      a. Design Data:
         1) Provide structural calculations for the following items:
            a) Equipment backboards and support structures not directly fastened to the walls.
            b) Hanging supports for conduit.
         2) Detailed drawings of proposed departures from the original design.
      b. Certificates:
         1) Testing Agency/Quality Verification:
            a) With the product data for electrical hangers and supports, provide evidence of quality verification, listing, and labeling by the Electrical

Testing Agency (ETA); either by a printed mark on the data, or by a separate listing card.

b) If an item does not have ETA quality assurance verification, provide a written quality assurance verification statement from the product manufacturer indicating why the item does not have the specified quality assurance verification.

(1) Such quality assurance verification statements are subject to approval by the Owner and the Engineer.

2) Manufacturers' Certificate of Compliance.

c. Qualification Statements:

1) Manufacturers' qualifications.

1.04 QUALITY ASSURANCE

A. Qualifications;

1. Electrical Testing Agency (ETA) Qualifications:
   a. Use the Electrical Testing Agency (ETA) qualified as specified in Section 26 05 00, Common Work Results for Electrical.
2. Manufacturers' Qualifications:
   a. Provide electrical support framing made by manufacturers that have been manufacturing support framing for a minimum of 5 years, and who carefully controls their operations to ensure that excellent product engineering, quality, safety, and reliability are achieved.
   b. Submit the manufacturer's qualifications to the Engineer for approval.

B. Certifications:

1. Electrical Testing Laboratory (ETL) Certification:
   a. Provide products that are listed and labeled by Underwriters Laboratory, Inc. (UL) or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) unless products meeting the requirements of these testing laboratories are not readily available or unless standards do not exist for the products.
2. Manufacturers Certificate of Compliance:
   a. Submit a manufacturer's Certificate of Compliance certifying that both the galvanizing and the products meet the requirements of the ASTM standards.

1.05 DELIVERY, STORAGE AND HANDLING

A. Packaging, Shipping, Handling, and Unloading:

1. Deliver, store, and handle the hangers and supports in accordance with Section 26 05 00 Common Work Results for Electrical, and as specified herein.
2. Deliver material to Site in the original factory packaging.

B. Storage and Protection:

1. Shelter and store the components under cover and supported off the ground and floors on blocking.

PART 2 PRODUCTS

2.01 MATERIALS

A. Carbon Steel Shapes:

1. Provide shapes of the sizes specified and as indicated on the Contract Drawings:

2. Provide steel shapes complying with the following material specifications for the type of steel shape listed:
   a. Steel Sections: ASTM A36/A 36M
   b. Steel Tubing: ASTM A 500, Grade B
   c. Plates: ASTM A 283/A 283M
   d. Sheets: ASTM A 1011/A 1011M
   e. Pipe: ASTM A 53/A 53M, Grade B, Schedule 40, hot-dipped, zinc-coated

B. Welding materials:
   1. Provide welding materials complying with the requirements of AWS D1.1/D1.1M for the type of material being welded.

2.02 MANUFACTURED UNITS

A. Metal U-Channel Electrical Support Framing Systems and Fittings:
   1. Carbon Steel U-Channel Support Framing Systems:
      a. Provide 1-5/8-inch nominal size U-channel supports fabricated from 12-gauge carbon steel electrolytically galvanized with a zinc-coating thickness commensurate with Service Condition SC 1 (mild) in conformance with the requirements of ASTM B 633.
         1) For Type II ASTM B 633 galvanized finishes, fabricate the framing from steel complying with the requirements for Grade 33 specified in ASTM A 1011/A 1011M.
         2) For Type III ASTM B 633 galvanized finishes, fabricate the framing from steel complying with the requirements of ASTM A 575, ASTM A 576, ASTM A 635/A 635M, or ASTM A 36/A 36M.
      b. Where combination members are required, spot-weld the members on 3-inch centers.
      c. Provide 1-3/8-inch or larger depths, except where supports are mounted directly to walls 13/16-inch or larger depths may be provided.
      d. Provide metal framing systems and fittings for metal framing systems from a single manufacturer.
      e. Manufacturers:
         1) Unistrut Corporation, Unistrut® Metal Framing System, www.unistrut.com.
         2) Thomas & Betts, Kindorf®, http://elec-cat.tnb.com.
         3) Cooper B-Line®, Inc., www.b-line.com.
         4) Power-Strut, www.power-strut.com.
         5) Approved Equal.

B. Conduit Supports:
   1. Malleable Iron Conduit Supports:
      a. Provide one-hole style galvanized malleable iron fasteners with pipe straps similar to those as manufactured by Thomas & Betts.
      b. Provide support devices consisting of threaded rods, channel supports, and conduit straps/fasteners.
   2. Stamped Steel Conduit Supports:
      a. Provide one-hole style galvanized stamped steel fasteners with pipe straps similar to those as manufactured by Thomas & Betts.
      b. Provide support devices consisting of threaded rods, channel supports, and conduit straps/fasteners.
   3. Manufacturers:
      a. Thomas & Betts, http://www-public.tnb.com/contractor/docs/superstrut.pdf.
      b. Approved equal

C. Cable Supports:
   1. Provide voltage rated cable supports fabricated from hot-dip galvanized malleable iron with a threaded collar.
   2. Provide tapered wedging cable plugs fabricated from hard fiber, impregnated hardwood, or canvas bakelite for the cable supports.
   3. Manufacturers:
      a. EGS Electrical Group, O-Z/Gedney, Inc., Type "M"
      b. Approved equal

D. Bolts, Nuts, and Washers:
   1. For bolts, nuts, and washers smaller than 1/4-inch trade size, provide 316 stainless steel fasteners complying with the requirements of ASTM A 325.
   2. For fastening galvanized components, provide stainless steel bolts, nuts, and washers galvanized in accordance with the requirements of ASTM A 325.

E. Anchors and Fasteners:
   1. Drive (Deep-Pitch) Screws:
      a. Provide Type 316 stainless steel self-tapping type drive (deep-pitch) screws that comply with the requirements of FF-S-107C (2).
   2. Drilled-In Anchors and Fasteners:
      a. Provide drilled-in anchors and fasteners that comply with the requirements of FF-S-107C (2).
      b. Masonry Anchors:
         1) Provide masonry anchors designed to accept both machine bolts and threaded rods as fasteners.
            a) Provide SAE J 429 Grade 2 machine bolt fasteners fabricated from AISI Type 316 stainless steel.
            b) Provide nuts and washers conforming to the requirements of ASTM A 563.
         2) Provide masonry anchors consisting of an expansion shield and expander nut contained inside the shield.
            a) Expander Nuts:
               (1) Fabricate square expander nuts with their sides tapered inward from the bottom to the top.
               (2) Design the expander nuts to simultaneously climb the bolt or rod thread and expand the shield as soon as the threaded expander nut reaches and bears against the shield bottom when being tightened.
            b) Expansion Shields:
               (1) Provide expansion shield bodies consisting of four legs, the inside of each tapered toward the shield bottom, or nut end.
               (2) The end of one leg shall be elongated and turned across shield bottom. Outer surface of shield body shall be ribbed for grip-action.
         3) Masonry Anchor Material:
            a) Provide die cast Zamac No. 3 zinc alloy having a minimum tensile strength of 43,000 psi.
         4) Manufacturers:
            a) U.S.E. Diamond, Inc., FORWAY System, , www.mktfastening.com
      c. Concrete Anchors:
         1) Carbon Steel Anchor/Fastener:
            a) Provide UL listed one-piece studs (bolts) with integral expansion wedges, nuts, and washers.
            b) Provide carbon steel anchor/fasteners complying with the physical requirements specified in FF-S-325 for Group II, Type 4, Class 1.
         2) Stainless Steel Anchor/Fastener:

a) Provide one-piece AISI Type 303 or 304 stainless steel studs (bolts) with integral expansion wedges, AISI Type 316 stainless steel nuts, and AISI Type 316 stainless steel washers.
b) Provide stainless steel anchor/fasteners complying with the physical requirements of FF-S-325 for Group II, Type 4, Class 1.

3) Acceptable Manufacturers:
a) U.S.E. Diamond, Inc.; SUP-R-STUD, www.mktfastening.com
b) Hilti Fastening Systems; KWIK-BOLT, hilti.com.
c) Molly Fastener Group; PARABOL
d) Phillips; RED HEAD Wedge-Anchor, www.phillipsfastener.com.

3. Hammer drive-type explosive charge drive-type anchors and fastener systems are unacceptable.
4. Lead shields, plastic-inserts, fiber-inserts, and drilled-in plastic sleeve/nail drive systems are unacceptable.

2.03 FABRICATION

A. Fit and shop assemble items in the largest sections practical for delivery to the Site.

2.04 FINISHES

A. Prime paint non-galvanized steel items.
1. Prepare surfaces to be primed in accordance with the requirements of SSPC-SP 2.
a. Clean surfaces of rust, scale, grease, and foreign matter prior to finishing.
2. Prime Painting: Apply one coat of primer.

B. Galvanizing items specified above as galvanized.
1. Galvanize the items after fabrication in accordance with the requirements of ASTM A 123/A 123M.
2. Provide a minimum galvanized coating of 1.25 ounces per square foott (380 grams per square meter).

C. Touch-Up Primer:
1. For un-galvanized metal surfaces: Provide primer complying with the requirements of SSPC-Paint 15 for Type I, Red Iron Oxide.
2. For galvanized surfaces: Provide primer complying with the requirements of SSPC-Paint 20 for Type I, Inorganic Zinc-Rich Primer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Field Measurement:
1. Although the Contract Drawings are generally indicative of the Work, take field measurements to verify actual conditions.
a. Due to the small scale of the Contract Drawings it is not possible to indicate all offsets, fittings, and apparatus required or the minor structural obstructions that may be encountered during the Work.
2. Carefully investigate the structural and finish conditions, and other construction work, at the Site which may affect the work of this Section.

3.02 PREPARATION

A. After carefully investigating structural and finish conditions and other in-place construction work, produce detailed Shop Drawings showing proposed departures from the original design due to field conditions or other causes.
   1. Layout the electrical work according to accepted standard electrical trade practice to suit actual field measurements.
   2. Arrange the electrical work to consider existing conditions and to preserve access to other equipment, rooms, areas, and similar features of the construction.
   3. Show equipment backboards and support structures not directly fastened to the walls on the Shop Drawings.
   4. Indicate the location and details of conflicting utility construction and slopes on the Shop Drawings.
   5. Submit the Shop Drawings to the Engineer for approval prior to performing the Work of this Section.

B. Obtain roughing-in dimensions of electrically operated equipment, including equipment being installed by both electrical and other construction trades.
   1. Set conduit and boxes only after receiving approved dimensions and checking such equipment locations.
   2. Arrange electrical Work accordingly and furnish such fittings and apparatus as required to accommodate such conditions and to preserve access to other equipment, rooms, areas, and similar spaces.

3.03 INSTALLATION

A. Install electrical Work in conformance to the requirements of NFPA 70 for wiring methods general requirements, and to other applicable Articles of the NEC governing methods of wiring.

B. Installing Anchors and Fasteners:
   1. For anchoring or fastening applications in masonry and hollow-core precast concrete structural elements, provide masonry anchors as specified herein.
   2. For anchoring or fastening applications in cast-in-place concrete and solid precast concrete structural elements, provide concrete anchors as specified herein.
   3. Threaded Bolts:
      a. Draw threaded bolted connections up tight using 316 stainless steel lock washers to prevent the bolt or nut from loosening.
   4. Drilled-In Expansion Anchors:
      a. Install expansion anchors in strict accordance with manufacturer's instructions and the following.
         1) Drill holes to the required diameter and depth in accordance with anchor manufacturer's instructions for the size of anchor being installed.
         2) Minimum Embedment:
            a) Embed expansion anchors to four and one-half bolt diameters minimum unless otherwise indicated on the Contract Drawings.

C. Installation of U-Channel Support Framing Systems: per Table 26 0528-1 below:

Table 26 0528-1 U-Channel Support Framing Selection

Condition 1	Condition 2	Type
Aboveground	Interior Dry Locations	Carbon steel

D. Installing Conduit Supports:
   1. For interior locations, provide stamped steel conduit supports.

E. Panelboard/Enclosure Feed Risers:
   1. Furnish and install cable supports in feeder risers as required by the underwriters.

F. Field Fabrication:
   1. Fabricated Items:
      a. Fabricate backboards, backboard supports, equipment supports, conduit supports, and the other items as detailed on the Contract Drawings.
         1) Hot-dip galvanize mild-steel fabrications in accordance with the requirements of ASTM A 153/A 153M.
      b. Supply components required for the anchorage of fabrications.
         1) Except where specifically noted otherwise, fabricate anchors and related components from the same material as the fabrication and apply the same finish.
   2. Tightly fit and secure joints.
      a. Make exposed joints butt tight, flush, and hairline.
      b. Weld fabricated assemblies in accordance with AWS D1.1/D1.1M.
         1) Continuously seal joined members using intermittent welds and plastic filler.
         2) Dress welds smooth and free of sharp edges and corners.
      c. Grind exposed joints flush and smooth with the adjacent finish surface.
   3. Ease exposed edges to a small uniform radius.
      a. Cut all backboard corners to a 1-inch radius.
   4. For the attachment of work and for bolted connections, accurately drill or punch holes for the fasteners as required.
      a. Burned holes are unacceptable.
      b. Provide holes no more than 3/32-inch larger than the fasteners.
   5. Exposed Mechanical Fastenings:
      a. Except where specifically noted otherwise in the Contract Documents, provide flush countersunk screws or bolts; unobtrusively located, and consistent with the design of the component.
   6. Fabrication Tolerances:
      a. Squareness: 1/8 inch (3 mm), maximum difference in diagonal measurements.
      b. Maximum offset between faces: 1/16 inch (1.5 mm).
      c. Maximum misalignment of adjacent members: 1/16 inch (1.5 mm).
      d. Maximum bow: 1/8 inch (3 mm) in 48 inches (1.2 m).
      e. Maximum deviation from plane: 1/16 inch (1.5 mm) in 48 inches (1.2 m).

3.04 REPAIR/RESTORATION

A. Coatings:
   1. Repair damage to coatings.
      a. Touch up damaged coating surfaces, using the specified primer for primed steel surfaces, and using zinc-rich primer for galvanized steel surfaces.

3.05 FIELD QUALITY CONTROL

A. Inspection:
   1. Verify the adequacy of coatings.
   2. Inspect the items provided under this Section for adherence to the fabrication tolerances specified above, and correct any discrepancies:

3.06 PROTECTION

A. Protect the items provided under this Section from damage during the work of other trades.

END OF SECTION 20 0528

PAGE INTENTIONALLY LEFT BLANK

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, apply to this Section.

1.02 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:
1. Division 26 Section "Wiring Devices" for devices installed in boxes.

1.03 DEFINITIONS

A. FMC: Flexible metal conduit.

B. RGS: Rigid galvanized steel conduit.

C. LFMC: Liquidtight flexible metal conduit.

1.04 SUBMITTALS

A. Product Data: For raceways and fittings, hinged-cover enclosures, and cabinets.

B. Shop Drawings: Show fabrication and installation details of components for raceways, fittings, boxes, enclosures, and cabinets.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.06 COORDINATION

A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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

2.02 METAL CONDUIT AND TUBING

A. Available Manufacturers:
1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Anamet Electrical, Inc.; Anaconda Metal Hose
4. Electri-Flex Co.
5. Grinnell Co./Tyco International; Allied Tube and Conduit Div.
6. LTV Steel Tubular Products Company
7. Manhattan/CDT/Cole-Flex
8. O-Z Gedney; Unit of General Signal
9. Wheatland Tube Co.
10. Or Approved Equal

B. Rigid Galvanized Steel Conduit: ANSI C80.1.

C. FMC: Zinc-coated steel.

D. LFMC: Flexible steel conduit with PVC jacket.

E. Fittings: NEMA FB 1; compatible with conduit and tubing materials.

2.03 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers:
1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. Emerson/General Signal; Appleton Electric Company
3. Erickson Electrical Equipment Co.
4. Hoffman
5. Hubbell, Inc.; Killark Electric Manufacturing Co.
6. O-Z/Gedney; Unit of General Signal
7. RACO; Division of Hubbell, Inc.
8. Robroy Industries, Inc.; Enclosure Division
9. Scott Fetzer Co.; Adalet-PLM Division
10. Spring City Electrical Manufacturing Co.
11. Thomas & Betts Corporation
12. Walker Systems, Inc.; Wiremold Company (The)
13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

E. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

F. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include

metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

2.04 FACTORY FINISHES

A. Finish: For surface raceway, wireway, enclosure, or cabinet components, provide manufacturer's standard prime-coat finish ready for field painting.

PART 3 EXECUTION

3.01 RACEWAY APPLICATION

A. Indoors:
1. Exposed: Rigid galvanized steel.
a. All feeder conduits shall be RGS.
2. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except use LFMC in damp or wet locations, including the Boiler room and Sub-Basement.
3. Damp or Wet Locations: Rigid galvanized steel conduit.
4. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
a. Damp or Wet Locations: NEMA 250, Type 3R.

B. Minimum Raceway Size: 3/4-inch trade size.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid Galvanized Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.02 INSTALLATION

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

B. Complete raceway installation before starting conductor installation.

C. Install temporary closures to prevent foreign matter from entering raceways.

D. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.

E. Make bends and offsets so inside diameter is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.

F. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
1. Run parallel or banked raceways together on common supports.
2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

G. Join raceways with fittings designed and approved for that purpose and make joints tight.
1. Use insulating bushings to protect conductors.

H. Terminations:

1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.

I. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

J. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.

K. Flexible Connections: Use maximum of 72 inches of flexible conduit for recessed and semi recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations, including the Boiler room and Sub-Basement. Install separate ground conductor across flexible connections.

L. Grounding Conductors in Raceways: Install a separate, green, ground conductor in all raceways.

M. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

N. Fire stopping: Use UL listed materials as shown in a UL listed detail for the configuration of the penetration. Submit UL detail showing materials used.

3.03 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.

3.04 CLEANING

A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 26 0533

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, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:
   1. Identification for raceways
   2. Identification for conductors and control cable
   3. Warning labels and signs
   4. Equipment identification labels/signs
   5. Miscellaneous identification products

B. The extent of electrical identification is indicated by drawings.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's product specifications and installation instructions for each identification material and device required. Include data substantiating that materials comply with requirements.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.04 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.145.

D. UL Compliance: Comply with applicable portions of UL safety standards pertaining to electrical marking and labeling identification systems.

E. NEC Compliance: Comply with NEC as applicable to installation of identifying labels and markers for wiring and equipment.

1.05 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation

and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. 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 ACCEPTABLE MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering identification products which may be incorporated in the work include, but are not limited to, the following:
1. Almetek Industries, Inc.
2. W.H. Brady Co.
3. Cole-Flex Corp.
4. Griffolyn Co.
5. Ideal Industries, Inc.
6. LEM Products, Inc.
7. National Band and Tag Co.
8. Radar Engineers Div., EPIC Corp.
9. Seton Nameplate Co.
10. Tesa Corp.

2.02 ELECTRICAL IDENTIFICATION MATERIALS

A. General: Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is Installer's option, but provide single selection for each application.

B. Cable/Conductor Identification Bands: Provide manufacturer's standard aluminum wrap-around cable/conductor markers, of size required for proper application, and numbered to show circuit identification, or provide manufacturer's standard vinyl-cloth self-adhesive cable/conductor markers of wrap-around type; either pre-numbered, plastic-coated type or write-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification.

C. Plasticized Tags: Provide manufacturer's standard pre-printed or partially pre-printed accident-prevention and operational tags, of plasticized card stock with matte finish suitable for writing, approximately 3-1/4" x 5-5/8", with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples: DANGER, CAUTION, DO NOT OPERATE).

D. Self-Adhesive Plastic Signs: Provide manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application (as examples: 208 VOLTS, EXHAUST FAN, RECTIFIER). Unless otherwise indicated or required by governing regulations, provide orange signs with black lettering.

E. Engraved Plastic-Laminate Signs: Provide engraving stock melamine plastic laminate signs, complying with FS L-P-387, in sizes and thicknesses indicated, engraved with engraver's standard letter style of sizes and wording indicated, black and white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

F. Thickness: 1/16", for units up to 20 sq. in. or 8" length; 1/8" for larger units.

G. Fasteners: Self-tapping stainless-steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate substrate.

2.03 LETTERING AND GRAPHICS:

A. General: Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of electrical systems and equipment.

2.04 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Warning label and sign shall include, but are not limited to, the following legends:
1. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.05 ARC FLASH WARNING LABELS

A. Arc Flash Warning Labels shall be prepared in accordance with NFPA 70, NFPA 70E, IEEE-1584 latest editions and ANSI Z535.
1. Minimum label size shall be 4" x 6" as provided by Duralabel or Brady with applicable header information identifying both warning and danger based upon the findings.
2. Minimum information to be included on the Arc Flash label shall consist of the following:
a. Prefaced electrical warning including universal symbol identification, approved safety color, and preface description noting that arc and shock hazard are present. Note where dual labeling is provided/required with the use of arc flash reduction maintenance settings within the equipment, such labels shall be uniquely identified by a different label safety color l, as approved by the Owner. Consult the Owner for acceptable color schemes to be used for the equipment.
b. Statement noting that personnel protective equipment (PPE) requirements are required. Also clearly identify all equipment as “Dangerous” where work on energized equipment is otherwise prohibited and/or where no safe PPE protection so exists.
c. Calculated arc flash hazard boundary, in inches.
d. Calculated arc flash hazard at 18 inches, in calories/cm^2.
e. Arc flash hazard risk category, including descriptive summary of required PPE items necessary for entry into energized equipment.
f. Voltage classification and description of conditions present for shock hazard.
g. Insulated glove classification rating, as required for contact conditions and measurements.
h. Limited approach boundary, in inches.

i. Restricted approach boundary, in inches.
j. Prohibited approach boundary, in inches.
k. Available short circuit current.
l. Unique equipment locator identification, corresponding to applicable device abbreviation identifiers utilized for the electrical system study / one-line diagram prepared by Contractor as specified in Section 26 0500.
m. Name, address & phone number of the responsible engineer, engineering company or agency contracted to perform the analysis. Also include the preparer's name, where prepared by a subcontract to the named company or agency contracted to perform the analysis report.
n. Respective contract (job) number for the analysis report.
o. Preparation date of the issued/approved Arc Flash Study (analysis) supporting the equipment labeling, as installed.
p. Suffix cautionary warning that "Changes in equipment settings or system configuration will invalidate the calculated values and PPE requirements."

2.06 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16-inch thick for signs up to 20 sq. in. and 1/8-inch thick for larger sizes.
1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.07 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

B. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.08 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
1. Minimum Width: 3/16 inch.
2. Tensile Strength: 50 lb, minimum.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 EXECUTION

3.01 APPLICATION

A. Accessible Raceways, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identify with orange self-adhesive vinyl label.

B. Accessible Raceways, Over 600 Volts: Identify the voltage carried in conduit or raceway by providing voltage labeling markers on all accessible raceways, or by other means as approved or directed by the School District.

C. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands: Revise list below to suit Project.
   1. Control Wiring: Green and red.

D. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.

E. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.

F. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
   1. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

G. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Labeling Instructions:
      a. Indoor Equipment: Adhesive film label with clear protective overlay. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where 2 lines of text are required, use labels 2 inches high.
      b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
      c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

   2. Equipment to Be Labeled:
      a. Panelboards, electrical cabinets, and enclosures
      b. Access doors and panels for concealed electrical items
      c. Disconnect switches
      d. Enclosed circuit breakers

H. Arc Flash Warning Labels: For each arc location or circuit analyzed as part of the Arc Flash Study required by Section 26 0500, furnish and install an Arc Flash Warning label.

3.02 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 nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
   1. Color shall be factory applied.
   2. Colors for 208/120-V Circuits:
      a. Phase A: Black
      b. Phase B: Red
      c. Phase C: Blue

   3. Colors for 480/277-V Circuits:
      d. Phase A: Brown
      e. Phase B: Orange
      f. Phase C: Yellow

B. Color-Coding for Phase and Voltage Level Identification, Over 600 Volts: Conform to requirements of the Local Electric Utility Company.

C. Painted Identification: Prepare surface and apply paint according to Division 09, “Painting” Section(s).

END OF SECTION 26 0553

SECTION 26 0563

ACCEPTANCE ELECTRICAL TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of materials to performance test electrical systems and equipment.
   1. Items Supplied Under This Section:
      a. Electrical System Testing
      b. Thermographic Testing
      c. Ground System Testing
      d. Equipment Testing
      e. Test Procedure
      f. Test Report

B. Related Sections:
   1. Division 01 – General Requirements
   2. Division 26 Sections, As Applicable

1.02 REFERENCES

A. Applicable Documents and Testing Requirements of:
   1. America National Standards Institute (ANSI): as applicable, including:
      a. ANSI C2 - National Electrical Safety Code
      b. ANSI Z244.1 - American National Standards for Personnel Protection.

   2. National Electrical Manufacturer's Association (NEMA): as applicable, including:
      a. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

   3. American Society for Testing and Materials (ASTM), as applicable.
   4. Institute of Electrical and Electronics Engineers (IEEE), as applicable.
   5. National Fire Protection Association (NFPA), as applicable, including:
      a. NFPA 70 - National Electrical Code (NEC)
      b. NFPA 70E - Electrical Safety Requirements for Employee Workplaces.

   6. Insulated Cable Engineer's Association (ICEA), as applicable.
   7. State and Local Codes and Ordinances as applicable.
   8. Occupational Safety and Health Administration (OSHA), as applicable, including:
      a. Title 29 - Parts 1907, 1910 and 1936.

   9. InterNational Electrical Testing Association (NETA) as applicable, including:
      a. ATS-2021 - Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems
      b. MTS-2019 - Maintenance Testing Specifications for Electric Power Distribution Equipment and Systems.

1.03 SUBMITTALS

A. Submit documentation as required by this Section of the Contract to the Design Engineer in strict accordance with the provisions of Section 26 05 00 for review, comments and subsequent approval.

B. Submission to include the following:
   1. Field inspection report as required for each item of material and/or equipment outlined herein.

C. Test Reports:
   1. Each test report prepared by the respective testing firm(s) comply, where applicable, to all stipulations specified in Section 26 0500 for Operation, Maintenance and Installation Manuals with reference to preparation, paper requirements, indexing and binders. Include in each test report the following:
      a. Summary of project
      b. Description of equipment tested
      c. Description of test
      d. Test results
      e. Conclusions and recommendations
      f. Appendix, including appropriate test forms
      g. Identification of test equipment used
      h. Signature of responsible test organization authority
      i. Furnish five copies of each completed report to the Design Electrical Engineer no later than 30 days after completion of each test. Assemble and certify the testing firm each final test report, which must be submitted to the Design Engineer for review, comments and subsequent approval.

1.04 QUALITY ASSURANCE

A. Qualifications of Testing Laboratory: Select an independent nationally recognized testing laboratory that is independent from electrical contractor that either is a member of The International Electrical Testing Association or meets the following qualifications:
   1. Is nationally recognized as an electrical testing laboratory.
   2. Has been regularly engaged in the testing of electrical systems and equipment for at least 2 years.
   3. Is independent from the electrical contractor, the Owner, the Engineer and all other contractors on the job.
   4. Has at least one Professional Engineer on staff that is licensed in the State where the project site is located.
   5. Derives more than 75 percent of its income from electrical testing.
   6. Owns or leases sufficient calibrated equipment to do the testing required.
   7. Has a means to trace all test instrument calibration to The National Institute of Standards and Technology.

B. Membership in the International Electrical Testing Association (NETA) shall be considered evidence of meeting items A. 1. through and including A. 5

C. Testing shall be done under the supervision of a technician certified by International Electrical Testing Association or by technicians that are both certified by the National Society of Professional Engineers and experienced in electrical testing with 5 years of testing experience.

D. The testing laboratory shall supervise or perform all testing of equipment and oversee setting of all circuit breakers and calibration of all instruments.

E. The testing firm used must be approved by the Engineer.

F. Include the cost of such tests in the Contractors Bid Price for the applicable bid item.

1.05 GENERAL REQUIREMENTS

A. Field Inspection:
   1. This Contractor is responsible for a complete inspection of all equipment, prior to testing and energizing to ascertain that it is free from any damage, scratches, or missing components and that all power connections are correct, and that they are tight in conformance with recommended standard practice. The inspection is to also include a check of control wiring, terminal connections and all bolts and nuts.
   2. Perform field inspection by this Contractor during a time when the Field Engineer and the Design Engineer are present to witness each inspection and its performance.
   3. Correct any deficiencies found during the inspection by this Contractor prior to the energizing and testing of the equipment.

1.06 SCHEDULING

A. Schedule all testing with work of other contractors to ensure an orderly sequence of startup and completion of work.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 ELECTRICAL INSPECTIONS AND TESTS

A. Perform, supervise, and furnish all test equipment needed to perform tests and provide safety measures, procedures and equipment required for each test.

B. Schedule all testing with the Construction Manager (CM). Perform testing in the presence of the CM, except when the CM approves in writing the conducting of a specific test without being present.

C. Notify all involved parties including the Construction Manager prior to tests, advising them of the test to be performed and the scheduled date and time.

D. Coordinate the tests with others involved.

E. Prepare written test procedures and forms used in the test reports and submit for approval prior to commencement of testing.

F. Include in each test report the following information:
   1. Job title
   2. Date of test

3. Equipment, system or cable identification
4. Type of test
5. Description of test instrument and date of latest calibration
6. Section of specification defining test along with description of test and evaluations as reported by the testing company
7. Test results (correct all readings at 20 degrees C)
8. Signature of person supervising test
9. Signature of Contractor
10. Space for Construction Manager's signature.

G. Refer to individual tests and inspections hereinafter specified for any additional or specified requirements.

H. Test Instrument Calibration:
1. The testing firm is to have a calibration program, which assures that all applicable test instrumentation are maintained within rated accuracy.
2. The accuracy is to be directly traceable to The National Institute of Standards and Technology.
3. Instruments are to be calibrated in accordance with the following frequency schedule.
   a. Field Instruments: Analog - 6 months maximum
      Digital - 12 months maximum
   b. Laboratory Instruments: 12 months
   c. Leased specialty equipment: 12 months

4. Make dated calibration labels visible on all test equipment.
5. Keep records up-to-date, which show date and results of instruments calibrated or tested.
6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.
7. Calibrating standard is to be of higher accuracy than that of the instrument tested.

I. Safety and Precautions:
1. Safety practices are to include, but are not limited to, the following requirements:
   a. Occupational Safety and Health Act of 1970-OSHA
   b. Accident Prevention Manual for Industrial Operations, National Safety Council, Chapter 4
   c. Applicable State and Local safety operating procedures
   d. IETA Safety/Accident Prevention Program
   e. Owner's safety practices
   f. National Fire Protection Association - NFPA 70E
   g. ANSI Z244.1 American National Standards for Personnel Protection

2. Perform all tests with apparatus de-energized except where otherwise specifically required.

3. The testing firm is to have a designated safety representative on the project to supervise all testing operations with respect to safety.

3.02 TESTING TO BE PERFORMED BY CONTRACTOR

A. The Contractor is required to obtain copies of NETA ATS-2017 and MTS-2015, and to keep at least one copy of each at the project site, to use as reference for testing requirements.

B. Continuity Test: Make test for continuity and correctness of wiring and identification on all conductors installed.

C. Wire and Cable:
1. Test all wires and cables sized No. 2 and larger in accordance with NETA ATS-2017.
2. Perform visual, mechanical, and electrical tests on all No. 4 and No. 6 power cables that operate at voltages exceeding 150 volts to ground in accordance with NETA ATS-2017.
3. Perform visual, mechanical, and electrical tests on all other wires and cables in accordance with NETA ATS-2017.
4. Replace any wires which have been damaged.
5. Correct causes of all readings which do not meet the acceptable minimum insulation readings are as stated in NETA ATS-2017. Exceed the nominal expected temperatures for the actual load.
6. Retest items requiring correction.

D. Surge Protective Devices (SPDs):
1. Visually and mechanically inspect the SPD unit and connections.
2. Use an AC voltmeter to check all voltages and ensure that normal operating voltages of the power system match the voltage rating on the SPD nameplate.
3. Check LED status indicators on the display panels and suppression modules to confirm normal status.
4. Press the alarm test button to confirm the audible alarm and LED.
5. Operate the alarm silence switch to confirm proper operation.

E. Ground Fault Circuit Interrupter (GFCI) Receptacles:
1. Test all GFCI receptacles as specified in Section 26 2726.

3.03 TESTING TO BE PERFORMED BY THE TESTING LABORATORY

A. The Contractor shall select, hire and pay an independent, nationally recognized electrical testing laboratory to perform all testing specified in this Article. Obtain Owner's approval of the testing laboratory and the testing laboratory's proposed test procedure prior to commencement of any tests.

B. Set all adjustments for all overcurrent protection devices in accordance with the protection and coordination study required by Section 26 0500.

C. Visually and mechanically inspect and electrically test items of equipment (as listed and required hereinafter) using the procedures of NETA ATS-2017. When a test for a particular item is not called out in ATS, test using the procedures in NETA MTS-2015.

D. Thermographic Inspection:
1. Perform thermographic inspection of the electrical equipment and installations, provided under this Project and as listed below, in accordance with NETA ATS-2017, and these Specifications. The following equipment is to be scanned:
   a. Service Entrance Equipment: all ratings
   b. Power Panelboards: 50-Ampere and larger
   c. Dry Type Transformers: 10 kVA and larger
   d. Disconnect Switches: 100 amp and larger

2. Provide report including the following items:
   a. Items scanned
   b. Whether item passed or failed

c. All items in NETA ATS-2017
d. The probable cause
e. Severity of defect
f. Recommended corrective measures
g. Video recording of test.

3. Scan using an infrared camera with video scanner output to a display screen with a range of at least 1 degree C to 75 degrees C with an accuracy of 0.1 degree C and with the following equipment:
   a. One 7 degree telephoto lens
   b. One 20 degree wide angle lens
   c. One 40 degree extra-wide angle lens

4. Record output of camera during testing onto a DVD or store digital images of each piece of equipment inspected onto a CD as a record of the temperature variations. Record either by order or by digital imprinting the actual equipment being scanned. Turn off recordings during inactive periods or edit DVD to eliminate dead periods.
5. Display data on a monitor capable of providing both a gray step mode and color monitor. These capabilities allow distinct temperature levels to be shown in black and white and color on the thermogram.
6. Submit three copies of report and two copies of the DVD or CD.
7. Include DVD or CD of thermographs of the defective equipment and installations. Also include in report.
8. Submit both copies of the report to the Engineer who will make the determination of corrective measurements.

E. Low Voltage Molded Case Circuit Breaker Tests:
   1. Visually and mechanically inspect and electrically test all low voltage circuit breakers in frame sizes rated 100-amperes or more in accordance with NETA ATS-2017.
   2. Acceptable values are as stated in NETA ATS-2017.

F. Low Voltage Panelboard Tests:
   1. Visually and mechanically inspect and electrically test all low voltage panelboards furnished under this Project in accordance with NETA ATS-2017.
   2. Acceptable values are as stated in NETA ATS-2017.
   3. Test all components as specified in this Section.

G. Dry Type Transformer Tests:
   1. Visually and mechanically inspect and electrically test low voltage dry-type transformers in accordance with NETA ATS-2017.
   2. Acceptable test values are as stated in NETA ATS-2017.

3.04 CORRECTION OF DEFICIENCIES

A. Report all unacceptable values immediately. Correct all deficiencies found in work of this contract and separately report deficiencies in work of items of other contracts.
   1. Retest items requiring correction. Correct or have corrected any remaining deficiencies and retest until work is acceptable.

3.05 RETESTING

A. After equipment has been in service for a period of nine months repeat the following tests:

1. Thermographic testing. Correct all causes of readings above the nominal expected reading for the load encountered.

END OF SECTION 26 0563

SECTION 26 22 00

LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of material for furnishing, installing, connecting, energizing, testing, cleaning and protecting transformers.

B. Related Section:
1. Section 26 05 00 - Common Work Results for Electrical.
2. Section 26 05 26 - Grounding and Bonding for Electrical Systems
3. Section 26 05 63 – Acceptance Testing of Electrical Systems
4. Section 26 05 33.13 – Conduits for Electrical Systems.

1.02 REFERENCES

A. Institute of Electrical And Electronic Engineers/American National Standards Institute (IEEE/ANSI):
1. IEEE/ANSI C57.12.01 General Requirements for Dry-type Distribution and Power Transformers.
2. IEEE/ANSI C57.12.59 Guide for Dry-type Transformer Through-Fault Current Duration.
3. IEEE/ANSI C57.12.70 Terminal Markings and Connections for Power and Distribution Transformers.
4. IEEE/ANSI C57.12.80 Standard Terminology for Power and Distribution Transformers.
5. IEEE/ANSI C57.12.91 Test Code for Power and Distribution Transformers.
6. IEEE/ANSI C57.94 Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.
7. IEEE/ANSI C57.96 Guide for Loading Dry-Type Distribution and Power Transformers.

B. National Electric Manufacturer's Association (NEMA):
1. NEMA ST 20 Dry Type Transformers for General Applications.
2. NEMA TR 1 Transformers, Regulators, and Reactors.

C. Underwriter’s Laboratory, Inc. (UL):
1. UL 1561 Transformers, Dry-Type General Purpose and Power.

D. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC).

1.03 DEFINITIONS

A. Definitions of terms are as indicated in NFPA 70, IEEE/ANSI C57.12.80 and NEMA ST 20 unless otherwise indicated, noted or specified.

1.04 SYSTEM DESCRIPTION

A. Design Criteria:
   1. Provide transformers with ratings as indicated.
   2. Provide transformers designed for the following conditions:
      a. 40 degrees C. maximum ambient temperature.
      b. -20 degrees C. minimum ambient.
      c. 1,000 feet (300m) above sea-level.
      d. Indoors unless otherwise indicated or specified.

B. Provide transformers for connecting to the following systems with nominal voltages and operating ranges as specified in IEEE/ANSI C84.1:
   1. 480Volt, 3-phase, 3-wire, grounded or ungrounded.

C. Provide transformers for supplying the following systems with nominal voltages and operating ranges as specified in IEEE/ANSI C84.1
   1. 208/120 Volt, 3-phase, 4-wire, grounded wye.

D. Provide transformers for connecting to systems with a let-through fault capability up to the limits of IEEE/ANSI C57.12.59.

1.05 SUBMITTALS

A. Testing Agency/Quality Verification: Provide with all product data evidence of testing agency/quality verification, listing, and labeling either by printed mark on the data or by a separate listing card. Provide from product manufacturers a written statement indicating why an item does not have a quality assurance verification. Such statements are subject to the approval of the Engineer.

B. Product Data:
   1. List of transformers and accessories to be furnished and installed.
   2. Catalog cuts of all transformers and accessories.

C. Shop Drawings: Provide shop drawings for the following:
   1. Complete outline drawing, showing overall length, width, and height and including ratings of equipment, impedance, and installation restrictions.

D. Submit Operation and Maintenance Manual.

1.06 QUALITY ASSURANCE

A. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory unless products meeting the requirements of these testing laboratories are not readily available or unless standards do not exist for the products. Provide products that are listed and labeled or

approved as stated above for the location installed in and listed and labeled or approved as indicated and specified for the applications the items are intended for.

B. Conform all work to NFPA 70, National Electrical Code.

C. Install work under supervision of skilled licensed electricians.

PART 2 PRODUCTS

2.01 SECONDARY TRANSFORMERS

A. Provide transformers of the general purpose, indoor, double-wound, ventilated, dry-type designed and tested in accordance with NEMA Standard ST 20 and ANSI Standard C57.12.01, Underwriter's Laboratories Standard UL-1561, and ANSI C57.12.91 of capacities and mounting arrangements, (floor or wall) as indicated on the Drawings. Provide wall-mounted transformers with the wall bracket that is adequate for the supporting weight.

B. Design transformers for continuous operation at rated KVA, 24 hours a day, 365 days a year, with normal life expectancy as defined in ANSI/IEEE C57.96. Provide a transformer which will make this performance obtainable without exceeding 150 degree C. average temperature rise by resistance or 180 degree C. hot spot temperature rise in a 40 degree C. maximum ambient and 30 degree C. average ambient. Do not exceed 220 degree C as the maximum coil hot spot temperature.

C. Provide proven 220 degree C. insulation systems.

D. Wind the coils with [copper] [aluminum], which has insulated, proven, high temperature resistant, 220 degree C. materials.

E. Use all materials in the transformer that are flame retardant and do not support combustion as defined in ASTM Standard Test Method D635.

F. Totally immerse the transformer in an insulating varnish, which will maintain superior bond strength, high dielectric strength, and outstanding power factors at temperatures associated with the 220 degree C. system as a final insulation treatment. After immersion, cure the varnish at normal operating temperatures for such a period of time as to assure complete curing of the varnish and scourging of volatiles in the varnish solvent.

G. Construct transformers with core materials of a high quality, low loss nature as to minimize exciting current, no-load losses, and interlaminar vibrations.

H. The core and coil assembly shall be installed on vibration-absorbing pads.

I. Transformer average sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

1.	Up to	9 kVA	40 db
2.	10 to	50 kVA	45 db
3.	51 to	150 kVA	50 db
4.	151 to	300 kVA	55 db
5.	301 to	500 kVA	60 db
6.	501 to	700 kVA	62 db
7.	701 to	1000 kVA	64 db
8.	1001 to	1500 kVA	65 db

J. Design the core-coil assembly and mechanically brace to withstand short circuit tests as defined in ANSI C57.12.91 by the use of full scale testing. The coil construction and mechanical bracing members shall be such as to prevent mechanical degradation of the insulation structures during short circuit.

K. Provide single phase transformers 2 KVA and below without taps. Provide 3 KVA and 5 KVA with 2-2 ½ percent above nominal full capacity (ANFC) and 2-2 ½ percent below nominal full capacity (BNFC) taps. Provide 7-1/2 KVA and above with 2-2 ½ percent ANFC and 4-2 ½ percent BNFC taps.

L. Provide three phase transformers with 2-2 ½ percent ANFC and 4-2 ½ percent BNFC taps.

M. Provide transformer with enclosures removable front and back panels, and must have screened or grilled ventilation openings designed to prevent accidental access to electrified parts.

N. The following factory tests shall be made on all transformers:
   1. Ratio tests at the rated voltage connection and at all tap connections.
   2. Polarity and phase relation tests on the rated voltage connection.
   3. Applied potential tests.
   4. Induced potential tests.
   5. No-load and excitation current at rated voltage on the rated voltage connection.

O. Transformers shall be low loss type with minimum efficiencies per NEMA TP-1 when operated at 35% of full load capacity.

P. Acceptable Manufacturers:
   1. Square D Company
   2. Eaton Electric
   3. General Electric
   4. Siemens Industry for LV Power Distribution
   5. Or Approved Equal

PART 3 EXECUTION

3.01 INSTALLATION

A. Install, connect, and interconnect products where indicated, and in accordance with NEMA Standards, manufacturer's printed installation instructions, and this Section. Make connections in a manner, which will insure electrical continuity and operability of the products.

B. Protect the equipment against foreign matter and moisture during installation.

C. Install a 3-foot (1m) length of liquid-tight flexible metal conduit between transformer and fixed conduit system in accordance with Section 26 05 33.13. Make power conductor connections in accordance with manufacturer's drawings, and as indicated on the Drawings.

D. Ground in accordance with Section 26 05 26. Provide ground bond for enclosure and neutral, minimum size #6 AWG to nearest structural steel and nearest water pipes to conform with Section 26 05 26 and the NEC.

3.02 FIELD QUALITY CONTROL

A. Dry out dry type transformers before they are energized.

B. Check transformer for tightness of external structural members and mechanical joints in order to minimize audible sound levels. Check the ground connections.

C. Test as specified in Section 26 05 63.

END OF SECTION

SECTION 26 2416

PANELBOARDS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:
   1. Lighting and appliance branch-circuit panelboards.

1.03 SUBMITTALS

A. Product Data: For each type of panelboard, overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Enclosure types and details for types other than NEMA 250, Type 1
      b. Bus configuration, current, and voltage ratings
      c. Short-circuit current rating of panelboards and overcurrent protective devices
      d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

   2. Wiring Diagrams: Power, signal, and control wiring.

C. Qualification Data: For testing agency.

D. Field quality-control test reports including the following:
   1. Test procedures used
   2. Test results that comply with requirements
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

F. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section “Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated. Refer to Section "Products."

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.05 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
1. Ambient Temperature: Not exceeding 122 deg F (50 deg C)
2. Altitude: Not exceeding 6600 feet.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Outages shall be scheduled to occur over the summer months when school is not in session; outages during the normal school year shall not be permitted.
2. Notify Construction Manager/Owner no fewer than fourteen (14) days in advance of proposed interruption of electrical service
3. Do not proceed with interruption of electrical service without Construction Manager's/Owner's written permission.

1.06 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Keys: Four (4) spares for each type of panelboard cabinet lock
a. All panelboards furnished under this Project shall be keyed alike, using Corbin lock as basis of design as specified hereinafter.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
      a. Eaton Corporation; Cutler-Hammer Products
      b. General Electric Co.; Electrical Distribution & Protection Division
      c. Siemens Energy & Automation, Inc.
      d. Square D Company.

2.02 MANUFACTURED UNITS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces.

B. Enclosures: Flush- and surface-mounted cabinets; NEMA PB 1, Type 12 or as otherwise required.
   1. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box
   2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover
   3. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat
   4. Directory Card: With transparent protective cover, mounted in metal frame, inside panelboard door.

C. Phase and Ground Buses:
   1. Material: Hard-drawn copper, 98 percent conductivity
   2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

D. Conductor Connectors: Suitable for use with conductor material.
   1. Main and Neutral Lugs: Compression type
   2. Ground Lugs and Bus Configured Terminators: Compression type.

E. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

2.03 PANELBOARD SHORT-CIRCUIT RATING

A. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.04 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Main Overcurrent Protective Devices (where required): Circuit breaker, thermal-magnetic type or as indicated on the Drawings.

B. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, thermal-magnetic type; replaceable without disturbing adjacent units.

C. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike using Corbin lock as basis of design.

2.05 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: UL 489, with series-connected rating to meet available fault currents.
   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
   1. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

2.06 ACCESSORY COMPONENTS AND FEATURES

A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including overcurrent protective devices and other components.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mount top of trim 74 inches above finished floor, unless otherwise indicated or required.

C. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

D. Install overcurrent protective devices.
   1. Set field-adjustable circuit-breaker trip ranges, as applicable.

E. Install filler plates in unused spaces.

F. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.02 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 26 053.

B. Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.03 CONNECTIONS

A. Ground equipment according to Section 26 0526.

B. Connect wiring according to Section 26 0519.

3.04 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.05 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 2416

PAGE INTENTIONALLY LEFT BLANK

SECTION 26 2816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following individually mounted, enclosed switches:
   1. Fusible switches
   2. Non-fusible switches
   3. Enclosures

1.03 DEFINITIONS

A. HD: Heavy duty.

B. SPDT: Single pole, double throw.

1.04 SUBMITTALS

A. Product Data: For each type of enclosed switch, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1
   2. Current and voltage ratings
   3. Short-circuit current rating
   4. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Qualification Data: For testing agency.

D. Field quality-control test reports including the following:
   1. Test procedures used
   2. Test results that comply with requirements
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements

E. Operation and Maintenance Data: For enclosed switches to include in emergency, operation, and maintenance manuals. In addition to items specified in Section "Closeout Procedures," include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches
   2. Time-current curves, including selectable ranges for each type fuse

1.05 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.06 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: Not exceeding 122 deg F (50 deg C).
   2. Altitude: Not exceeding 6600 feet.

1.07 COORDINATION

A. Coordinate layout and installation of switches, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.08 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Spare Fuses:
      a. Control-Power Fuses: 3 of each type installed
      b. Fuses for Fusible Switches: 3 of each type installed

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 FUSIBLE AND NON-FUSIBLE SWITCHES

A. Available Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products
2. General Electric Co.; Electrical Distribution & Control Division
3. Siemens Energy & Automation, Inc.
4. Square D/Group Schneider

B. Fusible Switch, 600A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Where indicated on the Drawings, furnish switches with an auxiliary set of contacts, arranged to mimic or follow the position of the main switch and open before the switch blades open.

2.03 ENCLOSURES

A. Provide enclosures sized to contain the safety switches, fuses, and all other required items.
1. Provide an interlock that prevents opening the enclosure door when the switch is in the “ON” position.
a. Provide an interlock defeater, which requires a common hand-tool to operate.

2. Provide a copper ground-bus or ground stud rated for 100 percent of capacity.

B. Provide each enclosure with an external operator that positively indicates the “ON”, “OFF”, and “TRIPPED” positions of the switch.

C. Provide the capability to pad-lock the switch in the “ON” and the “OFF” positions by using three padlocks.

D. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
1. Indoor, Dry Locations: NEMA 250, Type 12
2. Outdoor Locations: NEMA 250, Type 3R
3. Other Wet or Damp Indoor Locations: NEMA 250, Type 3R

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches for compliance with installation tolerances and other conditions affecting performance.

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

3.02 INSTALLATION

A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches.

B. Mount individual wall-mounting switches with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Electrical Identification."

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 26 Section "Electrical Identification."

3.04 FIELD QUALITY CONTROL

A. Prepare for acceptance testing as follows:
1. Inspect mechanical and electrical connections
2. Verify switch and relay type and labeling verification
3. Verify rating of installed fuses
4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification

B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Infrared Scanning:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch. Open or remove doors or panels so connections are accessible to portable scanner.
   b. Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
   c. Instruments, Equipment and Reports:
      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      2) Prepare a certified report that identifies enclosed switches included and describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.05 CLEANING

A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.

B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION 26 2816

GANNETT FLEMING
1010 ADAMS AVENUE
VALLEY FORGE, PA 19403