

010000 – GENERAL REQUIREMENTS

A. RELATED DOCUMENTS

1. Drawings, and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to all mechanical and electrical work.

B. SCOPE

1. All work shall be complete and ready for satisfactory service.
2. The contract drawings are diagrammatic and are intended to convey the general arrangement of the work.
3. The contractor is responsible for the means, methods, and work scheduling associated with the installation of the mechanical and electrical systems.

C. CODES AND STANDARDS

1. All work shall be performed in accordance with the edition of the following codes and standards that have been adopted by the authority having jurisdiction:
 - a. American Society of Testing and Materials (ASTM)
 - b. American National Standards Institute (ANSI)
 - c. National Electric Code (NEC)
 - d. Underwriters Laboratories (UL)
2. In the event the contract documents are in conflict with the applicable codes, the requirements of the applicable codes shall apply.

D. PERFORMANCE AND PAYMENT BOND

1. Provide a performance and payment bond for the project.

E. PERMITS

1. The contractor shall obtain all permits and certificates of inspection required by the authority having jurisdiction. There is no permit charge for the Howard County Public School System.
2. Prior to submitting the permit application, the contractor shall print the required number of sets of permit drawings and deliver them to the engineer to sign and seal. The engineer will return the signed and sealed permit sets to the contractor for his use in submitting the permit application.

F. SITE EXAMINATION

1. The contractor shall examine the site and observe the conditions under which the work will be installed. No allowances will be made for errors or omissions resulting from the contractor's failure to completely examine the site.

G. SUBCONTRACTOR AND MANUFACTURER LIST

1. Subcontractors and equipment manufacturers shall be listed on the Form of Proposal (Section 00300).

END OF SECTION 010000

010100 – SPECIAL REQUIREMENTS

A. FIRE PREVENTION

1. Each contractor shall:
 - a. Avoid accumulation of flammable debris and waste within the building and vicinity. Avoid large and unnecessary accumulations of combustible forms and form lumber.
 - b. Store flammable or volatile liquids in the open or in small detached structure or trailers. Handle liquids with low flash points that are to be used within the building in approved safety cans. Supervise closely the storage of paint materials and other combustible finishing and cleaning products. Do not permit oily rags to be stored in closets or other tight permanent spaces.
 - c. Tobacco use is prohibited on the school property.
 - d. Closely supervise welding and torch cutting operations near combustible materials.
 - e. Use only fire-resistant building paper, plastic sheet, and tarpaulins for temporary protection.
 - f. Do not store combustible material outdoors within 10 feet of a building or structure.
 - g. Do not use gasoline for cleaning within the building under any circumstances.
 - h. Do not burn any trash or other material on site.
 - i. Take other precautions suitable for hazardous conditions at the site to prevent fire.

B. ACCIDENT PREVENTION AND SAFETY

1. Each contractor shall:
 - a. Comply with all applicable laws, ordinances, rules, regulations, and orders of governing authorities having jurisdiction for the safety of persons and property to protect them from damage, injury, or loss.
 - b. Erect and maintain, as required by conditions and progress of the work, all necessary safeguards for safety and protection, including fences, railings, barricades, lighting, posting of danger signs and other warnings against hazards.

C. PROJECT SCHEDULE

1. Major construction milestones shall be as scheduled below. Should the contractor fail to complete major milestones as scheduled, the owner may issue a cure notice or take any action deemed necessary to return the delayed major milestones and any related successor functions back on schedule, as soon as possible, at the contractor's expense.
2. The contractor shall develop a detailed project schedule, approximately sequencing all required work, including shop drawing submittals, equipment fabrication periods, etc.

3. Major construction milestones shall be as follows:

Site Visit to School:	February 3, 2022,
Pre-Bid Meeting:	February 4, 2022,
Bids Due:	February 16, 2022
Contract Award:	March 11, 2022
Submittals Due:	March 25, 2022
Boilers Ordered:	April 1, 2022
Begin Construction	April 8, 2022
Boilers Delivered:	May 20, 2022
Substantial Completion:	August 19, 2022
Punchlist Completed:	September 9, 2022
Demonstration & Training:	September 16, 2022
Closeout Documents:	September 23, 2022

END OF SECTION 010100

011000 – SUMMARY

A. WORK IN EXISTING BUILDINGS

1. Sufficient provisions shall be made to protect occupied areas from all dirt and debris resulting from the work.
2. Where mechanical and electrical systems pass through renovated areas to serve other portions of the building, they shall remain or be suitably relocated and the system restored to normal operation.

B. OUTAGES

1. All proposed outages of the mechanical and electrical systems that are required for the proper execution and completion of the work by the contractor shall be requested by the contractor in writing at least one week in advance.
2. The contractor shall inform the owner of all systems that will be affected by the outages and also the duration of each outage.
3. The owner shall determine the date and time of each outage in order to minimize the disruption to the operation of the facility. In most cases, outages will be scheduled to occur outside of normal business hours. Additional compensation to the contractor shall not be made for any work associated with the outages.
4. The owner will be responsible to notify all affected personnel and to ensure that all affected systems are prepared for the outages.
5. The contractor shall be responsible for all work associated with the shutting down and starting up the affected systems which may include, but not be limited to, normal electric power, fire protection, plumbing, and HVAC systems.
6. The contractor may, at his option, pay to have the owner's personnel to be on-site during an outage to assist the contractor in coordinating the shutting down and starting up of the affected systems.
7. Where the duration of the proposed outages cannot be tolerated by the owner, the contractor shall provide temporary connection as required to maintain service.

C. CLEAN-UP

1. Throughout the course of the work, the contractor shall keep the premises free from the accumulation of dirt and debris.
2. Upon completion of the work, the contractor shall clean the premises to the satisfaction of the owner.

D. EXISTING SERVICES

1. The contractor shall verify the size and location of all existing services. The contractor shall notify the engineer of all discrepancies that exist between the

contract documents and the existing services before making any connections to the existing services.

E. DEMOLITION

1. Demolition shall be performed as neatly as practical and with the minimum disruption to the building activities and occupants.
2. Remove all existing hangers and supports associated with the demolition work.
3. All equipment and materials being removed, and not indicated to be given to the owner, shall be disposed of by the contractor in accordance with all federal, state, and local laws, ordinances, rules, and regulations.
4. All equipment and materials indicated to be reused or given to the owner shall be carefully removed so as not to damage the equipment or material, or affect its reuse. Any such equipment and materials damaged by the contractor shall be replaced new by the contractor at no expense to the owner.
5. Should the contractor encounter any known or suspected asbestos containing materials at any time during the course of the work, all workers shall be removed from the affected area and the Owner shall be notified immediately and await instructions from the Owner.
6. Should the contractor encounter any known or suspected lead paint at any time during the course of the work, it shall not be disturbed. The contractor shall immediately notify the Owner who will then take samples to have analyzed by a laboratory. Do not disturb suspected lead paint until the results of the paint samples have been obtained and further direction given to the contractor.
7. If hazardous materials removal is required, the Contractor shall utilize the on-call abatement contractor for HCPSS: Asbestos Specialist, Inc., PO Box 368, Linthicum Heights, MD 21090. POC: Sam Chairs III, 410-796-5379.

END OF SECTION 011000

013100 – PROJECT MANAGEMENT AND COORDINATION

A. CONSTRUCTION SUPERINTENDENT

1. The contractor shall provide a construction superintendent at the site at all times to oversee the mechanical and electrical work and be responsible for its accuracy.

B. PROGRESS MEETINGS

1. Conduct progress meetings at biweekly intervals at the project site.
2. The engineer will record and distribute the meeting minutes.

C. COORDINATION WITH BGE

1. The contractor shall coordinate all activities associated with the Baltimore Gas and Electric Company (BGE).

END OF SECTION 013100

013300 – SUBMITTAL PROCEDURES

A. SUBMITTAL SCHEDULE

1. Within no more than fourteen (14) calendar days after the award of the contract, the contractor shall provide submittals in Adobe Acrobat format to the engineer for approval for all equipment and materials proposed for the work. Equipment and materials for which submittals are not provided within fourteen (14) days shall be provided as specified - other products will not be allowed.

B. SUBMITTAL APPROVALS

1. No work shall be fabricated or equipment ordered until the engineer's approval has been given on the submittals.
2. Approval of submittals by the engineer does not relieve the contractor of his responsibility to provide the equipment and materials specified in the contract documents.

END OF SECTION 013300

016000 – PRODUCT REQUIREMENTS

A. MANUFACTURER'S WARRANTIES

1. All equipment and materials shall be new and installed in accordance with the manufacturer's instructions and conditions for warranty. In the event the contract documents are in conflict with the manufacturer's conditions for warranty, the equipment shall be installed in accordance with the manufacturer's instructions so as not to void any manufacturer's warranties.

B. PRODUCT SELECTION PROCEDURES

1. The contract documents describe systems designed in accordance with the equipment manufacturers specified. The contractor shall bear the cost of all appurtenances required for deviations from the equipment specified. These appurtenances shall include, but are not limited to: architectural, structural, mechanical, and electrical modifications necessary to install the equipment in accordance with the manufacturer's instructions.
2. The contractor shall use products of one manufacturer where two or more items of the same type of equipment are required.
3. The contractor shall notify the engineer of any changes in the electrical characteristics of the equipment being installed in contradiction to that described in the contract documents.

C. SUBSTITUTIONS

1. In the case where two (2) or more equipment manufacturers are specified, the contractor shall provide equipment by one of the specified manufacturers.
2. Any deviation from the specified equipment manufacturers shall constitute a substitution and shall be submitted to the engineer for approval as a request for substitution. The contractor must certify in his request that the proposed substitution complies with the requirements of the contract documents.

D. CLEARANCES

1. The contractor shall insure that adequate clearance exists for the installation and maintenance of all work shown on the drawings and described in the specifications.

E. ACCESSIBILITY

1. The contractor shall locate all equipment which must be serviced, operated, or maintained in fully accessible locations.

END OF SECTION 016000

017329 – CUTTING AND PATCHING

A. GENERAL

1. Unless otherwise directed, the contractor shall perform all cutting and patching required by the mechanical and electrical work.
2. The contractor shall not cut reinforced concrete or structural steel without the engineer's approval.
3. All patching shall be uniform in appearance and shall match the surrounding surface.
4. The contractor shall repair any damage to the existing building or furnishings resulting from the mechanical and electrical work.

END OF SECTION 017329

017700 – CLOSEOUT PROCEDURES

A. CONTRACTOR'S WARRANTY

1. The contractor shall warranty all mechanical and electrical work to be free from defects and installation deficiencies for a period of two years after the date of acceptance by the owner.
2. During the contractor's warranty period, the contractor shall repair all mechanical and electrical systems as required, including all necessary parts and labor, at no cost to the owner.

B. MANUFACTURER'S WARRANTIES

1. The contractor shall deliver to the owner all certificates of manufacturer's warranties which extend beyond the contractor's warranty period.

END OF SECTION 017700

017823 – OPERATION AND MAINTENANCE DATA

A. OPERATION AND MAINTENANCE MANUALS

1. Upon completion of the work, the contractor shall submit to the engineer for approval three (3) hard copies of operation and maintenance (O&M) manuals in 3-ring binders and one (1) Adobe Acrobat file on CD of the O&M manual for all mechanical and electrical equipment. Included in each manual shall be:
 - a. Approved submittals.
 - b. As-built mechanical, flue and hydronic piping shop drawings.
 - c. As-built automatic temperature control shop drawings.
 - d. Equipment start-up reports for the following:
 - 1) Boilers.
 - e. All manufacturers' technical and product information, rated capacities, accessories, maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list, source information, and warranties.
 - f. Contractor's warranty (two years from the date of acceptance by the owner).
 - g. Approved testing, adjusting, and balancing report.
 - h. Other pertinent information for each piece of equipment.

Note: Assemble the entire O&M manual, including the items listed above, into a single Adobe Acrobat file, with dividers identifying each section (approved submittals, as-built ATC shop drawings, etc.), and e-mail it to the engineer to review prior to submitting the three (3) hard copies of the O&M manuals to the engineer. (This cannot be done until the engineer has received, reviewed, and approved the testing, adjusting, and balancing report.) After receiving and incorporating the engineer's comments into the O&M manual, send three (3) hard copies and one (1) Adobe Acrobat file on CD of the O&M manual to the engineer for final review and acceptance.

END OF SECTION 017823

017839 – PROJECT RECORD DOCUMENTS

A. RED-LINED MARK-UP SET

1. Throughout the course of the construction, the contractor shall maintain at the site one (1) set of prints in good condition indicating in red ink any deviations from the original contract drawings.

B. RECORD DRAWINGS

1. Upon completion of the work, the contractor shall submit to the engineer for approval a reproducible set of record drawings and an Adobe Acrobat file clearly showing the location of equipment, piping, and ductwork, and any deviations from the original contract drawings.

END OF SECTION 017839

017900 – DEMONSTRATION AND TRAINING

A. DEMONSTRATION

1. Upon completion of the work, the contractor shall demonstrate to the owner's satisfaction that all components of the work are connected, calibrated, and operating in accordance with the intent of the system design.
2. Demonstrate to the owner's satisfaction that all automatic temperature controls for the HVAC systems have been fully integrated into the existing JCI building automation system in the school and at the central maintenance office on Mendenhall Court.

B. TRAINING

1. Thoroughly instruct the owner's representatives for no less than four (4) hours in the proper operation, adjustment, and maintenance of all mechanical and electrical products, equipment, and systems.

C. VIDEOTAPING

1. Demonstration and training sessions shall be professionally videotaped by the contractor. The recording shall be provided to the Owner on a compact disc as part of the closeout documents.
2. Describe scenes on the videotape by audio narration by microphone while videotape is being recorded. Include descriptions of items being viewed.

END OF SECTION 017900

220500 – COMMON WORK RESULTS FOR PLUMBING

A. GENERAL

1. All plumbing work shall be complete and ready for satisfactory service.
2. The contract drawings are diagrammatic and are intended to convey the general arrangement of the work.
3. The contractor is responsible for the means, methods, and work scheduling associated with the installation of the plumbing systems.

B. SUBMITTALS

1. The contractor shall provide submittals for the following:
 - a. Piping specialties, meters, and gauges.
 - b. General duty valves.
 - c. Plumbing insulation.
 - d. Piping.

A. EXISTING SERVICES

1. Verify the size and location of all existing services. Notify the engineer of all discrepancies that exist between the contract documents and the existing services before making any connections to the existing services.

B. COORDINATION WITH OTHER TRADES

1. Coordinate the size and location of roof penetrations and flashing requirements with the work of other trades.
2. Coordinate the installation of the plumbing systems with the existing conditions and the work of other trades. Provide offsets in piping as required at no additional cost to avoid obstructions.

C. ROUTING OF PIPING

1. Route piping systems parallel and perpendicular to the building lines. Mount at elevations shown or as close as possible to the underside of the building structure.

D. IDENTIFICATION

1. Label all mechanical piping and equipment as to its function and equipment number indicated on the drawings.
2. Label all plumbing piping systems with cylindrical self-coiling plastic sheet that snaps over piping insulation and is held tightly in place without the use of adhesive tape or straps. Pipe identification shall be provided with flow arrows and lettering that is at least one inch high.

3. Label all plumbing equipment with engraved, color-coded laminated plastic markers with contact-type, permanent adhesive. Match equipment schedules on the drawings as closely as possible for equipment designations.

END OF SECTION 220500

220519 – PIPING SPECIALTIES, METERS, AND GAUGES FOR PLUMBING

A. PIPING SPECIALTIES

1. Copper Unions:

- a. ASME B16.22, wrought-copper alloy body, hexagonal stock, with ball-and-socket joint, metal-to-metal seating surfaces, with soldered ends.

B. METERS AND GAUGES

1. Thermometers:

- a. Stem type, cast aluminum case, 9" scale, clear acrylic window, red indicating fluid, black lettering against a white background, with a scale range of 30 deg F to 240 deg F with 2 deg F increments. The adjustable angle brass stem shall have a stem of sufficient length so the end of the stem is near the middle of the pipe in which it is installed without reducing the thickness of any insulation.
- b. Provide brass thermometer sockets with threaded connections suitable for thermometer stems and temperature control sensing elements in pipeline.
- c. Furnish with extension necks for insulated piping systems.

END OF SECTION 220519

220523 – GENERAL-DUTY VALVES FOR PLUMBING PIPING

A. BALL VALVES

1. 2" and Smaller:
 - a. 150 psi steam working pressure (SWP), 600 psi non-shock water, oil, gas (WOG) pressure, solder-end, two-piece, cast bronze body, chrome plated brass/bronze ball, standard port, tetrafluoroethylene (TFE) seats and seals, separate packnut with adjustable stem packing, anti-blowout stem, and vinyl covered steel handle. Valve ends shall have extended solder connections and be manufactured to comply with MSS SP-110.
2. Ball valves shall be equipped with 2" stem extensions of non-thermal conductive material. Also, provide a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation.

B. SWING CHECK VALVES

1. 2" and Smaller:
 - a. Class 150 bronze swing check valve with bronze disc, ASTM B 62 bronze body and seat with regrinding-type bronze disc, y-pattern design, soldered or threaded end connections, and having 300 psig cold working pressure rating. Check valves shall be equal to Nibco Model S-433-B or T-433-B.

END OF SECTION 220523

220529 – HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

- A. Adjustable steel clevis, equal to B-Line B3100, with galvanized sheet metal shield, equal to B-Line B3151 Series.
- B. All hangers shall connect to the top chord of bar joists.

END OF SECTION 220529

220700 – PLUMBING INSULATION

A. PIPE INSULATION

1. Rigid Insulation:

- a. Molded glass fiber, minimum nominal density of 3.0 lb/cu.ft. and thermal conductivity of not more than 0.24 Btu/h/sq.ft./deg F/in. at 75 deg F mean temperature, minimum compressive strength of 25 psf at 10% deformation, rated for service to 450 deg F.
- b. Insulation shall have a factory applied, white, kraft reinforced foil vapor barrier all service jacket with a self-sealing pressure sensitive adhesive lap, maximum permeance of 0.02 perms and minimum beach puncture resistance of 50 units.
- c. Provide white, PVC fitting covers on all fittings.
- d. Shields and inserts:
 - 1) Piping systems 3" in diameter or less shall be supported by placing a galvanized steel shield, minimum 6" in length, under the insulation at each hanger.
 - 2) Inserts and shields shall be a minimum 180 degree coverage on the bottom of the supported piping.
 - 3) Pre-compressed 20 lb density molded fiberglass blocks, Hamfab or equal, of the same thickness as adjacent insulation may be substituted for calcium silicate inserts with one 1"x6" block for piping through 2" and three 1"x6" blocks for piping through 4".
 - 4) Wood blocks will not be accepted.
- e. Insulation thickness:
 - 1) Domestic water:
 - a) 1-1/2" and smaller – 1" thickness.
 - b) 2" and larger – 1-1/2" thickness.

END OF SECTION 220700

221116 – DOMESTIC WATER PIPING

A. PIPING ABOVE GROUND

1. ASTM B 88, Type L, hard-drawn copper tube with ASME B16.22 wrought copper solder-joint fittings using ASTM B 32, lead-free alloy solder and ASTM B 813 water-washable flux.

B. PIPE TESTING

1. All piping systems shall be tested for leaks and proved tight in the presence of the engineer or owner's representative before piping is concealed below floors, above ceilings or covered with insulation.
2. Conduct pressure tests with test medium indicated below. Minimum test time shall be 8 hours; additional time may be necessary to conduct an examination for leakage.
 - a. Domestic water: 100 psig, water

C. DISINFECTION

1. After the final testing for leaks, all new domestic water lines shall be thoroughly flushed to remove foreign material. Before placing the systems in service, the contractor shall engage a qualified service organization, Arc Water Treatment Company of Maryland, Inc., or approved equal, to sterilize the new water lines in accordance with the following procedure:
 - a. Through a 3/4" hose connection in the new piping, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 ppm.
 - b. Proceed from the point of chlorine application opening all drains until chlorine is detected. Close drains when chlorine is evident.
 - c. When chlorinated water has been brought to the entire new piping system with a minimum concentration of 200 ppm chlorine, retain this water in the system for three (3) hours.
 - d. Caution: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system. It is not necessary to retain chlorine in any system for twenty-four hours to achieve disinfection. AWWA states that 200 ppm chlorine for three hours is sufficient.
 - e. At the end of the retention period, no less than 100 ppm of chlorine shall be present at the extreme end of the system.
 - f. Proceed to open all drains and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 ppm.
 - g. Obtain representative water sample from the system for analysis by a recognized bacteriological laboratory.
 - h. If the sample tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the service organization to the contractor, certifying successful completion of the disinfection.
 - i. If any samples tested indicate the presence of coliform organisms, the entire disinfection procedure shall be repeated.

END OF SECTION 221116

223400 - FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.6 COORDINATION

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

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - 2. Warranty Periods: From date of Substantial Completion.

- a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: Three years.
 - 2) Controls and Other Components: One year(s).
- b. Expansion Tanks: Five years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following manufacturers:
 - 1. Basis of Design: A.O. Smith
 - 2. Acceptable Alternative: State Industries.
 - 3. No other manufacturers are acceptable.

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- B. ASME Compliance:
 - 1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.
- C. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.3 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

- A. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:
 - 1. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
 - 2. Standard: ANSI Z21.10.3/CSA 4.3.
 - 3. Description: Manufacturer's proprietary design to provide at least 95 percent thermal efficiency at optimum operating conditions.
 - 4. Storage-Tank Construction: ASME-code steel with 150-psig minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 and Smaller: Threaded ends in accordance with ASME B1.20.1.

- b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Lining: Glass complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
- 5. Factory-Installed, Storage-Tank Appurtenances:
 - a. Heat Exchanger: Helical coil.
 - b. Anode Rod: Powered, non-sacrificial to provide long lasting tank protection in varying water conditions.
 - c. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - d. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - e. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
 - f. Jacket: Steel with enameled finish.
 - g. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel.
 - h. Temperature Control: Adjustable thermostat.
 - i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - j. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
- 6. Venting: Conventional power venting or direct venting capabilities. Project utilizes direct venting for flue and combustion air with use of optional concentric vent kit when combined to penetrate the roof.
- 7. Condensate Neutralization: Provide with optional condensate neutralization kit.

B. Capacity and Characteristics:

- 1. Refer to Schedule on the Drawings.
- 2. Electrical Characteristics:
 - a. Refer to Schedule on the Drawings.
- 3. Minimum Vent Diameter: 3 inches .

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base.
 - 1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 - 2. Maintain manufacturer's recommended clearances.
 - 3. Arrange units so controls and devices that require servicing are accessible.

- B. Install domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
 - 1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping.
- C. Install gas-fired, domestic-water heaters in accordance with NFPA 54.
 - 1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
 - 2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
 - 3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
 - 4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Section 231123 "Facility Natural-Gas Piping."
- D. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 220519 "Piping Specialties, Meters and Gauges for Plumbing."
- F. Install thermometer on outlet piping of domestic-water heaters.
- G. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.
- H. Fill domestic-water heaters with water.
- I. Charge domestic-water expansion tanks with air to required system pressure.
- J. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

3.2 PIPING CONNECTIONS

- A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."
- B. Comply with requirements for gas piping specified in Section 231123 "Facility Natural-Gas Piping."
- C. Drawings indicate general arrangement of piping, fittings, and specialties.

- D. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220500 "Common Work Results for Plumbing."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Domestic-water heaters will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain commercial, gas-fired, storage, domestic-water heaters. Training shall be a minimum of one hour(s).

END OF SECTION 223400

DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING

230500 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

A. GENERAL

1. All mechanical work shall be complete and ready for satisfactory service.
2. The contract drawings are diagrammatic and are intended to convey the general arrangement of the work.
3. The contractor is responsible for the means, methods, and work scheduling associated with the installation of the mechanical systems.

B. SUBMITTALS

1. The contractor shall provide submittals for the following:
 - a. Piping specialties, meters, and gauges.
 - b. General duty valves.
 - c. Testing, adjusting, and balancing report.
 - d. Insulation.
 - e. Direct Digital Controls.
 - f. Piping.
 - g. HVAC Water Treatment.
 - h. Hydronic pumps and associated accessories.
 - i. Air separators and expansion tanks.
 - j. Boiler vent.
 - k. Boilers.

C. PIPING (GENERAL)

1. Provide manual air vents at all high points and drains at all low points of hydronic piping systems.
2. Pitch all hydronic piping 1/4" in 10 feet in the direction of terminal equipment to enable the system to be drained.

D. IDENTIFICATION

1. Identify all mechanical piping and equipment as to its function and equipment number indicated on the drawings.
2. Label all mechanical piping systems with preprinted, self-adhesive, color-coded pipe labels conforming to ANSI A13.1 for color and size of legend letters indicating service and showing flow direction.
3. Identify all mechanical equipment with engraved, self-adhesive laminated plastic markers with white letters and numerals on a black background. Match equipment schedules on the drawings as closely as possible for equipment designations.

END OF SECTION 230500

230519 – PIPING SPECIALTIES, METERS AND GAUGES FOR HVAC PIPING

A. PIPING SPECIALTIES

1. Strainers:

- a. Provide strainers of the "Y" or basket types as indicated on the drawings or required to suit the field conditions.

1) Strainers 2-1/2" and larger:

- a) Strainers shall have 125 psig working pressure, cast-iron body (ASTM A 126, Class B), flanged ends, bolted cover, perforated stainless-steel basket, and bottom drain connection. Screens shall be 18-8 stainless steel with 1/32" diameter perforations.

2. Copper Unions:

- a. ASME B16.22, wrought-copper alloy body, hexagonal stock, with ball-and-socket joint, metal-to-metal seating surfaces, with soldered ends.

3. Malleable-iron Unions:

- a. ASME B16.39, Class 150.

B. METERS AND GAUGES

1. Thermometers:

- a. Stem type, cast aluminum case, nine inch scale, clear acrylic window, red indicating fluid, black lettering against a white background, with a scale range of 30 deg F to 100 deg F with 2 deg F increments. The adjustable angle brass stem shall have a stem of sufficient length so the end of the stem is near the middle of the pipe in which it is installed without reducing the thickness of any insulation.
- b. Provide brass thermometer sockets with threaded connections suitable for thermometer stems and temperature control sensing elements in pipeline.
- c. Furnish with extension necks for insulated piping systems.

2. Pressure Gauges:

- a. Gauges: Cast aluminum case of not less than 4-1/2" diameter, double strength glass window, black lettering on a white background, phosphor bronze bourdon tube with bronze bushings, recalibration from the front of the dial, 99% accuracy over the middle half of the scale, 98.5% accuracy over the remainder of the scale, with scale range of 0 psi to 100 psi.
- b. Valves: 1/4" brass or stainless-steel needle type.
- c. Snubbers: Brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

END OF SECTION 230519

230523 – GENERAL-DUTY VALVES FOR HVAC PIPING

A. BALL VALVES

1. 2" and Smaller:
 - a. 150 psi steam working pressure (SWP), 600 psi non-shock water, oil, gas (WOG) pressure, solder-end, two-piece, cast bronze body, chrome plated brass/bronze ball, standard port, tetrafluoroethylene (TFE) seats and seals, separate packnut with adjustable stem packing, anti-blowout stem, and vinyl covered steel handle. Valve ends shall have extended solder connections and be manufactured to comply with MSS SP-110.
2. Ball valves shall be equipped with 2" extended handles of non-thermal conductive material. Also, provide a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation.

B. HIGH PERFORMANCE BUTTERFLY VALVES

1. 2-1/2" and Larger:
 - a. MSS SP-68, API 609 seat pressure and temperature ratings, ANSI B1634A body pressure and temperature ratings, ANSI B16.5 flange dimensions, ISO 5211, EN 12116 actuator mounting top works, capable of bi-directional dead-end service at full-rated pressure without use of downstream flange.
 - b. Single-flange, full-lug, 285-psig CWP rating.
 - c. Carbon-steel body, offset design, extended-neck for insulation, permanently lubricated 300-series stainless-steel bushings with graphite and modified PTFE seats, graphite packing and gasket, one-piece duplex stainless-steel stem, and stainless-steel disc. Maximum steam rating of 50 psig.
 - d. Valves 4" and larger shall have weatherproof gear operator.
 - e. Valves installed 84" AFF and higher shall have chainwheels.
 - f. Basis-of-design product: Nibco Model LCS6822-3/5, or a comparable product by one of the following:
 - 1) Jamesbury, Inc.
 - 2) Bray Controls; a division of Bray International
 - 3) Xomox Corporation
2. Butterfly valves shall be equipped with 2" extended handles of non-thermal conductive material. Also, provide a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation.

C. CALIBRATED BALANCING VALVES

1. 2" and Smaller:
 - a. Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall be venturi-type, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

2. 2-1/2" and Larger:

- a. Cast-iron or steel body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having flanged connections. Valves shall venturi-type, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

D. SWING CHECK VALVES

1. 2" and Smaller:

- a. Class 150 bronze swing check valve with bronze disc, ASTM B 62 bronze body and seat with regrinding-type bronze disc, y-pattern design, soldered or threaded end connections, and having 300 psig cold working pressure rating. Check valves shall be equal to Nibco Model S-433-B or T-433-B.

END OF SECTION 230523

230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

A. SCOPE

1. All heating, ventilating and air conditioning (HVAC) systems shall be tested, adjusted and balanced by an independent AABC or NEBB certified contractor.

B. TOLERANCE

1. Test, adjust and balance all hydronic systems to within 10% of the quantities indicated on the Drawings.

C. MEASUREMENTS AND ADJUSTMENTS

1. Measure and record the following for each pump:
 - a. Manufacturer's name, model number, and serial number.
 - b. Motor horsepower rating.
 - c. Motor rpm.
 - d. Efficiency rating.
 - e. Starter thermal protection element rating.
 - f. Nameplate and measured voltage, each phase.
 - g. Nameplate and measured amperage, each phase.
 - h. Brake horsepower.
 - i. Flow rate.
 - j. Head.
2. Permanently mark equipment settings, including balancing valve positions, control settings, and similar devices allowing settings to be restored. Set and lock all memory stops.

D. TESTING, ADJUSTING, AND BALANCING REPORT

1. Report all results on AABC or NEBB standard forms.

END OF SECTION 230593

230700 – HVAC INSULATION

A. PIPE INSULATION

1. Rigid Fiberglass Insulation:

- a. Minimum nominal density of 3 pcf, thermal conductivity of not more than 0.23 at 75 deg F, minimum compressive strength of 25 psf at 10% deformation, rated for service to 450 deg F. Insulation shall have a factory applied, white, kraft reinforced foil vapor barrier all service jacket with a self-sealing pressure sensitive adhesive lap, maximum permeance of 0.02 perms and minimum beach puncture resistance of 50 units. Provide white, PVC fitting covers to all fittings.
- b. Shields and inserts:
 - 1) Piping systems 3" in diameter or less shall be supported by placing a galvanized steel shield, minimum 6" in length, under the insulation at each hanger.
 - 2) For piping systems larger than 3" in diameter, provide a calcium silicate or polyisocyanurate, minimum 140 psi compressive strength, insert and a galvanized steel shield, minimum 6" in length, under the insert at each hanger.
 - 3) Inserts and shields shall be a minimum 180-degree coverage on the bottom of the supported piping.
 - 4) Pre-compressed 20 lb density molded fiberglass blocks, Hamfab or equal, of the same thickness as adjacent insulation may be substituted for calcium silicate inserts with one 1"x6" block for piping through 2" and three 1"x6" blocks for piping through 4".
 - 5) Wood blocks will not be accepted.
- c. Insulation thickness:
 - 1) Heating water – 2" thickness

END OF SECTION 230700

230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct digital control (DDC) system equipment and components for monitoring and controlling of HVAC, exclusive of instrumentation and control devices.

1.2 DEFINITIONS

- A. Algorithm:** A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
- B. Analog:** A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. BACnet Specific Definitions:**
1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data and services over a network.
 2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
 3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
 4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
- D. Binary:** Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.
- E. Controller:** Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: network controllers, programmable application controllers, and application-specific controllers.
- F. Control System Integrator:** An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

- G. COV: Changes of value.
- H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems to be capable of operating in a standalone mode using the last best available data.
- J. E/P: Voltage to pneumatic.
- K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- L. HLC: Heavy load conditions.
- M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
- N. I/P: Current to pneumatic.
- O. LAN: Local area network.
- P. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- Q. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.
- R. Modbus TCP/IP: An open protocol for exchange of process data.
- S. MS/TP: Master-slave/token-passing, ISO/IEC/IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- T. MTBF: Mean time between failures.
- U. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.
- V. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
- W. Peer to Peer: Networking architecture that treats all network stations as equal partners.

- X. POT: Portable operator's terminal.
- Y. RAM: Random access memory.
- Z. RF: Radio frequency.
- AA. Router: Device connecting two or more networks at network layer.
- BB. Server: Computer used to maintain system configuration, historical and programming database.
- CC. TCP/IP: Transport control protocol/Internet protocol.
- DD. UPS: Uninterruptible power supply.
- EE. USB: Universal Serial Bus.
- FF. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
- GG. VAV: Variable air volume.
- HH. WLED: White light emitting diode.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site .

1.4 ACTION SUBMITTALS

- A. Shop Drawings:
 - 1. General Requirements:
 - a. Include cover drawing with Project name, location, Owner, Architect, Contractor, and issue date with each Shop Drawings submission.
 - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
 - c. Drawings Size: 11 inches by 17 inches. .
 - 2. Include plans, elevations, sections, and mounting details where applicable.
 - 3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 4. Detail means of vibration isolation and show attachments to rotating equipment.
 - 5. Plan Drawings indicating the following:
 - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
 - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.

- c. Each desktop workstation network port, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
 - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
 - e. Network communication cable and raceway routing.
 - f. .
 - g. Proposed routing of wiring, cabling, conduit, and tubing; coordinated with building services for review before installation.
6. Schematic drawings for each controlled HVAC system indicating the following:
- a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
 - c. A graphic showing location of control I/O in proper relationship to HVAC system.
 - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 - e. Unique identification of each I/O that to be consistently used between different drawings showing same point.
 - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
 - g. Narrative sequence of operation.
 - h. Graphic sequence of operation, showing all inputs and output logical blocks.
7. Control panel drawings indicating the following:
- a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.
 - c. Front, rear, and side elevations and nameplate legend.
 - d. Unique drawing for each panel.
8. DDC system network riser diagram indicating the following:
- a. Each device connected to network with unique identification for each.
 - b. Interconnection of each different network in DDC system.
 - c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
 - d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
9. DDC system electrical power riser diagram indicating the following:
- a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
 - b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
 - c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
 - d. Power wiring type and size, race type, and size for each.

10. Monitoring and control signal diagrams indicating the following:
 - a. Control signal cable and wiring between controllers and I/O.
 - b. Point-to-point schematic wiring diagrams for each product.
 - c. Control signal tubing to sensors, switches, and transmitters.
 - d. Process signal tubing to sensors, switches, and transmitters.

B. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing, and events that initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:
 - a. Loss of power.
 - b. Loss of network communication signal.
 - c. Loss of controller signals to inputs and outpoints.
 - d. Server failure.
 - e. Gateway failure.
 - f. Network failure.
 - g. Controller failure.
 - h. Instrument failure.
 - i. Control damper and valve actuator failure.
4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

1.5 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Submittals:

1. Field quality-control reports.

B. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.

- e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
- f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
- g. Engineering, installation, and maintenance manuals that explain how to do the following:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
- h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
- i. Backup copy of graphic files, programs, and databases on electronic media.
- j. List of recommended spare parts with part numbers and suppliers.
- k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
- m. Licenses, guarantees, and warranty documents.
- n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- o. Owner training materials.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials and parts to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Include product manufacturers' recommended parts lists for proper product operation over four -year period following warranty period. Parts list to be indicated for each year.
- C. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during two -year period following warranty period.
- D. Furnish quantity indicated of matching product(s) in Project inventory for each unique size and type of following:
 - 1. Network Controller: One .
 - 2. Programmable Application Controller: One .
 - 3. Application-Specific Controller: One .
 - 4. General-Purpose Relay: Two .
 - 5. Current-Sensing Relay: Two .

6. Transformer: One .
7. DC Power Supply: One .

1.8 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least five past projects.
4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
 - e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within 50 Miles of Project.
3. Demonstrate past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
4. Demonstrate past experience on five projects of similar complexity, scope, and value.
5. Demonstrate past experience of each person assigned to Project.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support ongoing DDC system operation for a period of not less than five years after Substantial Completion.
9. DDC system manufacturer's backing to take over execution of the Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Welding Qualifications: Qualify procedures and personnel in accordance with the following welding codes:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.
3. AWS D1.3/D1.3M.
4. AWS D1.4/D1.4M.

1.9 WARRANTY

- A. Special Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
 - 1. Adjust, repair, or replace failures at no additional cost or reduction in service to Owner.
 - 2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
 - a. Install updates only after receiving Owner's written authorization.
 - 3. Perform warranty service during normal business hours and commence within 24 hours of Owner's warranty service request.
 - 4. Warranty Period: Two year(s) from date of Substantial Completion.
 - a. For Gateway: Two -year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Tridium, Inc.

2.2 DDC SYSTEM DESCRIPTION

- A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.
 - 1. DDC system consisting of high-speed, peer-to-peer network of distributed DDC controllers , other network devices, operator interfaces, and software.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS

- A. DDC system to be web compatible.
 - 1. Web-Compatible Access to DDC System:
 - a. server to perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.

- b. DDC system to support web browser access to building data. Operator using a standard web browser is able to access control graphics and change adjustable set points.
- c. Password-protected web access.

2.4 PERFORMANCE REQUIREMENTS

- A. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.
- B. DDC System Speed:
 - 1. Response Time of Connected I/O:
 - a. Update AI point values connected to DDC system at least every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
 - b. Update BI point values connected to DDC system at least every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
 - c. AO points connected to DDC system to begin to respond to controller output commands within two second(s). Global commands to also comply with this requirement.
 - d. BO point values connected to DDC system to respond to controller output commands within two second(s). Global commands to also comply with this requirement.
 - 2. Display of Connected I/O:
 - a. Update and display analog point COV connected to DDC system at least every five seconds for use by operator.
 - b. Update and display binary point COV connected to DDC system at least every five seconds for use by operator.
 - c. Update and display alarms of analog and digital points connected to DDC system within 30 seconds of activation or change of state.
 - d. Update graphic display refresh within eight seconds.
 - e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations to not exceed graphic refresh rate indicated.
- C. Network Bandwidth: Design each network of DDC system to include spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions. Minimum spare bandwidth as follows:
 - 1. Level 1 Networks: 20 .
 - 2. Level 2 Networks: 20 .
 - 3. Level 3 Networks: 10 .
 - 4. .
- D. DDC System Data Storage:

1. Include capability to archive not less than 36 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends, and other information indicated.
 2. Local Storage:
 - a. Coordinate with existing server to ensure data storage indicated. Server(s) to use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.
- E. DDC Data Access:
1. When logged into the system, operator able to also interact with any DDC controllers connected to DDC system as required for functional operation of DDC system.
 2. Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
- F. Future Expandability:
1. DDC system size is expandable to an ultimate capacity of at least 1.5 times total I/O points indicated.
 2. Design and install system networks to achieve ultimate capacity with only addition of DDC controllers, I/O, and associated wiring and cable. Design and install initial network infrastructure to support ultimate capacity without having to remove and replace portions of network installation.
 3. Operator interfaces installed initially do not require hardware and software additions and revisions for system when operating at ultimate capacity.
- G. Input Point Values Displayed Accuracy: Meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
1. Flow:
 - a. Natural Gas: Within 5 percent of design flow rate.
 - b. Water: Within 5 percent of design flow rate.
 2. Gas:
 - a. Carbon Monoxide: Within 5 percent of reading.
 3. Moisture (Relative Humidity):
 - a. Air: Within 5 percent RH.
 - b. Space: Within 5 percent RH.
 - c. Outdoor: Within 5 percent RH.
 4. Speed: Within 5 percent of reading.
 5. Temperature, Dew Point:
 - a. Air: Within 0.5 deg F .
 - b. Space: Within 0.5 deg F .
 - c. Outdoor: Within 2 deg F .
 6. Temperature, Dry Bulb:
 - a. Air: Within 0.5 deg F .
 - b. Space: Within 0.5 deg F .
 - c. Outdoor: Within 1 deg F .

- d. Heating Hot Water: Within 1 deg F .
- e. Other Temperatures Not Indicated: Within 1 deg F .
- 7. Temperature, Wet Bulb:
 - a. Air: Within 1 deg F .
 - b. Space: Within 1 deg F .
 - c. Outdoor: Within 2 deg F .
- H. Precision of I/O Reported Values: Values reported in database and displayed to have following precision:
 - 1. Current:
 - a. Milliamperes: Nearest 1/100th of a milliampere.
 - b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
 - 2. Energy:
 - a. Electric Power:
 - 1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
 - 2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
 - 3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
 - b. Fuel Oil (Usage): For gallons, nearest 1/10th of a gallon up to 100 gal.; nearest gallon for above 100 gal..
 - c. Natural Gas (Usage): Nearest 1/10th of a unit (cubic feet, MCF, therm) up to 100 units; nearest unit for above 100 units.
 - d. Thermal, Rate:
 - 1) Heating: For British thermal units per hour, nearest British thermal unit per hour up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For MBh, round to nearest MBh up to 1000 MBh; nearest 10 MBh between 1000 and 10,000 MBh; nearest 100 MBh above 10,000 MBh.
 - 2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.
 - e. Thermal, Usage:
 - 1) Heating: For British thermal unit, nearest British thermal unit up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For MBtu, round to nearest MBtu up to 1000 MBtu; nearest 10 MBtu between 1000 and 10,000 MBtu; nearest 100 MBtu above 10,000 MBtu.
 - 2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons.
 - 3. Flow:
 - a. Air: Nearest 1/10th of a cubic feet per minute through 100 cfm; nearest cubic feet per minute between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
 - b. Fuel Oil: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm

- c. Natural Gas: Nearest 1/10th of a cubic feet per hour through 100 cfh; nearest cubic feet per hour between 100 and 1000 cfh; nearest 10 cfh between 1000 and 10,000 cfh; nearest 100 cfh above 10,000 cfh.
 - d. Water: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.
 - e. Steam: Nearest 1/10th of a pound per hour through 100 lb/h; nearest pound per hour between 100 and 1000 lb/h; nearest 10 lb/h above 1000 lb/h.
 - 4. Gas:
 - a. Carbon Dioxide (ppm): Nearest ppm.
 - b. Carbon Monoxide (ppm): Nearest ppm.
 - c. Oxygen (Percentage): Nearest 1/10th of 1 percent.
 - d. Refrigerant (ppm): Nearest ppm.
 - e. Volatile Organic Compounds (ppm): Nearest ppm
 - 5. Moisture (Relative Humidity):
 - a. Relative Humidity (Percentage): Nearest 1 percent.
 - 6. Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.
 - 7. Speed:
 - a. Rotation (rpm): Nearest 1 rpm.
 - b. Velocity: Nearest 1/10th of feet per minute through 100 fpm; nearest feet per minute between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.
 - 8. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
 - 9. Pressure:
 - a. Air, Ducts and Equipment: Nearest 1/10th of an inch water closet.
 - b. Space: Nearest 1/100th of an inch water closet.
 - c. Steam: Nearest 1/10th of pounds per square inch gauge through 100 psig; nearest pounds per square inch gauge above 100 psig.
 - d. Water: Nearest 1/10 of a pound per square inch gauge through 100 psig; nearest pound per square inch gauge above 100 psig.
 - 10. Temperature:
 - a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
 - b. Outdoor: Nearest degree.
 - c. Space: Nearest 1/10th of a degree.
 - d. Chilled Water: Nearest 1/10th of a degree.
 - e. Condenser Water: Nearest 1/10th of a degree.
 - f. Heating Hot Water: Nearest degree.
 - g. Heat Recovery Runaround: Nearest 1/10th of a degree.
 - h. Steam: Nearest degree.
 - 11. Vibration: Nearest 1/10th of an inch per second.
 - 12. Voltage: Nearest 1/10 V up to 100 V; nearest volt above 100 V.
- I. Control Stability: Control variables indicated within the following limits:
- 1. Flow:
 - a. Water: Within 5 percent of design flow rate.
 - 2. Pressure:
 - a. Water: Within 1 percent of instrument range .
 - 3. Temperature, Dry Bulb:
 - a. Space: Within 2 deg F .

- b. Heating Hot Water: Within 1 deg F .

J. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products to operate without performance degradation under ambient environmental temperature, pressure, and humidity conditions encountered for installed location.
 - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated, cooled, and ventilated as required by product and application.
2. Protect products with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House products not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location dictates the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: Type 3 .
 - b. Outdoors, Unprotected: Type 4 .
 - c. Indoors, Heated with Non-Filtered Ventilation: Type 2orType 12 .
 - d. Mechanical Equipment Rooms:
 - 1) Chiller and Boiler Rooms: Type 12.

K. Environmental Conditions for Instruments and Actuators:

1. Protect instruments, actuators, and accessories with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House instruments and actuators not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location is to dictate the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: Type 12.
 - b. Outdoors, Unprotected: Type 4 .

L. DDC System Reliability:

1. Design, install, and configure DDC controllers, gateways, routers, to yield a MTBF of at least 20,000 hours, based on a confidence level of at least 90 percent. MTBF value includes any failure for any reason to any part of products indicated.
2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment being controlled, operational, and under automatic control.
3. See Drawings for critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated.

M. Electric Power Quality:

1. Power-Line Surges:
 - a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.1 and IEEE C62.41.2.
 - b. Do not use fuses for surge protection.

- c. Test protection in the normal mode and in the common mode, using the following two waveforms:
 - 1) 10-by-1000-microsecond waveform with a peak voltage of 1500 V and a peak current of 60 A.
 - 2) 8-by-20-microsecond waveform with a peak voltage of 1000 V and a peak current of 500 A.
- 2. Ground Fault: Protect products from ground fault by providing suitable grounding. Products to not fail due to ground fault condition.

N. Backup Power Source:

- 1. Serve DDC system products that control HVAC systems and equipment served by a backup power source also from a backup power source.

O. UPS:

- 1. DDC system products powered by UPS units are to include the following:
 - a. Servers.
 - b. Gateways.
 - c. Network and DDC controllers , except application-specific controllers.
 - d. Network switches, or any other component required for communication .

P. Continuity of Operation after Electric Power Interruption:

- 1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems are to automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 PANEL-MOUNTED, MANUAL OVERRIDE SWITCHES

A. Manual Override of Control Dampers:

- 1. Include panel-mounted, two-position, selector switch for each automatic control damper being controlled by DDC controller.
- 2. Label each switch with damper designation served by switch.
- 3. Label switch positions to indicate either "Manual" or "Auto" control signal to damper.
- 4. With switch in "Auto" position, control signal to damper actuator with control loop output signal from DDC controller.
- 5. With switch in "Manual" position, control signal to damper actuator at panel with either an integral or a separate switch to include local control.
 - a. For Binary Control Dampers: Manual two-position switch with "Close" and "Open" switch positions indicated. With switch in "Close" position, close damper. With switch in "Open" position, open damper.

- b. For Analog Control Dampers: A gradual switch with "Close" and "Open" switch limits indicated. Operator switches knob to adjust damper to any position from close to open.
6. DDC controller to monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller to signal an override condition to alert operator that damper is under manual, not automatic, control.
7. Configure manual override switches to allow operator to manually operate damper while at panel without DDC controller operational.
8. Terminal equipment including unit heaters do not require manual override unless otherwise indicated by sequence of operation.

B. Manual Override of Control Valves:

1. Include panel-mounted, two-position, selector switch for each automatic control valve being controlled by DDC controller.
2. Label each switch with valve designation served by switch.
3. Label switch positions to indicate either "Manual" or "Auto" control signal to valve.
4. With switch in "Auto" position, control signal to valve actuator with a control loop output signal from DDC controller.
5. With switch in "Manual" position, control signal to valve actuator at panel with either an integral or a separate switch to include local control.
 - a. For Binary Control Valves: Manual two-position switch with "Close" and "Open" switch positions indicated. With switch in "Close" position, close valve. With switch in "Open" position, open valve.
 - b. For Analog Control Valves: A gradual switch with "Open" and "Close" switch limits indicated. Operator rotates switch knob to adjust valve to any position from close to open.
6. DDC controller to monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller to signal an override condition to alert operator that valve is under manual, not automatic, control.
7. Configure manual override switches to allow operator to manually operate valve while at panel without DDC controller operational.
8. Terminal equipment including unit heaters do not require manual override unless otherwise indicated by sequence of operation.

2.6 SYSTEM ARCHITECTURE

A. System architecture consisting of no more than three levels of LANs.

1. Level 1 LAN: Connect network controllers and operator workstations.
2. Level 2 LAN: Connect programmable application controllers to other programmable application controllers and to network controllers.
3. Level 3 LAN: Connect application-specific controllers to programmable application controllers and to network controllers .

B. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.

2. LAN Connecting Programmable Application Controllers: 1000 kbps.
 3. LAN Connecting Application-Specific Controllers: 115,000 bps.
- C. Provide dedicated and separated DDC system LANs that are not shared with other building systems and tenant data and communication networks.
- D. Provide modular system architecture with inherent ability to expand to not less than 1.5 times system size indicated with no impact to performance indicated.
- E. Configure architecture to eliminate need to remove and replace existing network equipment for system expansion.
- F. Make number of LANs and associated communication transparent to operator. Configure all I/O points residing on any LAN to be capable of global sharing between all system LANs.
- G. Design system to eliminate dependence on any single device for system alarm reporting and control execution. Design each controller to operate independently by performing own control, alarm management, and historical data collection.
- H. Special Network Architecture Requirements:
1. Coordinate all network naming, architecture, addressing and other requirements with HCPSS IT Department and BAS Group to obtain network drop and ensure acceptable integration with the existing Niagara N4 network/database .

2.7 DDC SYSTEM OPERATOR INTERFACES

- A. Operator Means of System Access: Operator able to access entire DDC system through any of multiple means including, but not limited to, the following:
1. Portable operator terminal with hardwired connection through LAN port.
 2. Remote connection through web access.
- B. Make access to system, regardless of operator means used, transparent to operator.
- C. Network Ports: For hardwired connection of desktop or portable workstation. Network port easily accessible, properly protected, clearly labeled, and installed at the following locations:
1. Each boiler room.
- D. Critical Alarm Reporting:
1. Send operator-selected critical alarms to notify operator of critical alarms that require immediate attention.
 2. Send alarm notification to multiple recipients that are assigned for each alarm.
 3. Notify recipients by any or all means, including email, text message, and prerecorded phone message to mobile and landline phone numbers.

- E. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any of operator interfaces indicated.

2.8 NETWORKS

- A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:
 - 1. IP.
 - 2. ISO/IEC/IEEE 8802-3, Ethernet.
- B. Acceptable networks for connecting programmable application controllers include the following:
 - 1. IP.
 - 2. ISO/IEC/IEEE 8802-3, Ethernet.

2.9 NETWORK COMMUNICATION PROTOCOL

- A. Use network communication protocol(s) that are open to Owner and available to other companies for use in making future modifications to DDC system.
- B. ASHRAE 135 Protocol:
 - 1. Use ASHRAE 135 communication protocol as sole and native protocol used throughout entire DDC system.
 - 2. DDC system to not require use of gateways except to integrate HVAC equipment and other building systems and equipment; not required to use ASHRAE 135 communication protocol.
 - 3. If used, gateways to connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
 - 4. Use operator workstations, controllers, and other network devices that are tested and listed by BTL.
- C. Industry Standard Protocols:
 - 1. Use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:
 - a. ASHRAE 135.
 - 2. Operator workstations and network controllers are to communicate through ASHRAE 135 protocol.
 - 3. Provide portions of DDC system networks using ASHRAE 135 communication protocol as an open implementation of network devices complying with ASHRAE 135. Use network devices that are tested and listed by BTL.
 - 4. Provide portions of DDC system networks using CTA-709.1-D communication protocol as an open implementation of LonWorks technology using CTA-709.1-D

- communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for DDC system.
5. Provide portions of DDC system networks using Modbus Application Protocol Specification V1.1b3 communication protocol as an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b3.
 6. Use gateways to connect networks and network devices with different protocols.

2.10 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system capable of operating DOS and Microsoft Windows applications.
3. Database management software to manage all data on an integrated and non-redundant basis. Additions and deletions to database are to be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software to manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software to include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software to schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language pronouncing and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Make operator sign-off a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Make automatic sign-off period programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Record operator sign-on and sign-off activity and send to printer.
6. Security Access:
 - a. Use password control for operator access to DDC system.
 - b. Assign an alphanumeric password (field assignable) to each operator.
 - c. Grant operators access to DDC system by entry of proper password.
 - d. Use same operator password regardless of which computer or other operator interface means are used.
 - e. Automatically update additions or changes made to passwords.

- f. Assign each operator an access level to restrict access to data and functions the operator is cable of performing.
 - g. Provide software with at least five access levels.
 - h. Assign each menu item an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
 - i. Display menu items to operator with those capable of access highlighted. Make menu and operator access level assignments online programmable and under password control.
7. Data Segregation:
- a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
 - b. Include at least 32 segregation groups.
 - c. Make segregation groups selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
 - d. Make points assignable to multiple segregation groups. Display and output of data to printer or monitor is to occur where there is a match of operator or peripheral segregation group assignment and point segregations.
 - e. Make alarms displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
 - f. Assign operators and peripherals to multiple segregation groups and make all assignments online programmable and under password control.
8. Operators able to perform commands including, but not limited to, the following:
- a. Start or stop selected equipment.
 - b. Adjust set points.
 - c. Add, modify, and delete time programming.
 - d. Enable and disable process execution.
 - e. Enable and disable totalization for each point.
 - f. Enable and disable trending for each point.
 - g. Override control loop set points.
 - h. Enter temporary override schedules.
 - i. Enter and modify analog alarm limits.
 - j. Enter and modify analog warning limits.
 - k. View limits.
 - l. Display logic programming for each control sequence.
9. Reporting:
- a. Generated automatically and manually.
 - b. Sent to displays, printers and disc files.
 - c. Types of Reporting:
 - 1) General listing of points.
 - 2) List points currently in alarm.
 - 3) List of off-line points.
 - 4) List points currently in override status.
 - 5) List of disabled points.
 - 6) List weekly schedules.
 - 7) List of limits and deadbands.
10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface is to use a pointing device with pull-down or penetrating menus, color, and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Make descriptors for graphics, points, alarms, and such modifiable through operator's workstation under password control.
5. Make graphic displays online user definable and modifiable using the hardware and software provided.
6. Make data displayed within a graphic assignable regardless of physical hardware address, communication, or point type.
7. Make graphics online programmable and under password control.
8. Make points assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics to also contain software points.
10. Penetration within a graphic hierarchy is to display each graphic name as graphics are selected to facilitate operator understanding.
11. Provide a back-trace feature to permit operator to move upward in the hierarchy using a pointing device. Back trace to show all previous penetration levels. Include operator with option of showing each graphic full-screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Provide operator with ability to select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Display defined and linked graphic below that selection.
14. Include operator with means to directly access graphics without going through penetration path.
15. Make dynamic data assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Make colors variable for each class of points, as chosen by operator.
18. For operators with appropriate privilege, command points directly from display using pointing device.
 - a. For an analog command point such as set point, display current conditions and limits so operator can position new set point using pointing device.
 - b. For a digital command point such as valve position, show valve in current state such as open or closed so operator could select alternative position using pointing device.
 - c. Include a keyboard equivalent for those operators with that preference.
19. Give operator ability to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot, and other information on other quadrants on screen.

This feature allows real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.

20. Help Features:
 - a. Online context-sensitive help utility to facilitate operator training and understanding.
 - b. Bridge to further explanation of selected keywords and contain text and graphics to clarify system operation.
 - 1) If help feature does not have ability to bridge on keywords for more information, provide a complete set of user manuals in an indexed word-processing program, which runs concurrently with operating system software.
 - c. Available for Every Menu Item:
 - 1) Index items for each system menu item.
21. Provide graphic generation software to allow operator ability to add, modify, or delete system graphic displays.
 - a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.
 - b. Use a pointing device in conjunction with a drawing program to allow operator to perform the following:
 - 1) Define background screens.
 - 2) Define connecting lines and curves.
 - 3) Locate, orient, and size descriptive text.
 - 4) Define and display colors for all elements.
 - 5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
 - a. Room layouts with room identification and name.
 - b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
 - c. Location and identification of each hardware point being controlled or monitored by DDC system.
3. Control schematic for each of following, including a graphic system schematic representation , similar to that indicated on Drawings, with point identification, set point and dynamic value indication , sequence of operation and control logic diagram. The Sequence and control logic shall be accessible on a separate page via a link on the main graphics for the associated system.
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways and other network devices.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. At a minimum, include the following modification capability:
 - a. Operator Assignment: Designation of operator passwords, access levels, point segregation, and auto sign-off.
 - b. Peripheral Assignment: Assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points, and enabling and disabling of print-out of operator changes.
 - c. System Configuration and Diagnostics; Communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points, and application programs and initiation of diagnostics.
 - d. System Text Addition and Change: English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time, and trouble condition.
 - e. Time and Schedule Change: Time and date set, time and occupancy schedules, exception and holiday schedules, and daylight-savings time schedules.
 - f. Point related change capability is to include the following:
 - 1) System and point enable and disable.
 - 2) Run-time enable and disable.
 - 3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
 - 4) Assignment of alarm and warning limits.
 - g. Application program change capability is to include the following:
 - 1) Enable and disable of software programs.
 - 2) Programming changes.
 - 3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.
4. Provide software to allow operator ability to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Make additions and modifications online programmable using operator workstations, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, upload and record database on hard drive and disc for archived record.
5. Include high-level language programming software capability for implementation of custom DDC programs. Include a compiler, linker, and up- and down-load capability.
6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic, and relational operators for implementation of control sequences. Also include, at a minimum, the following:
 - a. Proportional control (P).
 - b. Proportional plus integral (PI).

- c. Proportional plus integral plus derivative (PID).
- d. Adaptive and intelligent self-learning control.
 - 1) Algorithm monitors loop response to output corrections and adjust loop response characteristics in accordance with time constant changes imposed.
 - 2) Algorithm operates in a continuous self-learning manner and retains in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.
- 7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
- 8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
- 9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
- 10. Relational operators such as "Equal to," "Not Equal to," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

- 1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
- 2. Include first in, first out handling of alarms in accordance with alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
- 3. Make alarm handling active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
- 4. Alarms display is to include the following:
 - a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
 - b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
 - c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
 - d. Include extended message capability to allow assignment and printing of extended action messages. Capability is to be operator programmable and assignable on a per point basis.
- 5. Direct alarms to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
- 6. Send email alarm messages to designated operators.
- 7. Send email, page, text, and voice messages to designated operators for critical alarms.
- 8. Categorize and process alarms by class.
 - a. Class 1:
 - 1) Associated with fire, security, and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
 - 2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.

- 3) All conditions make an audible alarm sound and require individual acknowledgment to silence audible sound.
- b. Class 2:
 - 1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
 - 2) Acknowledgement may be through a multiple alarm acknowledgment.
- c. Class 3:
 - 1) General alarms; printed, displayed, and placed in unacknowledged alarm buffer queues.
 - 2) Configure so each new alarm received makes an audible alarm sound that are silenced by "acknowledging" alarm or by pressing a "silence" key.
 - 3) Make acknowledgement of queued alarms either on an individual basis or through a multiple alarm acknowledgement.
 - 4) Print alarms returning to normal condition without an audible alarm sound or require acknowledgment.
- d. Class 4:
 - 1) Routine maintenance or other types of warning alarms.
 - 2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.
9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, make it possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Setup each report so data content, format, interval, and date are operator definable.
3. Sample and store report data on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server for historical reporting.
4. Make it possible for operators to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Store reports and logs on servers hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Make reports and logs readily printable and set to be print either on operator command or at a specific time each day.

H. Standard Reports: Provide standard DDC system reports with operator ability to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.

5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:
 - a. Alarm history.
 - b. System messages.
 - c. System events.
 - d. Trends.
 - e. Operator overrides, including the time, point commanded, value, and operator performing the action .
- I. Custom Reports: Operator able to easily define and prepare any system data into a daily, weekly, monthly, annual, or other historical report. Reports to include a title with time and date stamp.
- J. Standard Trends:
 1. Trend all I/O point present values, set points, and other parameters indicated for trending.
 2. Associate trends into groups, and setup a trend report for each group.
 3. Store trends within DDC controller and upload to server automatically once per day.⁷⁵
 4. Preset trend intervals for each I/O point after review with Owner.
 5. Make trend intervals operator selectable from 10 seconds up to 60 minutes. Make minimum number of consecutive trend values stored at one time 100 per variable.
 6. When drive storage memory is full, overwrite oldest data with most recent data.
 7. Make archived and real-time trend data available for viewing numerically and graphically by operators.
- K. Custom Trends: Operator-definable custom trend log for any I/O point in DDC system.
 1. Include each trend with interval, start time, and stop time.
 2. Sample and store data on DDC controller and upload to server once per day.
 3. Make data retrievable for use in spreadsheets and standard database programs.
- L. Programming Software:
 1. Include programming software to execute sequences of operation indicated.
 2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
 3. Programming software is to be one of the following:
 - a. Graphic Based: Use a library of function blocks made from preprogrammed code designed for DDC control systems.
 - 1) Assemble function blocks with interconnection lines that represent to control sequence in a flowchart.
 - 2) Make programming tools viewable in real time to show present values and logical results of each function block.
 - b. Menu Based: Done by entering parameters, definitions, conditions, requirements, and constraints.
 - c. Line by Line and Text Based: Programming is to declare variable types such as local, global, real, integer, and so on, at the beginning of the

program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

M. Database Management Software:

1. Where a separate SQL database is used for information storage, include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
2. Secure database access using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Include database management function summarizing information on trend, alarm, event, and audit for the following database management actions:
 - a. Backup.
 - b. Purge.
 - c. Restore.
4. Database management software supporting the following:
 - a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
 - b. Maintenance: Include method of purging records from trend, alarm, event, and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
 - c. Backup: Include means to create a database backup file and select a storage location.
 - d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.
5. Information of current database activity, including the following:
 - a. Ready.
 - b. Purging record from a database.
 - c. Action failed.
 - d. Refreshing statistics.
 - e. Restoring database.
 - f. Shrinking a database.
 - g. Backing up a database.
 - h. Resetting Internet information services.
 - i. Starting network device manager.
 - j. Shutting down the network device manager.
 - k. Action successful.
6. Database management software monitoring functions is to continuously read database information once operator has logged on.
7. Include operator notification through on-screen pop-up display and email message when database value has exceeded a warning or alarm limit.
8. Monitoring settings window with the following Sections:
 - a. Allow operator to set and review scan intervals and start times.
 - b. Email: Allow operator to create and review email and phone text messages to be delivered when a warning or an alarm is generated.
 - c. Warning: Allow operator to define warning limit parameters, set reminder frequency, and link email message.

- d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency, and link email message.
- e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event, and audit databases as well as operator proper security access to restore a database.
- 9. Monitoring settings taskbar with following informational icons:
 - a. Normal: Indicates by color and size, or other easily identifiable means, that all databases are within their limits.
 - b. Warning: Indicates by color and size, or other easily identifiable means, that one or more databases have exceeded their warning limit.
 - c. Alarm: Indicates by color and size, or other easily identifiable means, that one or more databases have exceeded their alarm limit.

2.11 ASHRAE 135 GATEWAYS

- A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.
- B. Include gateways to connect BACnet to legacy systems where indicated, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment.
- C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
- D. Gateway Minimum Requirements:
 - 1. Read and view all readable object properties on non-BACnet network to BACnet network, and vice versa, where applicable.
 - 2. Write to all writable object properties on non-BACnet network from BACnet network, and vice versa, where applicable.
 - 3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet, and vice versa.
 - 4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs in accordance with ASHRAE 135.
 - 5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
 - 6. Backup programming and parameters on CD media with ability to modify, download, backup, and restore gateway configuration.

2.12 DDC CONTROLLERS

- A. DDC system consisting of a combination of network controllers, programmable application controllers, and application-specific controllers to satisfy performance requirements indicated.
- B. DDC controllers to perform monitoring, control, energy optimization, and other requirements indicated.
- C. DDC controllers are to use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
- D. Each DDC controller is capable of full and complete operation as a completely independent unit and as a part of DDC system wide distributed network.
- E. Environment Requirements:
 - 1. Controller hardware suitable for anticipated ambient conditions.
 - 2. Controllers located in conditioned space rated for operation at 32 to 120 deg F .
 - 3. Controllers located outdoors rated for operation at 40 to 150 deg F .
- F. Power and Noise Immunity:
 - 1. Operate controller at 90 to 110 percent of nominal voltage rating and perform an orderly shutdown below 80 percent of nominal voltage.
 - 2. Protect against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.
- G. DDC Controller Spare Processing Capacity:
 - 1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
 - a. Network Controllers: 50 percent.
 - b. Programmable Application Controllers: Not less than 60 percent.
 - 2. Memory for DDC controller's operating system and database are to include the following:
 - a. Monitoring and control.
 - b. Energy management, operation, and optimization applications.
 - c. Alarm management.
 - d. Historical trend data of all connected I/O points.
 - e. Maintenance applications.
 - f. Operator interfaces.
 - g. Monitoring of manual overrides.
- H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:
 - 1. Network Controllers:
 - a. 20 percent of each AI, AO, BI, and BO point connected to controller.
 - b. Minimum Spare I/O Points per Controller:
 - 1) AIs: Two .

- 2) AOs: Two .
 - 3) BIs: Three .
 - 4) BOs: Three .
 - 5) Option to provide universal I/O to meet spare requirements.
 2. Programmable Application Controllers:
 - a. 10 percent of each AI, AO, BI, and BO point connected to controller.
 - b. Minimum Spare I/O Points per Controller:
 - 1) AIs: Two .
 - 2) AOs: Two .
 - 3) BIs: Three .
 - 4) BOs: Three .
 - 5) Option to provide universal I/O to meet spare requirements.
- I. Maintenance and Support: Include the following features to facilitate maintenance and support:
 1. Mount microprocessor components on circuit cards for ease of removal and replacement.
 2. Means to quickly and easily disconnect controller from network.
 3. Means to quickly and easily access connect to field test equipment.
 4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.
- J. General Requirements for CTA-709.1-D DDC Controllers:
 1. LonMark certified.
 2. Distinguishable and accessible switch, button, or pin, when pressed is to broadcast its 48-bit Node ID and Program ID over network.
 3. TP/FT-10 transceiver in accordance with CTA-709.3 and connections for TP/FT-10 control network wiring.
 4. TP/XF-1250 transceiver in accordance with CTA-709.3 and connections for TP/XF-1250 control network wiring.
 5. Communicate using CTA-709.1-D protocol.
 6. Controllers configured into subnets, as required, to comply with performance requirements indicated.
 7. Network communication through LNS network management and database standard for CTA-709.1-D network devices.
 8. Locally powered, not powered through network connection.
 9. Functionality required to support applications indicated including, but not limited to, the following:
 - a. I/Os indicated and as required to support sequence of operation and application in which it is used. SNVTs to have meaningful names identifying the value represented by SNVT. Unless SNVT of an appropriate engineering type is unavailable, all network variables to be of SNVT with engineering units appropriate to value the variable represents.
 - b. Configurable through SCPTs defined in LonMark SCPT List, operator-defined UCPTs, network configuration inputs (NCIs) of SNVT type defined in LonMark SNVT List, NCIs of an operator-defined network variable type, or hardware settings on controller itself for all settings and parameters used by application in which it is used.

10. Programmable controllers comply with "LonMark Interoperability Guidelines" and have LonMark certification.

K. I/O Point Interface:

1. Connect hardwired I/O points to network, programmable application, and application-specific controllers.
2. Protect I/O points so shorting of point to itself, to another point, or to ground will not damage controller.
3. Protect I/O points from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:
 - a. Include monitoring of low-voltage (0 to 10 V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
 - b. Compatible with, and field configurable to, sensor and transmitters installed.
 - c. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
 - d. Signal conditioning including transient rejection for each AI.
 - e. Capable of being individually calibrated for zero and span.
 - f. Incorporate common-mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
 - g. External conversion resistors are not permitted.
5. AOs:
 - a. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
 - b. Output signals range of 4 to 20 mA dc or 0 to 10 V dc as required to include proper control of output device.
 - c. Capable of being individually calibrated for zero and span.
 - d. Drift is to be not greater than 0.4 percent of range per year.
 - e. External conversion resistors are not permitted.
6. BIs:
 - a. Accept contact closures and ignore transients of less than 5 ms duration.
 - b. Isolate and protect against an applied steady-state voltage of up to 180 V ac peak.
 - c. Include a wetting current of at least 12 mA to be compatible with commonly available control devices and protected against effects of contact bounce and noise.
 - d. Sense "dry contact" closure without external power (other than that provided by controller) being applied.
 - e. Pulse accumulation input points complying with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Include buffer to totalize pulses. Pulse accumulator is to accept rates of at least 20 pulses per second. Reset the totalized value to zero on operator's command.
7. BOs:
 - a. Include relay contact closures or triac outputs for momentary and maintained operation of output devices.
 - 1) Relay contact closures to have a minimum duration of 0.1 second and at least 180 V of isolation.

- 2) Include electromagnetic interference suppression on all output lines to limit transients to non-damaging levels.
- 3) Minimum contact rating to be 1 A at 24 V ac.
- 4) Triac outputs to have at least 180 V of isolation and minimum contact rating of 1 A at 24 V ac.
- b. Include BOs with two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
- c. BOs to be selectable for either normally open or normally closed operation.
- d. Include tristate outputs (two coordinated BOs) for control of three-point, floating-type electronic actuators without feedback.

2.13 NETWORK CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Include enough memory to support its operating system, database, and programming requirements with spare memory indicated.
4. Share data between networked controllers and other network devices.
5. Operating system of controller to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Include network controllers with a real-time clock.
7. Controller to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller is to assume a predetermined failure mode and generate an alarm notification.
8. Make controllers fully programmable.

B. Communication:

1. Network controllers communicate with other devices on DDC system Level 1 network.
2. Network controller to also perform routing if connected to network of programmable application controllers and application-specific controllers.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to portable operator's workstation .

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain Basic Input Output System (BIOS) and programming information in event of power loss for at least 96 hours.

2.14 PROGRAMMABLE APPLICATION CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide enough memory to support its operating system, database, and programming requirements with spare memory indicated.
3. Share data between networked controllers and other network devices.
4. Include controller with operating system to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Include controllers that perform scheduling with a real-time clock.
6. Controller is to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller assumes a predetermined failure mode and generates an alarm notification.
7. Fully programmable.

B. Communication:

1. Programmable application controllers are to communicate with other devices on network.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to portable operator's workstation .

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain BIOS and programming information in event of power loss for at least 72 hours.

2.15 CONTROLLER SOFTWARE

A. General:

1. Software applications are to reside and operate in controllers. Edit applications through operator workstations.
2. Identify I/O points by up to 30 -character point name and up to 16 -character point descriptor. Use same names throughout, including at operator workstations.
3. Execute control functions within controllers using DDC algorithms.
4. Configure controllers to use stored default values to ensure fail-safe operation. Use default values when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Secure operator access using individual security passwords and user names.
 2. Passwords restrict operator to points, applications, and system functions as assigned by system manager.
 3. Record operator log-on and log-off attempts.
 4. Protect from unauthorized use by automatically logging off after last keystroke. Make the delay time operator-definable.
- C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule is to consist of the following:
1. Weekly Schedule:
 - a. Include separate schedules for each day of week.
 - b. Each schedule should include capability for start, stop, optimal start, optimal stop, and night economizer.
 - c. Each schedule may consist of up to 10 events.
 - d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
 2. Exception Schedules:
 - a. Include ability for operator to designate any day of the year as an exception schedule.
 - b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
 3. Holiday Schedules:
 - a. Include capability for operator to define up to 99 special or holiday schedules.
 - b. Place schedules on scheduling calendar with ability to repeated each year.
 - c. Operator able to define length of each holiday period.
- D. System Coordination:
1. Include standard application for proper coordination of equipment.
 2. Include operator with a method of grouping together equipment based on function and location.
 3. Include groups that may be for use in scheduling and other applications.
- E. Binary Alarms:
1. Set each binary point to alarm based on operator-specified state.
 2. Include capability to automatically and manually disable alarming.
- F. Analog Alarms:
1. Provide each analog object with both high and low alarm limits.
 2. Include capability to automatically and manually disable alarming.
- G. Alarm Reporting:
1. Include ability for operators to determine action to be taken in event of an alarm.
 2. Route alarms to appropriate operator workstations based on time and other conditions.

3. Include ability for alarms to start programs, print, be logged in event logs, generate custom messages, and display graphics.
- H. Remote Communication:
1. Include ability for system to notify operators by phone message, text message, and email in event of an alarm.
- I. Maintenance Management: Monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.
- J. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.
- K. Control Loops:
1. Support any of the following control loops, as applicable to control required:
 - a. Two-position (on/off, open/close, slow/fast) control.
 - b. Proportional control.
 - c. Proportional plus integral (PI) control.
 - d. Proportional plus integral plus derivative (PID) control.
 - 1) Include PID algorithms with direct or reverse action and anti-windup.
 - 2) Algorithm to calculate a time-varying analog value used to position an output or stage a series of outputs.
 - 3) Make controlled variable, set point, and PID gains operator-selectable.
 - e. Adaptive (automatic tuning).
- L. Staggered Start: Prevent all controlled equipment from simultaneously restarting after a power outage. Make the order which equipment (or groups of equipment) is started, along with the time delay between starts, operator-selectable.
- M. Energy Calculations:
1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
 2. Include algorithm that calculates a sliding-window average (rolling average). Make algorithm flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
 3. Include algorithm that calculates a fixed-window average. Use a digital input signal to define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.
- N. Anti-Short Cycling:
1. Protect BO points from short cycling.
 2. Feature to allow minimum on-time and off-time to be selected.
- O. On and Off Control with Differential:

1. Include algorithm that allows BO to be cycled based on a controlled variable and set point.
2. Use direct- or reverse-acting algorithm and incorporate an adjustable differential.

P. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. Assign a high run-time alarm, if required, by operator.

2.16 ENCLOSURES

A. General:

1. House each controller and associated control accessories in enclosure. Enclosure is to serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies, and transformers.
2. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure. Coordinate keys with HCPSS Maintenance Division.
3. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
4. Individual, wall-mounted, single-door enclosures maximum of 36 inches wide and 60 inches high.
5. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
6. Supply each enclosure with complete set of laminated as-built schematics, tubing, and wiring diagrams and product literature located in pocket on inside of door.

B. Internal Arrangement:

1. Arrange internal layout of enclosure to group and protect electric, and electronic components associated with controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling, and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install maximum of two wires on each side of terminal.
9. Include enclosure field electric power supply with toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with line-voltage nominal 20 A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with 5 A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).

12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). Nameplates are to have at least 1/4-inch- high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with continuous removable cover.
14. Label each end of cable, wire, and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 15 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction, and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 1:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cooper B-line; brand of Eaton, Electrical Sector.
 - b. Hammond Mfg. Co. Inc.
 - c. Hoffman; brand of nVent Electrical plc.
 - d. Saginaw Control and Engineering.
2. NRTL listed in accordance with UL 50 or UL 50E.
3. Construct enclosure of steel, not less than the following:
 - a. Enclosure Size Less Than 24 Inches: 0.053 inch thick.
 - b. Enclosure Size 24 Inches and Larger: 0.067 inch thick.
4. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior Color: Manufacturer's standard .
 - b. Interior Color: Manufacturer's standard.
5. Hinged door full size of front face of enclosure and supported using the following:
 - a. Enclosures Sizes Less Than 36 Inches Tall: Multiple butt hinges.
 - b. Enclosures Sizes 36 Inches Tall and Larger: Continuous piano hinges.

6. Removable internal panel with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
 - b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.
7. Internal panel mounting hardware, grounding hardware, and sealing washers.
8. Grounding stud on enclosure body.
9. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall-Mounted, NEMA 250, Types 4 and 12:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cooper B-line; brand of Eaton, Electrical Sector.
 - b. Hammond Mfg. Co. Inc.
 - c. Hoffman; brand of nVent Electrical plc.
 - d. Saginaw Control and Engineering.
2. NRTL listed in accordance with UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
5. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
6. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
7. Construct enclosure of steel, not less than the following:
 - a. Size Less Than 24 Inches: 0.053 inch or 0.067 inch thick.
 - b. Size 24 Inches and Larger: 0.067 inch thick.
8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior Color: Manufacturer's standard .
 - b. Interior Color: Manufacturer's standard.
9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
 - a. Sizes through 24 Inches Tall: Two hinges.
 - b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
 - c. Sizes Larger Than 48 Inches Tall: Four hinges.
10. Removable internal panel with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
 - b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.
11. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
12. Grounding stud on enclosure body.
13. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Accessories:

1. Bar handle with keyed cylinder lock set.

2.17 RELAYS

A. General-Purpose Relays:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. IDEC Corporation.
 - b. Functional Devices.
2. NRTL listed.
3. Heavy-duty, electromechanical type; rated for at least 10 A at 250 V ac and 60 Hz.
4. SPDT, DPDT, or three-pole double-throw, as required by control application.
5. Plug-in-style relay with multiblade plug for DPDT relays and multiblade plug for three-pole double-throw relays.
6. Prepackaged relay with factory sealed housing.
7. Construct contacts of silver, silver alloy, or gold.
8. Enclose removable relay block in a clear transparent polycarbonate dust-tight cover.
9. If using prepackaged relay, attach relay to exterior of enclosure or junction box using locking ring.
10. Clearly label all relays.
11. Include LED indication. If using prepacked relays, include manual rocker switch to allow local override.
12. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Pickup Time: 15 ms or less.
 - d. Dropout Time: 10 ms or less.
 - e. Pull-in Voltage: 85 percent of rated voltage.
 - f. Dropout Voltage: 50 percent of nominal rated voltage.
 - g. Power Consumption: 5 VA or less.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
13. Equip relays with coil transient suppression to limit transients to non-damaging levels.
14. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
15. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

2.18 ELECTRICAL POWER DEVICES

A. Control Transformers:

1. Sizing Criteria: Size control transformers for total connected load, plus additional 25 percent of connected load for future spare capacity.
2. Transformer Minimum Capacity: 100 VA.
3. Protection: Provide transformers with both primary and secondary fuses. Integral circuit breaker is acceptable in lieu of fuses.
4. Enclosure: House control transformers in NEMA 250 enclosures, type as indicated in "Performance Requirements" Article for application.

2.19 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

- A. Furnish local UPS units, of type indicated, installed with DDC system.
- B. DIN Rail Mounted UPS:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. APC by Schneider Electric.
 - b. Emerson Electric Co., Automation Solutions.
 - c. Phoenix Contact.
 - 2. Provide continuous, regulated output power without using batteries during brown-out, surge, and spike conditions.
 - 3. Performance:
 - a. Capacity: Load not to exceed 75 percent of rated capacity.
 - b. Input Voltage: Single phase, 120 V ac, compatible with field power source.
 - c. Load Power Factor Range (Crest Factor): 0.65 to 1.0 .
 - d. Output Voltage: 101 to 132 V ac, while input voltage varies between 89 and 152 V ac.
 - e. On Battery Output Voltage: Sine wave.
 - f. Inverter Overload Capacity: Minimum 150 percent for 30 seconds.
 - g. Battery Backup: Five minutes of operation at full load with battery power.
 - h. Battery Recharge Time: Maximum of six hours to 90 percent capacity after full discharge.
 - i. Transfer Time: 6 ms.
 - j. Surge Voltage Withstand Capacity: IEEE C62.41.1 and IEEE C62.41.2, Categories A and B.
 - 4. Automatic bypass operation during fault or overload conditions.
 - 5. Integral line-interactive, power condition topology to eliminate all power contaminants.
 - 6. Include power switch and visual indication of power, battery, fault.
 - 7. Include audible alarm of faults with silence feature.
 - 8. Batteries: Sealed; maintenance free; replacement without dropping load.
- C. Tower UPS Models through 1000 VA:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. APC by Schneider Electric.
 - b. Eaton.
 - 2. Provide continuous, regulated output power without using batteries during brown-out, surge, and spike conditions.
 - 3. Performance:
 - a. Capacity: Load not to exceed 75 percent of rated capacity.
 - b. Efficiency: Complying with ENERGY STAR requirements; minimum 91 percent.
 - c. Input Voltage: Single phase, 120 V ac, compatible with field power source.
 - d. Load Power Factor Range (Crest Factor): 0.65 to 1.0 .
 - e. Output Voltage: 101 to 132 V ac, while input voltage varies between 89 and 152 V ac.
 - f. On Battery Output Voltage: Sine wave.

- g. Inverter Overload Capacity: Minimum 150 percent for 30 seconds.
- h. Battery Backup: Five minutes of operation at full load with battery power.
- i. Battery Recharge Time: Maximum of six hours to 90 percent capacity after full discharge to cutoff.
- j. Transfer Time: 0 ms.
- k. Surge Voltage Withstand Capacity: IEEE C62.41.1 and IEEE C62.41.2, Categories A and B; 6 kV/200 and 500 A; 100 kHz ring wave.
- 4. Automatic bypass operation during fault or overload conditions.
- 5. Integral line-interactive, power condition topology to eliminate all power contaminants.
- 6. Include power switch and visual indication of power, battery, fault, and temperature.
- 7. Include audible alarm of faults and front panel silence feature.
- 8. Receptacles: Minimum two , NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
- 9. Batteries: Sealed type; maintenance free. Battery replacement is to be front accessible by user without dropping load.
- 10. Install tower models in enclosures rated for location.

2.20 CONTROL WIRE AND CABLE

- A. Single, Twisted-Shielded, Instrumentation Cable 24 V and Less:
 - 1. Wire Size: Minimum 18 AWG.
 - 2. Conductors: Twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
 - 3. Conductor Insulation: Nominal 15-mil thickness, constructed from flame-retardant PVC.
 - 4. Conductor Insulation Colors:
 - a. Twisted Pair: Black and white.
 - b. Twisted Triad: Black, red, and white.
 - 5. Shielding: 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 - 6. Outer Jacket Insulation: 300 V, 105 deg C rating, and Type PLTC cable.
 - 7. Furnish on spools.
- B. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

2.21 RACEWAYS

- A. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems" for electrical power raceways and boxes.
- B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cables and optical fiber cables.

2.22 ACCESSORIES

A. Control Damper Blade Limit Switches:

1. Application: Sense positive open and/or closed position of damper blades.
2. NEMA 250, , oiltight construction. Install in instrument enclosure where required for additional environmental protection.
3. Arrange for mounting application, and to prevent "over-center" operation.
4. Self-contained mercury style switches are the only acceptable type. Mount directly to damper blades.

2.23 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Self-adhesive label Laminated acrylic or melamine plastic sign bearing unique identification.
 - a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
2. Letter size as follows:
 - a. DDC Controllers: Minimum of 0.5 inch high.
 - b. Gateways: Minimum of 0.5 inch high.
 - c. Repeaters: Minimum of 0.5 inch high.
 - d. Enclosures: Minimum of 0.5 inch high.
 - e. Electrical Power Devices: Minimum of 0.25 inch high.
 - f. UPS units: Minimum of 0.5 inch high.
 - g. Accessories: Minimum of 0.25 inch high.
 - h. Instruments: Minimum of 0.25 inch high.
 - i. Control Damper and Valve Actuators: Minimum of 0.25 inch high.
3. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded black with contrasting white center exposed by engraving through outer layer.
4. Fastened with drive pins.
5. Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tag Size: Minimum 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as tape banding for conduits. After painting, label cover plate "HVAC Controls".

D. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size at least 14-point type with white lettering on red background.
3. Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering to be enclosed in a white line border. Edge of label is to extend at least 0.25 inch beyond white border.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
- E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

- A. Communication Interface to Equipment with Integral Controls:
 1. DDC system has communication interface with equipment having integral controls and having communication interface for remote monitoring or control.
 2. Equipment to Be Connected:
 - a. Boilers specified in Section 235216 "Condensing Boilers."

- 1) BACnet points within boiler controller to be integrated with the DDC system include, but are not limited to, the following:
 - a) 001: Boiler Outlet Temperature
 - b) 002: Boiler Inlet Temperature
 - c) 004: Boiler Outdoor Temperature
 - d) 005: Boiler Header Temperature
 - e) 006: Boiler Stack Temperature
 - f) 007: Boiler Active CH Setpoint
 - g) 009: Boiler Active LL Setpoint
 - h) 010: Boiler CH Operating Point
 - i) 012: Boiler LL Operating Point
 - j) 013: Boiler Firing Rate
 - k) 014: Boiler Fan Speed
 - l) 015: Boiler Flame Signal
 - m) 016: Boiler Alarm Status
 - n) 017: Boiler Alarm Code
 - o) 018: Boiler Alarm Reason
 - p) 019: Boiler Low Water Input Status
 - q) 020: Boiler Air Switch Input Status
 - r) 021: Boiler Low Gas Pressure Input Status
 - s) 022: Boiler High Gas Pressure Input Status
 - t) 023: Boiler High Back Pressure Input Status
 - u) 024: Boiler High Condensate Input Status
 - v) 025: Boiler High Temp Input Status
 - w) 030: Boiler Burn Cycle Count
 - x) 031: Boiler Burner Run Hours
 - y) 032: Boiler CH Enable
 - z) 036: Boiler LL Enable
 - aa) 037: Boiler LL Setpoint Input
 - bb) 038: Boiler Burner Demand Source
 - cc) 039: Boiler Burner Status
 - dd) 040: Boiler Remote Operating Mode
 - ee) 041: Boiler Remote Firing Rate

B. Communication Interface to Other Building Systems:

1. DDC system communicates with systems having communication interface.
2. Systems to Be Connected:

3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

- A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
- B. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
 1. Control valves, which are specified in Section 230923.11 "Control Valves."

2. Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."
3. Pipe-mounted sensors, switches, and transmitters. Flow meters are specified in Section 230923.14 "Flow Instruments."
4. Tank-mounted sensors, switches, and transmitters. Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
5. Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
6. Pipe- and tank-mounted thermowells. Liquid thermowells are specified in Section 230923.27 "Temperature Instruments."

3.4 GENERAL INSTALLATION REQUIREMENTS

- A. Install products to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Support products, tubing, piping wiring, and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to force.
- D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
- E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- F. Welding Requirements:
 1. Restrict welding and burning to supports and bracing.
 2. No equipment is cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
 3. Welding, where approved, is to be by inert-gas electric arc process and is to be performed by qualified welders in accordance with applicable welding codes.
 4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.
- G. Fastening Hardware:
 1. Wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- H. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.5 INSTALLATION OF SERVERS

- A. Coordinate with HCPSS to add system to existing servers located at Central Maintenance Facility on Mendenhall Court.
- B. Install software indicated on server(s) and verify that software functions properly.
- C. Develop Project-specific graphics, trends, reports, logs, and historical database.

3.6 INSTALLATION OF GATEWAYS

- A. Install gateways if required for DDC system communication interface requirements indicated.
 - 1. Install gateway(s) required to suit indicated requirements.
- B. Test gateways to verify that communication interface functions properly.

3.7 INSTALLATION OF ROUTERS

- A. Install routers if required for DDC system communication interface requirements indicated.
 - 1. Install router(s) required to suit indicated requirements.
- B. Test routers to verify that communication interface functions properly.

3.8 INSTALLATION OF CONTROLLERS

- A. Install controllers in enclosures to comply with indicated requirements.
- B. Connect controllers to field power supply and UPS units..
- C. Install controllers with latest version of applicable software and configure to execute requirements indicated.
- D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
- E. Installation of Network Controllers:
 - 1. DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.
 - 2. Install controllers in a protected location that is easily accessible by operators.
 - 3. Locate top of controller within 72 inches of finished floor.
- F. Installation of Programmable Application Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of programmable application controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor, except where dedicated controllers are installed at terminal units.

G. Application-Specific Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of application-specific controllers to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a location that is easily accessible by operators.

3.9 INSTALLATION OF ENCLOSURES

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Controllers.
3. Electrical power devices.
4. UPS units.
5. Relays.

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 , Type 4, Type 12, and any other Enclosures: Use galvanized-steel strut and hardware.
2. For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top or bottom of adjacent enclosures of like size.

D. For floor-mounted enclosures located in mechanical equipment rooms: attach enclosure legs using galvanized-steel or stainless steel anchors.

E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireways used for application are to have protection equal to NEMA 250 rating of connected enclosures.

3.10 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade to provide a fully functioning DDC system. Work is to comply with NFPA 70 and other requirements indicated.

- C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.
- E. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.11 INSTALLATION OF IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.
- B. Install self-adhesive labels or laminated acrylic or melamine plastic signs with unique identification on face for each of the following:
 - 1. Gateway.
 - 2. Router.
 - 3. Protocol analyzer.
 - 4. DDC controller.
 - 5. Enclosure.
 - 6. Electrical power device.
 - 7. UPS unit.
- C. Install unique instrument identification for each instrument connected to DDC controller.
- D. Install unique identification for each control damper and valve actuator connected to DDC controller.
- E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.
- F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.
- G. Warning Labels and Signs:
 - 1. Permanently attach to equipment that can be automatically started by DDC control system.
 - 2. Locate where highly visible near power service entry points.

3.12 INSTALLATION OF NETWORKS

- A. Install balanced twisted pair cable when connecting between the following network devices located in same building:

1. Operator workstations.
 2. Operator workstations and network controllers.
 3. Network controllers.
 4. Network controllers and IT drops coordinated with HCPSS IT department. .
- B. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:
1. Gateways.
 2. Gateways and network controllers or programmable application controllers.
 3. Routers and network controllers or programmable application controllers.
 4. Network controllers and programmable application controllers.
 5. Programmable application controllers.
 6. Programmable application controllers and application-specific controllers.
 7. .
- C. Install cable in continuous raceway.
1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.13 NETWORK NAMING AND NUMBERING

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.
- B. ASHRAE 135 Networks:
1. MAC Address:
 - a. Assign and document a MAC address unique to its network for every network device.
 - b. Ethernet Networks: Document MAC address assigned at its creation.
 - c. MS/TP Networks: Assign from 00 to 64.
 2. Network Numbering:
 - a. Assign unique numbers to each new network.
 - b. Provide ability for changing network number through device switches or operator interface.
 - c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.
 3. Device Object Identifier Property Number:
 - a. Assign unique device object identifier property numbers or device instances for each device network.
 - b. Provide for future modification of device instance number by device switches or operator interface.
 - c. LAN is to support up to 4,194,302 unique devices.
 4. Device Object Name Property Text:
 - a. Device object name property field to support 32 minimum printable characters.
 - b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

- 1) Example 1: Device object name for device controlling heating water boiler plant at Building 1000 would be "Heating Water System Bldg. 1000."
 - 2) Example 2: Device object name for VAV terminal unit controller could be "VAV Unit 102."
5. Object Name Property Text for Other Than Device Objects:
 - a. Object name property field is to support 32 minimum printable characters.
 - b. Assign object name properties with plain-English names descriptive of application.
 - 1) Example 1: "Zone 1 Temperature."
 - 2) Example 2 "Fan Start and Stop."
6. Object Identifier Property Number for Other Than Device Objects:
 - a. Assign object identifier property numbers according to Drawings or tables indicated.
 - b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented, and be unique for like object types within device.

3.14 INSTALLATION OF PROCESS TUBING

- A. Install process tubing for signal to instruments in liquid systems. Instruments include, but are not limited to, the following:
 1. Meters.
 2. Sensors.
 3. Switches.
 4. Transmitters.
- B. Support tubing in accordance with MSS SP-58, but at intervals no more than 60 inches apart.
- C. Install minimum NPS 1/2 process tubing for industrial-grade sensors, transmitters, and switches. Install bushings where required.
- D. Make smooth tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.
- E. Support tubing independent of other trades.
- F. Route tubing parallel to and at right angles to building construction.
- G. Install tubing concealed in areas with ceilings.
- H. Install dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.
- I. Insulate process piping and tubing connected to hot water and steam systems for personnel protection if surface temperature exceeds 120 deg F. Only insulate piping and tubing within maintenance personnel reach from floor, platform, or catwalk.

- J. Wrap pipe threads of fitting in process tubing with service temperatures below 350 deg F with single wrap of PTFE tape.
- K. Coat pipe threads of fittings on process tubing in services with temperatures exceeding 350 deg F with pipe compound before being made up to reduce possibility of galling.
- L. Do not make tubing connections to a fitting before completing makeup of connection.
- M. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.
- N. Do not install fittings close to a bend. Straight length of tubing, not deformed by bending, is required for proper connection.
- O. Align tubing with fitting when installed. Avoid springing tube into position.
- P. Install tubing with extreme care to keep foreign matter out of system. Plug open tubing ends to keep out dust, dirt, and moisture.
- Q. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.
- R. Identify above-grade process tubing as follows:
 - 1. Every 50 ft. of straight run.
 - 2. At least once for each branch within 36 inches of main tee.
 - 3. Near each change in direction.
 - 4. Within 36 inches of each ceiling, floor, roof, and wall penetration.
 - 5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
 - 6. Near each isolation valve.
 - 7. Mark each instrument tube connection with a number-coded identification. Each unique tube is to have same unique number at instrument connection and termination at opposite end of tube.
- S. Process Tubing Isolation Valves Installation:
 - 1. Install valves full size of piping and tubing.
 - 2. Install isolation valves at the following locations:
 - a. Process connection.
 - b. Inlet to each instrument including, sensors, transmitters, switches, gauges, and other control devices.
 - 3. Locate valves to be readily accessible from floor.
 - 4. Install needle valves for isolation and throttling applications. Option to install ball valves in lieu of needle valves for isolation only applications.

3.15 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

- A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
 - a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
2. Terminate wiring in a junction box.
 - a. Clamp cable over jacket in a junction box.
 - b. Individual conductors in the stripped section of cable is to be slack between the clamping point and terminal block.
3. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
4. Install signal transmission components in accordance with IEEE C2, REA Form 511a, NFPA 70, and as indicated.
5. Use shielded cable to transmitters.
6. Use shielded cable to temperature sensors.
7. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section 260533 "Raceway and Boxes for Electrical Systems" for control-voltage conductors.
2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.16 FIELD QUALITY CONTROL

- A. Testing Agency: a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.
- C. Testing of Pneumatic and Air-Signal Tubing:
1. After any demolition of existing pneumatic tubing that is no longer required, test remaining pneumatics for leaks caused by removal.
 2. After foreign matter is expelled and line is free from obstructions, plug far end of tubing run.
 3. For remaining tubing, apply test pressure of 1.5 times instrument operating pressure range. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period to not exceed five percent of test pressure.

3.17 DDC SYSTEM I/O CHECKOUT PROCEDURES

- A. Check installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.

- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
- E. Control Damper Checkout:
 - 1. Verify that control dampers are installed correctly for flow direction.
 - 2. Verify that proper blade alignment, either parallel or opposed, has been provided.
 - 3. Verify that damper frame attachment is properly secured and sealed.
 - 4. Verify that damper actuator and linkage attachment are secure.
 - 5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
 - 6. Verify that damper blade travel is unobstructed.
- F. Control Valve Checkout:
 - 1. Verify that control valves are installed correctly for flow direction.
 - 2. Verify that valve body attachment is properly secured and sealed.
 - 3. Verify that valve actuator and linkage attachment are secure.
 - 4. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
 - 5. Verify that valve ball, disc, or plug travel is unobstructed.
 - 6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace valve if leaks persist.
- G. Instrument Checkout:
 - 1. Verify that instrument is correctly installed for location, orientation, direction, and operating clearances.
 - 2. Verify that attachment is properly secured and sealed.
 - 3. Verify that conduit connections are properly secured and sealed.
 - 4. Verify that wiring is properly labeled with unique identification, correct type, and size and is securely attached to proper terminals.
 - 5. Inspect instrument tag against approved submittal.
 - 6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
 - 7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
 - 8. For temperature instruments, verify the following:
 - a. Sensing element type and proper material.
 - b. Length and insertion.

3.18 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION, AND TESTING

- A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

- B. Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- C. For each analog instrument, make three-point test of calibration for both linearity and accuracy.
- D. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.
- E. Provide diagnostic and test equipment for calibration and adjustment.
 - 1. Use field testing and diagnostic instruments and equipment with an accuracy at least twice the instrument accuracy of instrument to be calibrated. For example, test and calibrate an installed instrument with accuracy of 1 percent using field testing and diagnostic instrument with accuracy of 0.5 percent or better.
- F. Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.
- G. If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.
- H. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.
- I. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 - 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- J. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact making or breaking.
- K. Control Dampers:
 - 1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
 - 2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
 - 3. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- L. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
 2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
 3. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- M. Meters: Check meters at zero, 50, and 100 percent of Project design values.
- N. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- O. Switches: Calibrate switches to make or break contact at set points indicated.
- P. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
 2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.
- 3.19 DDC SYSTEM CONTROLLER CHECKOUT
- A. Verify power supply.
1. Verify voltage, phase, and hertz.
 2. Verify that protection from power surges is installed and functioning.
 3. Verify that ground fault protection is installed.
 4. If applicable, verify if connected to UPS unit.
 5. If applicable, verify if connected to backup power source.
 6. If applicable, verify that power conditioning units are installed.
- B. Verify that wire and cabling are properly secured to terminals and labeled with unique identification.
- C. Verify that spare I/O capacity is provided.
- 3.20 DDC CONTROLLER I/O CONTROL LOOP TESTS
- A. Testing:
1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
 2. Test every I/O point throughout its full operating range.
 3. Test every control loop to verify that operation is stable and accurate.
 4. Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.

5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
 - a. Upper quarter of range.
 - b. Lower quarter of range.
 - c. At midpoint of range.
8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller, and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller, and at field instrument must match.
10. Prepare and submit report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

3.21 DDC SYSTEM VALIDATION TESTS

- A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
- B. After review of Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.
- C. After testing is complete, submit completed Pretest Checklist.
- D. Pretest Checklist: Submit the following list with items checked off once verified:
 1. Detailed explanation for any items that are not completed or verified.
 2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
 3. HVAC equipment motors operate below full-load amperage ratings.
 4. Required DDC system components, wiring, and accessories are installed.
 5. Installed DDC system architecture matches approved Drawings.
 6. Control electric power circuits operate at proper voltage and are free from faults.
 7. Required surge protection is installed.
 8. DDC system network communications function properly, including uploading and downloading programming changes.
 9. Using BACnet protocol analyzer, verify that communications are error free.
 10. Each controller's programming is backed up.
 11. Equipment, products, tubing, wiring cable, and conduits are properly labeled.
 12. All I/O points are programmed into controllers.
 13. Testing, adjusting, and balancing work affecting controls is complete.
 14. Dampers and actuators zero and span adjustments are set properly.
 15. Each control damper and actuator goes to failed position on loss of power and loss of signal.
 16. Valves and actuators zero and span adjustments are set properly.
 17. Each control valve and actuator goes to failed position on loss of power and loss of signal.
 18. Meter, sensor, and transmitter readings are accurate and calibrated.

19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.
26. Record Drawings are completed.
27. .

E. Test Plan:

1. Prepare and submit validation Test Plan including test procedures for performance validation tests.
2. Address all specified functions of DDC system and sequences of operation in Test Plan.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include Test Checklist to be used to check and initial that each test has been successfully completed.
6. Submit Test Plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
 - a. Verify analog I/O points at operating value.
 - b. Make adjustments to out-of-tolerance I/O points.
 - 1) Identify I/O points for future reference.
 - 2) Simulate abnormal conditions to demonstrate proper function of safety devices.
 - 3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. 24 hours after initial validation test, do as follows:
 - a. Re-check I/O points that required corrections during initial test.
 - b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
5. 24 Hours after second validation test, do as follows:
 - a. Re-check I/O points that required corrections during second test.
 - b. Continue validation testing until I/O point is normal on two consecutive tests.
6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation

re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

3.22 VERIFICATION OF DDC SYSTEM WIRELESS NETWORK

- A. DDC system Installer is to design wireless DDC system networks to comply with performance requirements indicated.
- B. Verify wireless network performance through field testing and document results in a field test report.
- C. Testing and verification of all wireless devices to include, but not be limited to, the following:
 - 1. Speed.
 - 2. Online status.
 - 3. Signal strength.

3.23 FINAL REVIEW

- A. Submit written request to Architect Construction Manager when DDC system is ready for final review. State the following:
 - 1. DDC system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
 - 2. DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
 - 3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
 - 4. DDC system is complete and ready for final review.
 - 5. .
- B. Upon receipt of written request for final review, Owner and Construction Manager to start review within reasonable period and upon completion issue field report(s) documenting observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in reviewer's field report(s) and submit second written request after all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Compensation for Subsequent Reviews: Should more than two reviews be required, DDC system manufacturer and Installer to compensate entity/entities performing reviews for total costs (labor and expenses) associated with subsequent reviews. Estimated cost of each subsequent review to be submitted and approved by DDC system manufacturer and Installer before review.
- E. Prepare and submit closeout submittals when no deficiencies are reported.

- F. Part of DDC system final review shall to include demonstration to parties participating in final review.
1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
 2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
 3. Demonstration to include, but not be limited to, the following:
 - a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
 - b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points to be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
 - c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
 - d. Operation of randomly selected dampers and valves in normal-on, normal-off, and failed positions.
 - e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
 - f. Trends, summaries, logs, and reports set up for Project.
 - g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
 - h. Software's ability to communicate with controllers, operator workstations, and uploading and downloading of control programs.
 - i. Software's ability to edit control programs offline.
 - j. Data entry to show Project-specific customizing capability including parameter changes.
 - k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
 - l. Execution of digital and analog commands in graphic mode.
 - m. Spreadsheet and curve plot software and its integration with database.
 - n. Online user guide and help functions.
 - o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
 - p. System speed of response compared to requirements indicated.
 - q. For Each Network and Programmable Application Controller:
 - 1) Memory: Programmed data, parameters, trend, and alarm history collected during normal operation are not to be lost during power failure.
 - 2) Operator Interface: Ability to connect directly to each type of digital controller with portable workstation and mobile device. Show that

- maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
- 3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
- 4) Electric Power: Ability to disconnect any controller safely from its power source.
- 5) Wiring Labels: Match control drawings.
- 6) Network Communication: Ability to locate controller's location on network and communication architecture matches Shop Drawings.
- 7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
- r. For Each Operator Workstation:
 - 1) I/O points lists agree with naming conventions.
 - 2) Graphics are complete.
 - 3) UPS unit, if applicable, operates.
- s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Requirements must be met even if only one manufacturer's equipment is installed.
 - 1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
 - 2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
 - 3) Set-Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated.
 - 4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
 - 5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
 - 6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
 - 7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
 - 8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
 - 9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
 - 10) Device and Network Management:
 - a) Display of network device status.
 - b) Display of BACnet object information.
 - c) Silencing devices transmitting erroneous data.
 - d) Time synchronization.

- e) Remote device re-initialization.
- f) Backup and restore network device programming and master database(s).
- g) Configuration management of routers.
- t. .

3.24 EXTENDED OPERATION TEST

- A. Operate DDC system for operating period of 14 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.
- B. During operating period, DDC system to demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.
 - 1. Correct defects of hardware and software when they occur.
- C. Definition of Failures and Downtime during Operating Period:
 - 1. Failed I/O point constituting downtime is I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
 - 2. Downtime is when any I/O point in DDC system is unable to fulfill its required function.
 - 3. Calculate downtime as elapsed time between detected point failure as confirmed by operator, and time point is restored to service.
 - 4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation is to be 0.5 hours.
 - 5. Log downtime in hours to nearest 0.1 hour.
 - 6. Power outages do not count as downtime, but do suspend test hours unless systems are provided with UPS and served through a backup power source.
 - 7. Hardware or software failures caused by power outages do count as downtime.
- D. During operating period, log downtime and operational problems are encountered.
 - 1. Identify source of problem.
 - 2. Provide written description of corrective action taken.
 - 3. Record duration of downtime.
 - 4. Maintain log showing the following:
 - a. Time of occurrence.
 - b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
 - c. Downtime for each failed I/O point.
 - d. Running total of downtime and total time of I/O point after each problem has been restored.
 - 5. Make log available to Owner for review at any time.
- E. For DDC system to pass extended operation test, total downtime is limited to 2 percent of total point-hours during operating period.

1. If DDC system testing results fail to comply with minimum requirements of passing at end of operating period indicated, extend operating period one consecutive day at a time until DDC system passes requirement.

F. Base evaluation of DDC system passing test on the following calculation:

1. Count downtime on point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
2. One point-hour of downtime is one I/O point down for one hour. For example, three I/O points down for five hours is total of 15 point-hours of downtime. Four points down for one-half hour is two point-hours of downtime.
3. Example Calculation: Maximum allowable downtime for 30-day test for DDC system with 1000 total I/O points (combined analog and binary) and passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

G. Prepare test and inspection reports.

3.25 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.26 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration, and adjusting as required for proper operation. Use only manufacturer's authorized replacement parts and supplies.

3.27 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, verify that service agreement includes software support for two year(s).
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.
 1. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.28 DEMONSTRATION

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.
- B. Extent of Training:
 - 1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
 - 2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
 - 3. Minimum Training Requirements:
 - a. Provide not less than four hours of training total.
- C. On-Site Training:
 - 1. Training to occur on site located at the equipment. A portable operator terminal suitable for viewing the graphics shall be provided by the DDC installer.
- D. Training Content for Daily Operators:
 - 1. Basic operation of system.
 - 2. Understanding DDC system architecture and configuration.
 - 3. Understanding each unique product type installed including performance and service requirements for each.
 - 4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm, and each unique optimization routine.
 - 5. Operating operator workstations, printers, and other peripherals.
 - 6. Logging on and off system.
 - 7. Accessing graphics, reports, and alarms.
 - 8. Adjusting and changing set points and time schedules.
 - 9. Recognizing DDC system malfunctions.
 - 10. Understanding content of operation and maintenance manuals including control drawings.
 - 11. Understanding physical location and placement of DDC controllers and I/O hardware.
 - 12. Accessing data from DDC controllers.
 - 13. Operating portable operator workstations.
 - 14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
 - 15. Running each specified report and log.
 - 16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
 - 17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
 - 18. Executing digital and analog commands in graphic mode.

19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
 - a. Operation of HVAC equipment in normal-off, normal-on, and failed conditions while observing individual equipment, dampers, and valves for correct position under each condition.
 - b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
 - c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles, and other modes of operation indicated.
 - d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
 - e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
 - f. Each control loop responds to set-point adjustment and stabilizes within time period indicated.
 - g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

END OF SECTION 230923

231123 – FACILITY NATURAL-GAS PIPING

- A. 2" and Smaller:
 - 1. ASTM A 53, Grade B, Type F Schedule 40 black steel pipe with ASTM a 197/ANSI B16.3 class 150 black malleable iron fittings with threaded joints.
- B. All natural gas piping shall be electrically continuous and bonded to any grounding electrode, in accordance with NFPA 70.
- C. All existing and new natural gas piping and gas vent piping shall be painted OSHA Safety yellow with two coats of a rust-inhibiting paint. Paint all existing and new interior gas piping within the boiler room, all exterior gas service piping up to the utility company's equipment.
- D. Gas Valves:
 - 1. 2" and smaller:
 - a. AGA approved, 600 psi cold working pressure (CWP) @ 100 deg F (1/2" - 2"), 400 psi CWP @ 100 deg F (2-1/2" - 4"), threaded-end, one-piece, forged brass body and ends, chrome plated brass ball, full port, PTFE seats, seals and packing, brass threaded packing gland, Viton "O" ring stem seal, brass anti-blowout stem, and vinyl covered steel handle. Valves shall be equipped with a plugged 1/8" NPT test gauge connection.
- E. Pipe Testing:
 - 1. All piping systems shall be tested for leaks and proved tight in the presence of the engineer or owner's representative before piping is concealed below floors, above ceilings or covered with insulation.
 - 2. Conduct pressure tests with test medium indicated below. Minimum test time shall be 8 hours; additional time may be necessary to conduct an examination for leakage.
 - a. Natural gas: 100 psig, air

END OF SECTION 231123

232113 – HYDRONIC PIPING

A. HEATING WATER PIPING

1. Copper tube 2" and smaller:
 - a. ASTM B 88, Type L, hard-drawn copper tube with ASME B16.22 wrought copper solder-joint fittings using ASTM B 32, lead-free alloy solder and ASTM B 813 water-washable flux.
2. Black steel pipe 2" and smaller:
 - a. ASTM A 53, Grade B, Type E or S Schedule 40 black steel pipe with ASTM A 197/ANSI B16.3 Class 150 black malleable iron fittings with threaded joints.
3. Black steel pipe 2-1/2" and larger:
 - a. ASTM A 53, Grade B, Type E or S, schedule 40 black steel pipe with ASTM A 234 Grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.
 - b. Flanged joints:
 - 1) Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
 - c. Welded joints:
 - 1) Construct joints according to AWS D10.12, using qualified processes and welding operators.

B. CONDENSATE DRAIN PIPING

1. ASTM B 88, Type L, hard-drawn copper tube with ASTM B 145/ANSI B16.23 cast red bronze or ASTM B 75/ANSI B16.29 wrought solder-type drainage fittings.

C. PIPE TESTING

1. All piping systems shall be tested for leaks and proved tight in the presence of the engineer or owner's representative before piping is concealed below floors, above ceilings or covered with insulation.
2. Conduct pressure tests with test medium indicated below. Minimum test time shall be 8 hours; additional time may be necessary to conduct an examination for leakage.
 - a. Heating water: 100 psig, water

D. TANGENTIAL-TYPE AIR SEPARATORS

1. Tank: Welded steel, designed and constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and labeled for 125 psig minimum working pressure.
2. Maximum Operating Temperature: 375 deg F.
3. Strainer: Type 304 stainless steel with 3/16" diameter perforations and 51% open area. Provisions shall be made in the unit shell for strainer removal. Provide a blowdown connection located so that the inside surface of the strainer can be cleaned by draining the system fluid through the blowdown connection.
4. Air Collector Tube: Perforated stainless steel, constructed to direct released air to high capacity automatic air vent.
5. High Capacity Automatic Air Vent: Float-actuated operation for instant venting of free air. Cast iron construction with stainless steel, brass, and EPDM internal components. Positive shut-off at pressures up to 150 psig.
6. Basis of Design: Armstrong Series VAS with strainer and high capacity automatic air vent.

E. BLADDER-TYPE EXPANSION TANKS

1. Tank: Welded steel, designed and constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and labeled for 125 psig minimum working pressure.
2. Maximum Operating Temperature: 240 deg F.
3. Bladder: Heavy duty butyl rubber securely sealed into tank to separate air charge from system water.
4. Air Charge Fitting: Schrader valve, stainless steel construction with EPDM seats.
5. Basis of Design: Taco Model CA for hydronic systems and Taco Model PAX for domestic water systems.

F. CLEANING

1. Flush entire heating water system in the school with an alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
2. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.
3. Flushing and cleaning shall be coordinated with the Owner.

G. CHEMICAL TREATMENT

1. Perform a water analysis to determine the type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling. Submit a copy of the report to illustrate water quality available at project site. The analysis shall include the following:
 - a. pH
 - b. Total alkalinity
 - c. Chlorides
 - d. Total dissolved solids
2. Fill system and perform initial chemical treatment.
3. Water Treatment Chemicals:
 - a. Chemicals shall be specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.
 - b. Furnish sufficient chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.
4. The contractor shall engage a reputable water treatment contractor to provide a complete water treatment service for the heating water system.
 - a. Service shall be provided for a period of two (2) years from date of start-up.
5. It shall be the responsibility of the water treatment contractor to:
 - a. Make service visits once per month when systems are in operation. During these visits, adjust feeding equipment, apply chemicals, and obtain and analyze samples in order to maintain conditions as specified below.
 - b. Obtain a signed work order after each visit and leave a report indicating which systems were serviced, and the test results.
 - c. Maintain complete records of the treatment program for each system.
 - d. Instruct mechanical contractor in field on piping of chemical feeding equipment.
 - e. Furnish all necessary labor, chemicals, and feeding equipment required for the specified treatment. All equipment, once installed, will remain the property of the owner.
 - f. Maintain the following conditions in each system:
 - 1) Heating water
 - a) pH 8.0 to 10.5
 - b) Corrosion inhibitor 100 to 150 ppm (as Molybdate)

END OF SECTION 232113

232123 – HYDRONIC PUMPS

A. MANUFACTURERS

1. Subject to compliance with requirements, provide products by one of the following manufacturers:
 - a. Bell & Gossett.
 - b. Taco.
 - c. Armstrong.

B. 3-PIECE INLINE PUMPS – PERMANENTLY LUBRICATED

1. Pumps shall be of a horizontal, permanently lubricated type, specifically designed for quiet operation. Suitable for 225 degree F operation at 175 psig working pressure.
2. Pumps shall be single stage, vertical split case design, in cast iron bronze fitted construction (or all bronze construction for domestic water applications). Pump internals shall be capable of being serviced without disturbing piping connections.
3. Pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupler.
4. Pumps shall have a solid SAE1144 steel shaft supported by two sealed ball bearings. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.
5. Pumps shall be equipped with an internally flushed mechanical seal assembly. Seal assembly shall have a brass housing, Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.
6. Bearing assembly shaft shall connect to either a cast bronze impeller. Impeller shall be hydraulically and dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut.
7. A flexible type coupling shall be employed between the pump and motor.
8. Pumps shall be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.
9. Pump volute shall be of cast iron design for heating or chilled water systems and cast bronze for domestic water systems. The connection style on cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles, and vent and drain ports.
10. To ensure alignment the motor shall be mounted to the bearing assembly via a bolted motor bracket assembly, and a rubber motor mount shall be used to assist in aligning the motor shaft with the pump shaft.
11. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors through 1 HP shall be resilient mounted, motors over 1.5 HP shall be rigid mounted. Motors shall have permanently lubricated ball bearings and must be completely maintenance free. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.
12. Pump shall be of a maintainable design and for ease of maintenance shall use machine fit parts and not press fit components.
13. Pump manufacturer shall be ISO-9001 certified and be of U.S. manufacturer.

14. Each pump shall be factory tested and name-plated before shipment and shall be provided with a (3) year warranty from date of installation.
15. Basis of Design: Bell & Gossett Series 60.

C. HORIZONTAL BASE-MOUNTED, END-SUCTION PUMPS

1. General Description: Pumps shall be single, end suction type with radially split, top center-line discharge, self-venting casing.
2. Maximum pump operation condition shall comply with ANSI 125 (175 psig at 150 degrees F, 140 psig at 250 degrees F).
2. Casings Construction: Cast iron, bronze fitted (all iron, all bronze, ductile iron) and shall be fitted with a long-life, product lubricated, drip-tight mechanical seal, with O-ring seat retainer, designed for the specified maximum temperature and pressure. Provide with flanged piping connections, and threaded gauge tapings at inlet and outlet flange connections.
3. Impeller Construction: Statically and dynamically balanced, closed, overhung, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to shaft and secured by a locking capscrew.
4. The shaft shall be fitted with a stainless steel shaft sleeve and be supported by two heavy duty ball bearings. The design shall allow Back Pull Out servicing, enabling the complete rotating assembly to be removed without disturbing the casing piping connections.
6. Seals: Type 2A seal with EPDM secondary seal, consisting of stainless steel rotating hardware, stainless steel spring, silicone carbide seat.
7. Pump Coupler: Flexible, capable of absorbing torsional vibration and shaft misalignment; complete with steel OSHA coupler guard.
8. Mounting Frame: Factory-welded frame and cross members, fabricated of steel channels and angles conforming to ASTM B 36. Fabricate for mounting pump casing, coupler guard, and motor. Grind welds smooth prior to application of factory finish. Motor mounting holes for field-installed motors shall be field-drilled.
9. Motor: TEFC induction type premium efficiency motor secured to mounting frame with adjustable alignment on mounting frame.

D. PUMP SPECIALTY FITTINGS

1. Suction Diffuser: Angle or straight pattern, 175-psig (1200-kPa) pressure rating, cast-iron body and end cap, pump-inlet fitting. Include bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory- or field-fabricated support.
2. Flexible Connectors: Flanged, braided stainless steel.
3. Triple Duty Valve: Not acceptable for this project.
4. Refer to Section 230523 for Check Valves, High-Performance Butterfly Valves and Venturi-type Balancing Valves.
5. Refer to Pump Detail on the Drawings for additional requirements.

END OF SECTION 232123

235100 – BREECHINGS, CHIMNEYS, AND STACKS

A. LISTED SPECIAL GAS VENT

1. All products furnished under this Section shall conform to the requirements of The National Fuel Gas Code, ANSI Z223.1/ NFPA-54 where applicable and shall comply with and be listed to UL 1738, the U.S. Standard for Venting Systems for Gas-Burning Appliances, Category II, III and IV and ULC-S636-95, the Canadian Standard for Type BH gas vent systems. Components coming in direct contact with products of combustion shall carry the appropriate UL or ULC label.
2. The vent shall be of the double wall, factory-built type, designed for use in conjunction with Category I, II, III or IV condensing or non-condensing gas fired appliances or as specified by the heating equipment manufacturer. The vent can also be used on L-Vent certified appliances.
3. Maximum continuous flue gas temperature shall not exceed 550 deg F.
4. Vent shall be listed for a maximum positive pressure rating of 6" w.c. and shall have passed at 35" w.c.
5. The vent system shall be continuous from the appliance's flue outlet to the vent termination outside the building. All system components shall be listed to UL or ULC standard and supplied from the same manufacturer.
6. The vent shall be constructed with an inner and outer tube, where the annular air space between the tubes is 1 inch.
7. The inner tube (flue gas conduit) shall be constructed from AL29-4C stainless steel, with a minimum wall thickness of .020" for 4" through 12" diameter vents, and .024" for 14" to 24" diameter vents.
8. The outer tube (jacket) shall be constructed from 441 or 430 stainless steel, with a minimum wall thickness of .020" for 4" through 10" diameter vents and .024" for 12" through 24" diameter vents.
9. All system components such as vent supports, roof or wall penetrations, terminations, appliance connectors and drain fittings require to install the vent system shall be listed to UL/ULC standard and provided by the vent manufacturer.
10. Vent layout shall be designed and installed in compliance with manufacturer's installation instructions and all applicable local codes.
11. The sizing of the complete vent system shall be guaranteed by the manufacturer and a copy of the sizing calculations submitted to the engineer for review and approval prior to the contractor placing an order and release.
12. The manufacturer shall submit a venting drawing for approval showing all vent system components. The contractor must position all venting components, equipment, water, and gas piping to accommodate the vent system design.

13. The manufacturer shall warrant the listed special gas vent system against defects in material and workmanship for a period of 15 years from the date of original installation. Any portion of the vent repaired or replaced under the warranty shall be warranted for the remainder of the original warranty period.
14. Basis of Design: Secure Seal SSD by Security Chimneys International.

B. VENTILATION INTAKE PIPING

1. ASTM D 1784 Schedule 40 virgin rigid polyvinyl chloride (PVC) pipe having a cell class of 12454-B. Pipe shall be iron pipe size (IPS) conforming to ASTM D 1785. PVC fittings shall conform to ASTM D 2466. Provide PVC pressure pipe fittings joined with solvent cement.

END OF SECTION 235100

235113 – CONDENSING BOILERS

PART 1 - GENERAL

1.1 SUMMARY

- A. The work to be performed includes all new equipment, labor and materials required to furnish and install ultra-high efficiency Fulton Endura Condensing Hydronic Boilers as described in this product guide specification.

1.2 REFERENCES

- A. ASME
- B. CAN-1.3.1-77, Industrial and Commercial Gas Fired Packaged Boilers
- C. CSD1, Controls and Safety Devices
- D. GE GAP
- E. NEC, National Electric Code
- F. UL-795 7th Edition

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model, weights (shipping, installed and operating), installation and start-up instructions, and furnished accessory information.
- B. Shop Drawings: Submit manufacturer's end assembly drawings indicating dimensions, connection locations, and clearance requirements.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for the boiler including ladder type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of condensing hydronic boilers with welded steel pressure vessels, whose products have been in satisfactory use in service for not less than ten (10) years. The specifying engineer, contractor and end customer must have the option to visit the factory during the manufacture of the boilers and be able to witness test fire and other relevant procedures.
- B. The boiler shall have an ASME Section IV pressure vessel rated for a maximum allowable working pressure of 160 PSIG and a maximum allowable working temperature of 210°F.
- C. The flame safeguard control on the boiler shall be integrated with temperature control functionality.
- D. The entire boiler system and its installation shall conform to the manufacturer's instructions, applicable codes and associated National Board requirements.
- E. The equipment shall be in strict compliance with the requirements of this specification and shall be the manufacturer's standard commercial product unless specified otherwise. Additional equipment features, details, accessories, etc. which

are not specifically identified but which are a part of the manufacturer's standard commercial product, shall be included in the equipment being furnished.

1. Examples of standard items included with every Endura boiler:
 - a. Low water cut off probe installed in the pressure vessel
 - b. High and low gas pressure switches
 - c. Lockup style regulator mounted within the boiler cabinet
 - d. Housing for combustion air inlet filter
- F. The equipment shall be of the type, design, and size that the manufacturer currently offers for sale and appears in the manufacturer's current catalog.
- G. The equipment shall fit within the allocated space, leaving ample allowance for maintenance and inspection.
- H. The equipment shall be new and fabricated from new materials. The equipment shall be free from defects in materials and workmanship.
- I. All units of the same classification shall be identical to the extent necessary to ensure interchangeability of parts, assemblies, accessories, and spare parts wherever possible.
- J. In order to provide unit responsibility for the specified capacities, efficiencies, and performance, the boiler manufacturer shall certify in writing that the equipment being submitted shall perform as specified.

1.5 WARRANTY

- A. The boiler manufacturer will repair or replace any part of the boiler that is found to be defective in workmanship or material within twenty-four (24) months from substantial completion.
- B. The boiler's pressure vessel is warranted against failure due to thermal shock for a period of ten (10) years from the date of shipment from the factory is installed, controlled, operated and maintained in accordance with the Installation, Operation and Maintenance Manual.
- C. The pressure vessel and heat exchanger is covered against failures resulting from flue gas corrosion and/or defective material or workmanship for a period of five (5) years from substantial completion. Waterside corrosion or scaling is not covered. The manufacturer will repair or replace.

1.6 MAINTENANCE SERVICE

- A. In addition to startup service specified, the qualified service and maintenance organization shall provide a 5-year service agreement covering all parts and labor for regular service, emergencies and repairs.
- B. Regular service: One visit at annual startup of boilers and second visit at the end of the heating season.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. This specification is based on the Endura Series boilers as manufactured by Fulton Heating Solutions, Inc. Equivalent units and manufacturers must meet all performance criteria for all fuel options and will be considered upon prior approval.
- B. Basis of Design: Fulton Heating Solutions, Inc.
 - 1. Models: Endura EDR Series Firetube Condensing Hydronic Boilers.
- C. Other Acceptable Manufacturers:
 - 1. Veissmann.
 - 2. AERCO Benchmark Platinum Series.
 - 3. These additional manufacturers are acceptable if they meet the operating and performance requirements specified or shown on schedule drawings.
- D. The boiler manufacturer shall have a factory authorized service training program, where technicians have attended a training class and are certified to perform start-up, maintenance and basic troubleshooting on the Fulton boiler. The boiler manufacturer shall have a minimum of ten (10) full time service technicians on staff. Resumes for the factory technicians should be available upon request.
- E. Customers, engineers and contractors shall have the option to visit the boiler manufacturer's factory to witness manufacturing, test fire and other operational safety inspections associated with the referenced boilers.

2.2 BOILER CONSTRUCTION

- A. The boiler shall be completely factory assembled as a self-contained unit. Each boiler shall be neatly finished, thoroughly tested, and properly packaged for shipping.
- B. The pressure vessel design and construction shall be in accordance with Section IV of the ASME Code for heating boilers. The boiler shall comply with CSD-1 code requirements.
- C. The pressure vessel shell shall be a minimum 1/4" thick steel, SA-790 or SA-516 Grade 70 plate.
- D. Tube sheets should be designed with low weld intensity with a tube-to-tube minimum spacing of 2" center to center and minimum 5/8" tube to tube ligament.
- E. The firetube area of the heat exchanger where the flue gases will condense shall be constructed using duplex alloys of stainless steel. Alloys of the 300 series stainless steels, such as 316L or 304, have a relatively high coefficient of linear expansion and thus are unacceptable.
- F. Heat exchange capability shall be maximized within the pressure vessel via the use of corrugator fire tube technology. All heat transfer enhancements shall be stainless steel; aluminum heat transfer enhancers are unacceptable.
- G. Boilers with heat exchangers using cast aluminum, cast iron or copper finned tube design platforms are unacceptable.
- H. The boiler shall be a fire tube design. The furnace location shall be such that all furnace components are within water-backed areas.
- I. The water volume of the boiler shall not be less than:
 - 1. As indicated in product data for the specific models scheduled.

2. If boilers having a lower water volume are supplied, a buffer tank is mandated to make equivalent total volume of the Endura boilers.

2.3 BOILER DESIGN

- A. External convection and radiation heat losses to the boiler room from the boiler shall be less than 0.5% of the rated boiler input.
- B. The boiler shall have its efficiency witnessed and certified by an independent third party, and the efficiency must be listed on the AHRI directory (www.ahridirectory.org) for natural gas operation. The test parameters for efficiency certification shall be the BTS-2000 standard, with 80°F return water temperature, 180°F supply water temperature, steady state operation at full input firing capacity. The certified thermal efficiency for natural gas firing shall not be less than that indicated in the product data of the specified models scheduled.
- C. The boiler shall have no minimum return water temperature requirements.
- D. A zero flow or low flow condition shall not cause any harm to the pressure vessel or heat exchanger of the boiler. Flow switches, dedicated circulator pumps, or primary/secondary piping arrangements are not required to protect the heat exchanger or pressure vessel from thermal shock or other system related considerations.
- E. It shall be acceptable to vent the boiler using sealed combustion (drawing in fresh air from the outdoors) or to draw air from the mechanical room itself.
 1. The flue (exhaust) stack must be UL-1738/C-UL S636 approved for Category IV (condensing, positive pressure) applications and in compliance with Listed Special Gas Vent specification section.
 2. If combustion air intake piping is utilized, it shall be Schedule 40 PVC or equivalent.
 3. The boiler shall be capable of operating with an exhaust draft not exceeding - 0.04" wc and a combined air intake and exhaust venting pressure drop not exceeding +1.50" wc.
 4. The boiler shall have a pre-mix combustion system, capable of operating at 4" wc incoming gas pressure while simultaneously achieving emissions performance, full modulation/turndown, and full rated input capacity.
- F. The noise emission from the boiler shall not exceed 60dBA measured 5 feet from the front of the boiler at high fire and 55 dBA at low fire.
- G. The exhaust manifold shall be constructed of stainless steel, with a collection area for the ultimate disposal of flue gas condensate. The boiler exhaust connection shall allow for immediate vertical rise off the boiler without the use of an elbow or tee.

2.4 CONTROLS

- A. Ignition shall be via direct spark. A UV scanner shall be utilized to ensure precise communication of flame status back to the flame programmer. Flame rods are not acceptable.
- B. The boiler shall be set up for a maximum 5:1 turndown when firing on natural gas. Any boiler claiming turndown greater than 8:1 must provide references for five (5)

installations of similar capacity operating at the claimed turndown for at least (3) complete heating seasons.

1. Up to 8:1 turndown is achievable, depending on site conditions.
 2. Factory default setting is 5:1.
- C. The boiler shall operate at no greater O₂% than 7.0% over a 5:1 turndown range in order to maximize seasonal efficiency. The boiler shall also maintain <20ppm NO_x at all operating conditions at excess air no greater than 35% with 5:1 turndown.
- D. For an individual boiler, the boiler's control shall provide boiler status, configuration, history and diagnostics:
1. Flame programming/flame safeguard control.
 2. Temperature (PID) load control capability for up to two loops (central heat and/or domestic hot water).
 3. Color touch screen display with screen saver, screen disable for cleaning, contrast control and volume control for alarm features
 4. ModBus communication capabilities
 5. BacNet communication with a gateway (coordinate with Controls subcontractor).
 6. Firing rate limiting
 7. Time of day display
 8. Enable/disable control of up to three (3) devices (pumps, valves, etc.) with programmable time delay for disable of the device(s)
 9. Customizable boiler name display
 10. Display fifteen (15) most recent alarms including equipment status at time of lockout
 11. Ability to accept a remote 4-20mA signal for setpoint or firing rate (one or the other, not both)
 12. Password protect options
 13. Outdoor reset capabilities for an individual boiler with warm weather shutdown
- E. Each individual boiler shall be able to set up appropriately with programmable limits for (information displayed on the boiler display):
1. Outlet water temperature
 - a. Parameters within the control will be used to manage boiler operating temperatures and turndown to adhere with published manufacturer guidelines.
 2. Exhaust/stack temperature
 3. Inlet water temperature (when return water temperature monitoring is utilized)
 4. Outdoor/ambient air temperature
- F. The boilers can be configured to perform integrated sequencing (lead/lag) functions for up to eight (8) boilers installed in the same hydronic loop. This is done integral to the control thus does not require a third-party panel.

1. General configuration of the controls for integrated sequencing capabilities:
 - a. One (1) boiler in the system must be factory programmed as the MASTER and subsequent boilers will be programmed as lag units.
 - i. If at any point the MASTER boiler is taken out of the hydronic system, lag boilers will default to local control. One of the lag boilers will have to be reprogrammed in order to resume sequencing functionality in the system.
 2. The boilers will communicate with each other via a ModBus network (twisted pair, daisy chain).
 3. BacNet communication protocol is required, which can be done by including one (1) BacNet gateway on the MASTER boiler.
 - a. Lag boilers do not need their own gateway.
 - b. The building management system will communicate only to the MASTER boiler with the BacNet protocol, points available via the BacNet protocol shall be provided upon request (coordinate with the controls subcontractor).
- G. Outdoor reset controls for multiple boiler systems using the SOLA control:
1. The following sensors shall be provided:
 - a. Outdoor air/ambient temperature sensor and module shipped loose (must be installed in the field and wired to the MASTER boiler).
 - b. Hydronic loop temperature sensor and well shipped loose (must be installed in the field and wired to the MASTER boiler).
 2. The MASTER boiler shall be field programmed with the customer's desired outdoor reset schedule.
 3. The MASTER boiler shall have the ability to disable the entire hydronic boiler system based on a programmable outdoor air temperature (warm weather shutdown).
- H. Sequencing logic of multiple boilers using the integrated sequencing capabilities of the boiler control system:
1. Boilers will be rotated based on a sequenced order and a programmable number of run hours.
 2. Boilers will be enabled/disabled at a programmable minimum firing rate and modulated in parallel to meet load requirements. For example, in a two-boiler system:
 - a. Upon call for heat in the system, the first boiler will be enabled and will modulate to the programmed minimum firing rate, for example 20%. This value is adjustable in the field.
 - b. If the heating load is not satisfied, the second boiler will be enabled also at 20%.
 - c. Both boilers will modulate up and down in parallel (infinite modulation points) to meet heating load requirements.
 - d. As the load decreases, the boilers will be sequentially disabled.

3. Each individual boiler can control up to three (3) devices (enable/disable only). The enable of each device, for example a pump or motorized isolation valve, will be simultaneous to the call for heat in that boiler. This disable of each device will be based on a programmable time delay when the call for heat is no longer present.
- I. Burner selection:
 1. The burner shall be a premix low emission design with a built in flame arrestor functionality.
 2. The burner shall include an internal vortex shedding device to remove harmonics.
 3. The burner shall feature direct spark ignition. Pilot assemblies are not accepted.
- J. Boiler safety controls shall include:
 1. Operating Temperature Controller for automatic start and stop.
 2. High Limit Temperature Controller with manual reset.
 3. One Low Water Cutoff Probe in the boiler shell.
 4. Air Safety Switch to prevent operation unless sufficient combustion air is assured.
 5. Flame detector to prove combustion.
- K. All controls are to be burner or panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls. All controls shall be mounted and wired according to UL requirements. Electrical power supplied shall be 120/60/1.

2.5 MAIN FUEL TRAIN COMPONENTS

- A. A factory mounted main gas train shall be supplied. The gas train shall be fully assembled, wired, and installed on the boiler and shall comply with CSD-1 code. The fuel train components shall be enclosed within the boiler cabinet.
- B. A lock up regulator (upstream of the fuel train) shall be furnished as standard within the boiler cabinet.
- C. Standard CSD-1 fuel trains shall comply with IRI, which has been replaced by GE GAP.

2.6 BOILER FITTINGS & TRIM

- A. The boiler shall be supplied with an ASME Section IV safety relief valve. The safety relief valve size shall be in accordance with ASME code requirements.
- B. The boiler shall be supplied with a temperature/pressure gauge to be mounted on the water outlet piping of the boiler.
- C. A condensate drain connection shall be available on the boiler, allowing flue gas condensate to freely drain out of the exhaust manifold of the boiler. A Fulton condensate drain trap kit shall accompany the boiler system and be provided with pH neutralization tank.

- D. The water supply and return connections on the boiler shall be 150# flanged connections. Water connections shall not be designed to support any external structural load from the piping system.
- E. The boiler shall come with lifting eyes and fork truck accessibility for rigging.
- F. Instructions for installation, operation and maintenance of the boiler shall be contained in a manual provided with each boiler.
- G. A wiring diagram corresponding to the boiler configuration shall be included with each boiler.
- H. Each boiler shall be installed and operated in a functioning hydronic system, inclusive of venting, as part of the manufacturing process. A factory test fire report corresponding to the boiler configuration shall be included with each boiler.

2.7 EMISSIONS

- A. When operating on Natural Gas, the boiler shall have CO emissions less than 50 ppm corrected to 3% O₂ and NO_x emissions less than 20 ppm corrected to 3% O₂, over the entire turndown range. The boiler shall maintain this emissions performance at all firing rates and water temperatures with a maximum of 35% excess air.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment and materials shall be installed in an approved manner and in accordance with the boiler manufacturers' installation requirements.
- B. The installer shall construct a level continuous concrete pad (min. 3 1/2 inches high) for the entire boiler system according to the boiler manufacturer's erecting instructions.
- C. Assemble unit sections and parts shipped loose or unassembled for shipment purposes. Follow manufacturer's installation recommendations and instructions.
- D. Install electrical control items furnished by manufacturer per wiring diagram provided by manufacturer.
- E. Complete water piping installation as required by manufacturer for operation of system.
- F. Provide air intake and exhaust piping, size and type as recommended by the manufacturer.
- G. Provide boiler manufacturer recommendation manifold pipe and fittings from each boiler to nearest floor drain or as indicated.

3.2 FIELD QUALITY CONTROL

- A. After boiler installation is completed, the manufacturer shall provide the services of a field representative for starting the unit and training the operator.
- B. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boilers and piping. Obtain certification for complete.

3.3 Training

- A. Provide a minimum of 4 hours training on the operations, control, and maintenance of the boilers and exhaust vent systems.

3.4 CLEANING AND FLUSHING

- A. The boilers shall be cleaned with an alkaline-type boiling out compound to remove grease, oil, mill scale, and other foreign matter. The compound shall be used at a rate of 12 pounds per 20 boiler horsepower. After cleaning, the boilers shall be completely drained, flushed, refilled with fresh water, and vented. All water treatment chemicals shall comply with the Maryland Water Resources Laws and Regulations.

3.5 FIELD HYDROSTATIC TEST

- A. Perform a hydrostatic test of the assembled boiler in accordance with the boiler manufacturer's requirements. Provide documentation of hydrostatic test.

3.6 START-UP

- A. Start up on the unit shall be performed by factory trained and authorized personnel. A copy of the startup report shall be provided to the owner.

3.7 BURNER START UP INFORMATION AND TEST DATA

- A. Upon completion of the burner system start up, the installing contractor shall complete the "Burner Start Up Information and Test Data" form and "Control Settings" form and deliver to the Engineer.
- B. The installing contractor shall also provide printed receipts of the combustion analysis along with the start-up forms.
- C. Complete the Manufacturer's/Installing Contractor's Report for ASME CSD-1 for each boiler. The report form can be found in Nonmandatory Appendix C of ASME CSD-1 – 2012.

3.8 DEMONSTRATION AND TRAINING

- A. Provide the services of a factory-authorized service representative to demonstrate the operation of the boilers and gas burners and train the Owner's maintenance personnel as specified below:
 - 1. Operate boilers and burners, including accessories and controls, to demonstrate compliance with requirements.
 - 2. Train the owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
 - 3. Schedule training with the Owner with at least seven days in advance.

3.9 BOILER REGISTRATION

- A. The contractor shall register the boilers with the Maryland Department of the Environment and pay the necessary fees. A copy of the forms and payment receipt shall be provided to the owner.

3.10 POSTING

- A. Post the CSD-1 CG-500 Installing Contractor's Report and the State Notice of Installation Report in the boiler room.

BURNER START UP INFORMATION & TEST DATA

The following information shall be recorded for each burner start up:

Power Flame Model _____ Job No. _____ Serial No. _____
Installation Name _____ Start Up Date _____
Start Up Contractors Name _____ Phone _____
Name of Technician doing Start Up _____
Type of Gas: Nat. ☐ LP ☐ Other ☐

Gas Firing

Gas Pressure at Train Inlet

Burner in Off Position _____ "W.C."
Low Fire _____ "W.C."
High Fire _____ "W.C."

Combustion Efficiency

Low Fire _____ %
High Fire _____ %

Gas Pressure at Firing Head

Low Fire _____ "W.C."
High Fire _____ "W.C."

Windbox O₂

Low Fire _____ %
High Fire _____ %

Gas Pressure at Pilot Test

Tee _____ "W.C."

Flame Signal Readings D.C. Volts ☐ Micro

Amps ☐

Pilot _____
Low Fire _____
High Fire _____

CO₂ or O₂ (Specify)

Low Fire _____ %
High Fire _____ %

CO

Low Fire _____ PPM
High Fire _____ PPM

Input Rate

Low Fire _____ BTU/HR
High Fire _____ BTU/HR

Overfire Draft

Low Fire _____ "W.C."
High Fire _____ "W.C."

NO_x (Corrected to 3% O₂)

Low Fire _____ PPM
High Fire _____ PPM

Stack Outlet Test Point Draft

Low Fire	_____	"W.C.
High Fire	_____	"W.C.

Net Stack Temperature

Low Fire	_____	° F
High Fire	_____	° F

CONTROL SETTINGS

Operating control cut out setting _____
Operating control cut in setting _____

Limit control cut out setting _____
Limit control cut in setting _____

Power supply: Volts _____ P _____ Hz _____
h _____

Control circuit: Volts _____
Blower motor amps at high fire _____

Other _____

Gas

Low gas pressure switch _____ "W.C.

High gas pressure switch _____ "W.C.

Other _____

Operation Checklist

Checked For Proper Operation Of:	Yes	No		Yes	No
Low water cut off	_____	_____	Barometric damper	_____	_____
High water cut off	_____	_____	Boiler room combustion air &	_____	_____
Flame safeguard control ignition failure	_____	_____	ventilation provision correct	_____	_____
Flame safeguard control main flame failure	_____	_____	Oil tank vent system correct	_____	_____
Burner air flow switch	_____	_____	All oil lines checked for leaks	_____	_____
Induced draft fan controls	_____	_____	All gas lines checked for leaks	_____	_____
Over fire draft controls	_____	_____	Gas lines & controls properly vented	_____	_____
Fresh air damper end switch	_____	_____	Other system components (specify)	_____	_____

Notified _____ of the following system deficiencies: _____

END OF SECTION 235223

SECTION 260160 - BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.1 DESCRIPTION

- A. Drawings and general provisions of the Contract, including General and Supplementary condition and General Requirements, and Division 01 specifications apply to the work specified in specifications of Division 26.
- B. This section includes general administrative and procedural requirements for electrical installations. The administrative and procedural requirements such as Submittal, Operating and Maintenance Manuals, Handling and storage of equipment, etc. are included in this section to expand the requirements specified in Division 01.

1.2 SCOPE

- A. The work of all sections of Division 26 includes furnishing and installing the material, equipment and systems complete as specified therein and indicated on drawings. The electrical installation when finished shall be complete and coordinated, whole and ready for satisfactory use.
- B. Specifications are intended to include everything necessary for a first class installation. If mention has been omitted herein of any items of the work or materials usually furnished for, or necessary, for the complete installation of electrical work or if there are conflicting points in the specifications and/or drawings, the attention of the Owner or their representative should be called to such items in sufficient time for a formal addendum to be issued. Any and all conflicting points in the specifications and/or drawings which are not questioned by the Contractor and clarified by a formal addendum prior to opening of bids shall be subject to the interpretation of the Owner or their designated representative after award of the contract and his/her interpretation shall be binding upon the Contractor.
- C. All materials and equipment shall be installed and completed in a first-class and workmanlike manner and in accordance with the best modern methods and practices. Any materials installed which do not present an orderly and reasonably neat or workmanlike appearance, or are not installed in accordance with these specifications, or the contract drawings, shall be removed and replaced when so directed in writing by the Owner or their designated representative at the Contractor's expense.
- D. Should the Contractor discover any discrepancies between actual conditions and those indicated pertaining to the existing work which may prevent following good practice or the intent of the drawings and specifications, the Contractor shall notify the construction manager and shall not proceed with the work until instructions have been received from the Owner or their designated representative.
- E. The Contractor shall furnish and install all labor, materials, equipment, tools, and services necessary for and reasonably incidental to furnishing and completing the

installation of all electrical work, including the installation of conduits, wires, boxes, devices, equipment, etc. as shown on the contract drawings and/or called for in the specifications, and deliver it to the Owner in proper working condition.

- F. It is intended that the specifications and drawings include everything requisite and necessary to complete the entire work properly, notwithstanding the fact that every item involved may not be specifically mentioned.
- G. The specifications outlines, in general manner, the work required to be performed by the Contractor. The Contractor is responsible for work which may be reasonably interpreted from the specifications and/or drawings as necessary for a complete installation ready for service. The words "install" and/or "installation" shall be interpreted as the inclusion of the following work:
 - 1. Setting, plumbing, aligning, and anchoring of equipment on foundations.
 - 2. Placing all mounting bolts, base channels, cable clamps and supports.
 - 3. Mounting and connecting of electrical items shipped separately and removing and replacing equipment parts to facilitate handling.
 - 4. Making internal connections on equipment which were omitted for shipment. Provision of jumpers and local temporary interconnections that may not be listed in the cable tabulations at no additional cost to the Owner.
 - 5. Cleaning and checking of electrical equipment and connections.
 - 6. Repair to damaged surfaces and equipment shall be made to the satisfaction of the construction manager at no additional cost to the Owner.
- H. The Contractor shall protect work in progress from physical damage and against the intrusion of dirt. The work area shall be kept clear of debris to prevent interference with other operations. The Contractor will be solely responsible for all refuse, debris, and trash attributable to this work. Removal shall be in accordance with all applicable ordinances and the Contractor shall pay any and all fees associated with the disposal of rubbish.
- I. Suitable warning and/or protection shall be provided around temporary openings, handholes, open trenches, removed sections of gratings, or other hazardous areas and conditions.

1.3 RESPONSIBILITY

- A. The General Contractor shall be responsible for all work included in Division 26 and the delegation of work to subcontractors shall not relieve him of his responsibility. The term "contractor" is used throughout this Division and shall mean the General Contractor, although the actual performance of the work may be by a Subcontractor.
- B. The Contractor shall carefully examine all plans, specifications, and documents. After careful examination of all documents, the Contractor shall visit the construction site and thoroughly acquaint himself with the conditions under which the work will be executed. Lack of knowledge and the items which could have been discovered or detected at the time of field visit will not be considered acceptable for extra work compensation.

1.4 REFERENCES AND DEFINITIONS

- A. The following are definitions of the terms and expressions used in Division 26 Sections:

Construction Manager:	Owner's designated representative
Provide:	"furnish and install"
Directed:	"directed by the Engineer or Owner"
Indicated:	"Indicated in contract drawings"
Concealed:	"hidden from normal sight; includes items in shafts, duct spaces (chases), and above ceilings.
Exposed:	"not concealed"

- B. Listed: Equipment or device is listed of a kind mentioned which:

1. Is published by a nationally recognized laboratory which makes periodic inspections of production of such equipment.
2. States that such equipment meets nationally recognized standards or has been tested and found safe for use in a specified manner.

- C. Labeled: Equipment or device is labeled when:

1. It embodies a valid label, symbol, or other identifying mark of a nationally recognized testing laboratory such as Underwriters Laboratories, Inc.
2. The laboratory makes periodic inspections of the production of such equipment.
3. The labeling indicates compliance with nationally recognized standards or tests to determine the safe use in a specified manner.

- D. Certified: Equipment or product is certified which:

1. Has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner.
2. Production of equipment or product is periodically inspected by a nationally recognized testing laboratory.
3. Bears a label, tag or other record of certification.

- E. Nationally recognized testing laboratory: Is a company, which is approved, in accordance with OSHA regulations, by the Secretary of Labor, Federal Government.

1.5 CODES, REGULATIONS AND PERMITS

- A. Give all necessary notices and obtain all required permits. Pay all fees and other costs, including utility connections in connection with the work. File all necessary plans, prepare all documents and obtain all necessary permits and approvals from all governmental agencies having jurisdiction. Obtain all required certificates of inspection and deliver same to the construction manager before request for acceptance and payment for the work.

- B. All materials furnished, and all work installed, shall comply with the latest editions in effect at the time and date of invitation of bids, of codes, standards, rules and regulations and recommendations of the bodies, such as:

1. American National Standards Institute (ANSI)
2. American Society of Testing and Materials (ASTM)
3. Insulated Cable Engineer Association (ICEA)

4. National Electrical Code (NEC) – 2011 Edition
5. National Electrical Manufacturers Association (NEMA)
6. National Fire Protection Association (NFPA)
7. Occupational Safety and Health Agency (OSHA)
8. Underwriters Laboratories, Inc. (UL)
9. National Electrical Safety Code (NESC)
10. Institute of Electrical and Electronics Engineers (IEEE)
11. International Building Code (IBC)
12. American Disability Act (ADA)

- C. Drawings and specifications shall govern in those instances, where the requirements indicated on the construction documents are greater than the requirements required by applicable codes and other standards, rules and regulations.

1.6 SUBMITTALS

- A. See Section 010000 "General Requirements."

1.7 WARRANTY

- A. All material and equipment provided under this division shall be free from defects in workmanship and materials for a period of two years after date of certification of completion and acceptance of work. All defects in workmanship, materials, or performance which appear within the guarantee period shall be corrected by the Contractor on notice from the Owner or their designated representative, without cost to the Owner. In default thereof, Owner may have such work done by others and charge the cost of same to the Contractor.

1.8 SITE VISIT

- A. Prior to preparing the bid, the Contractor shall visit the site and familiarize himself with existing conditions, make necessary investigations as to locations of existing equipment, utilities, etc. and all other matters which can affect work under the contract. No additional compensation will be paid to the Contractor as a result of his failure to completely familiarize himself with the existing conditions (under which the work must be performed), which could have been discovered at the site visit.
- B. See Instructions to Bidders.

1.9 DRAWINGS

- A. The drawings are diagrammatic and are intended to indicate general arrangement and manner of connections. They are not intended to show all details of construction or exact locations of the work. The exact final location of all electrical items shall be approved by the Engineer and Owner before installation.
- B. The Contractor shall carefully examine all contract documents and shall be responsible for the proper fitting of all materials and equipment.

- C. Although the location of materials and equipment may be shown on the drawings in a certain place, the construction may develop conditions that render this location inaccessible or impractical. The Contractor shall call the condition to the attention of the Owner or their designated representative for his direction, before fabricating and installing the work. When requested by the Owner or their designated representative, a detailed drawing of the proposed departure due to field conditions or their causes shall be submitted by the Contractor for approval. The Owner, or their designated representative, shall make all final written decisions as to the conditions which require the changing of any work.
- D. A reasonable shifting in the locations of outlets and/or equipment before installation is expected and shall be done at no increased cost to the Owner.
- E. IT is the intention and requirement of the specification that proper service be provided to and for all pieces of equipment requiring the same. As far as possible, the proper service to each piece of equipment has been indicated on the plans. The Contractor shall verify the service requirements of all pieces of equipment before making final provisions. Shop drawings shall be obtained for check before installation. The Contractor shall also check the exact point of connection so that service for each piece of equipment may be brought to the proper location.

1.10 TEMPORARY POWER FOR CONSTRUCTION AND LIGHT

- A. The Contractor shall provide temporary power for construction and power (If and where needed). All costs associated with temporary power, such as permits, fees, etc. shall be paid by Contractor. Temporary wiring shall be maintained by Contractor in a safe operating condition for all areas where work is in progress.
- B. All temporary work shall be in accordance with the latest OSHA, State of Maryland and local authorities having jurisdiction safety requirements and shall be completely removed upon completion of the project.
- C. Permanent building power wiring and equipment can be used as temporary power for construction power and light, with the written approval from University.

1.11 ELECTRICAL SYMBOLS

- A. Electrical equipment indicated on plans by symbols shall be taken to mean a complete installed device, including all items as may be required by the NEC or any other code or standard referenced and made a part of herein.

PART 2 GENERAL

2.1 RELATED DOCUMENTS

- A. All electrical materials and equipment shall be new, shall carry a UL label when such material, equipment, and/or systems are of a type or class listed by UL and shall be suitable for the conditions and duties imposed on them. If a UL label is not available from the manufacturer when requested by owner and/or required by authorities having jurisdiction, then the equipment shall be tested by an approved electrical testing company in accordance with NEC, at no additional charge to the

Owner. Submit data indicating compliance with standards prior to installation. The description, characteristics, and requirements of materials to be used shall be in accordance with qualifying conditions established in the specifications.

- B. All component parts of each item of equipment or device shall bear the manufacturer's name plate, giving name of manufacturer, description, size, type, serial or model number, electrical characteristics, etc. in order to facilitate maintenance or replacement. The nameplate of a subcontractor or distributor shall not be acceptable.
- C. In specifying materials, three general procedures are used. The three classifications are as follows:
 - 1. Group 1: When the material or equipment is specified by name or other identifying information and one name brand only is used, it is considered that the use of that particular item is essential to the project and the Contractor shall base his proposal on the cost of that item. Where any item of material or equipment is specified by proprietary name, trade name or manufacturer, it is understood that the item named, is intended to be used.
 - 2. Group 2: When the material or equipment is specified with the phrase "or approved equal." after a brand name and other identifying information, it is intended that the brand name used is for the purpose of establishing a minimum acceptable standard of quality and performance and the Contractor may base his bid proposal on any item which is in all respects equal or better to that specified and presents essentially the same appearance, size, operation, performance, and will fit in the available space.
 - 3. Group 3: When material is specified as complying with the requirements of published "Standard Specification" of trade associations, ANSI, ASTM, government specifications, etc. the Contractor shall base his proposal on any item which can be shown to comply in all respects with the referred "Standard Specification".
- D. It is distinctly understood:
 - 1. that the Owner or their designated representative will use his own judgement in determining whether or not any materials, equipment or methods offered for approval as an equal are equal to those specified and will fit the space available.
 - 2. that the decision of the architect/engineer on all such question of equality is final
 - 3. all acceptable material, equipment or methods will be provided at no increase in cost to the Owner
- E. Upon receipt of written notice from the Owner or their designated representative that the material, equipment or methods have been reviewed and accepted (no exceptions taken or comments as noted), the Contractor may proceed with the accepted equal material, equipment or methods, providing the Contractor assumes full responsibility for and performs any change or adjustment in construction, such as clearances in accordance with NEC, Article 110 and/or as recommended by equipment manufacturer, that may be required by the use of such materials, equipment or methods, including services provided under other divisions at the Contractor's expense.

- F. In the event of adverse decisions by the Owner of their designated representative, no claim of any sort shall be made or allowed against the Architect or the Engineer or the Owner.

2.2 INSTALLATION

- A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate electrical systems, equipment, and materials installation with other building components.
 - 2. Verify all dimensions by field measurements.
 - 3. Arrange for concrete pads, chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
 - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
 - 5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
 - 7. Coordinate connection of electrical systems with exterior underground services. Comply with requirements of governing regulations, utility companies, and controlling agencies. Provide required connection for each service.
 - 8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements refer conflict to the Engineer and Owner.
 - 9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
 - 10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
 - 11. Install access panel or doors where units are concealed behind finished surfaces.
 - 12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

2.3 EQUIPMENT SUPPORTS, FOUNDATIONS AND STANDS

- A. The Contractor shall provide all supports, foundations and stands required for the electrical equipment and shall provide, align and set all necessary anchor bolts.
- B. Where equipment is indicated or specified to be floor mounted stands shall be constructed of structural steel sections (or steel pipe and fittings braced and fastened with flanges) bolted to the floor.

- C. Concrete pads shall be not less than four inches high unless otherwise indicated on drawings and shall extend minimum four (4) to six (6) inches beyond the equipment base on all sides. Exposed edges and corners shall be chamfered and exposed surfaces shall be finished smooth.
- D. All conduit penetrations through floor slabs or other fire rated walls shall be complete with fire seals as manufactured by OZ Gedney "Fire Stop" or equal UL approved.

2.4 NAMEPLATES AND LABELS

- A. All panelboards, disconnect switches, starters, VFDs, unit enclosed circuit breakers, control equipment, and instrumentation, etc. shall be provided with engraved laminated black and white phenolic nameplates with beveled trim. Data and installation shall be approved by Owner or his designated representative. Nameplate lettering shall be minimum 1/8" high etched letters. All nameplates shall be fastened with screws without altering the NEMA classification of the enclosure.
- B. All wiring in junction boxes, pull boxes, etc shall be identified as to point of origin and termination. Tagging of such circuits shall be permanent. Paper or tape tags are not acceptable.

PART 3 EXECUTION

3.1 COORDINATION OF WORK

- A. The Contractor shall have a competent foreman on the premises at all times to check, layout, and superintend the installation of the work shown on the drawings and described in these specifications. He shall provide information regarding location and sizes of chases and openings and shall be responsible for the accuracy of such information. The foreman at site shall supervise and layout the installation of all hangers, inserts, sleeves and other work in masonry and concrete in advance of and during construction, giving consideration to the work of other trades to prevent interference in the location of other equipment.
- B. Exact locations of electrical equipment, underground raceway conduits, panels, starters, disconnect switches, etc. and other electrical work shall be coordinated with all other trades and there will be no interference between the trades. Where conflicts result, they shall be resolved by the Contractor to the satisfaction of the Owner or their designated representative at no expense to the Owner.

3.2 WORKMANSHIP

- A. Workmanship shall be of the highest quality obtainable in the trade working with the materials specified. Workmanship shall be satisfactory to the Owner or his designated representative and his decision as to acceptable quality is final.
- B. All work shall be performed by skilled electricians and mechanics in the trades involved.

3.3 OVERTIME

- A. Any work required to be performed at other than normal working hours (nights, holidays, weekends, etc.) shall be taken into consideration by the Contractor when computing the bids. Extra compensation shall not be allowed to the Contractor for any work performed at other than normal working hours.

3.4 HANDLING AND STORAGE OF MATERIALS

- A. Paper and suitable tools, equipment and appliances for the safe and convenient handling and placing of all materials and equipment shall be used. During loading, unloading, and placing, care shall be taken in handling the equipment or materials, so that no equipment or materials are damaged.
- B. All electrical material and equipment delivered to the job site shall be under roof or other approved covering, on pedestals above ground. All enclosures for equipment shall be weatherproof.
- C. The Contractor shall be held accountable for all material and equipment received by him as evidenced by the list prepared by the Contractor and in the event of loss or disappearance of or damage to any such material or equipment, the Contractor shall replace such items without additional cost to the Owner.
- D. Storing and maintaining materials and equipment after receipt until the completed installation is accepted by the Owner. Such storage and maintenance shall be in accordance with the manufacturer's recommendations and the requirements of these specifications. The Contractor shall be accountable for any deterioration of materials or equipment occasioned by improper storage or maintenance and shall recondition, repair, or replace any such deteriorated materials or equipment without additional cost to the Owner.
 - 1. Electrical conduit shall be stored so as to provide protection from the weather and accidental damage. Plastic conduit shall be stored on even supports and in locations not subject to direct sun rays or excessive heat.
 - 2. Cables shall be sealed, stored and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather.
- E. Materials and equipment which are found to be defective or damaged as a result of improper handling and or storage, shall be subject to removal, at the direction of the Owner or his designated representative and replaced with new materials and equipment with no additional cost to the Owner.

3.5 EQUIPMENT CONNECTIONS

- A. All equipment requiring electrical service shall be installed and connected in accordance with the latest codes, contract documents, the best engineering practices and in accordance with manufacturer's recommendations.
- B. Equipment connections indicated on drawings shall be considered diagrammatic. The actual connections shall be made to best suit the requirements of each case and to minimize the space used.

- C. All conduits, outlets, wiring and all necessary fittings or accessories for connections to all electrical equipment shall be provided. All equipment ratings shown on the drawings are for the specified equipment. Should equipment of different ratings be furnished, all circuit components shall be adjusted accordingly, at the Contractor's expense, after approval by the Owner or his designed representative. The Contractor shall be responsible for confirming the proper size and location of each equipment connection before fabrication and installation of work.

3.6 WATERPROOFING

- A. All waterproofing and damp-proofing of the building shall be held unharmed by the installation of work under this division. Wherever any of the work or conduits under this division penetrate waterproofing and damp-proofing, including outside walls, such penetrations shall be made only when approved by the Owner or their designated representative and the pierced surface shall be made watertight. Any waterproofing damaged or destroyed shall be replaced at the Contractor's expense.

3.7 CUTTING, PATCHING AND PAINTING

- A. All cutting, patching and painting necessary for the installation of the electrical work shall be done under Division 02. Any damage done to work already in place shall be redone at the Contractor's expense. Patching shall be uniform in appearance and shall match surrounding surfaces. Painting, wherever required, shall match existing paint.
- B. All exposed equipment, including conduit installed under this Division, shall be cleaned and left in a condition ready for painting. All items not provided with a corrosion-resistant finish shall be painted. Unless otherwise directed by owner, all electrical panels, control equipment, and supporting framework, except as indicated otherwise, shall have a light gray enamel finish which may be the manufacturer's standard gray, if acceptable to Owner. Where the finish becomes scratched or marred, it shall be touched up or repainted to match the original finish as directed by the construction manager. Particular caution shall be exercised so as not to obscure the nameplate.

3.8 SLEEVES AND PLATES

- A. 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.
- B. Sleeves shall be provided for all conduit, etc. passing through concrete, masonry, construction. Caulk the annular space of sleeves with an elastic fire resistant caulking compound to make installation fire, air and watertight.
- C. 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.

- D. At all sleeves where objectionable noise can be transmitted, at smoke barriers, at walls above ceilings that extend to underside of the structure of floor above, or at fire rated separations, seal all openings between conduit, etc. and corresponding sleeves to prevent sound transmission and to maintain fire rating. Use UL approved resilient sealant for penetration seals. Submit method of sealing for approval. Where watertight sleeves are indicated or required to suite the installation, provide Link Seal rubber seals as manufactured by Thunderline Corporation, between pipe and sleeves.
- E. Where conduit motion due to expansion and contraction will occur, make sleeves of sufficient diameter to permit free movement of conduit. Check construction to determine proper length for various locations; make actual lengths to suite conditions.

3.9 EXCAVATING AND BACKFILLING

- A. Not used.

3.10 GROUNDING

- A. The entire electrical installation shall be grounded in accordance with Article 250 of the National Electrical Code, National Electrical Safety Code, IEEE recommendations, and Underwriters Laboratories, Inc., latest editions.

3.11 TESTING AND INSPECTIONS

- A. Low Voltage Testing (600 Volt Or Less)
 - 1. Upon completion of the work, the contractor shall in the presence of the owner and engineer, operate, test, adjust, and retest if necessary, the complete electrical systems. All systems shall function fully and complete as intended in design, and are ready to be occupied.
 - 2. The contractor shall furnish all labor, materials, supplies, equipment, instruments, and power necessary for measurements, testing and settings as required. The measurement, testing and setting shall demonstrate:
 - a. That all the lighting, power, and control circuits are continuous and free from short circuits and other defects.
 - b. That all the circuits are free from unspecified grounds
 - c. That all circuits and equipment are properly connected in accordance with applicable wiring diagrams and are operable by demonstrating the functioning of each control device not less than ten (10) times and by continuous operation of each circuit for not less than one half hour.
 - d. Measure the ground resistance of the electrical installations of grounding systems. The ground resistance shall not exceed 3 ohms as specified in Section 260526.
 - e. Any other testing required under other section of Division 26 work.
 - f. Make tests of each motor provided under Mechanical Division to measure the actual service parameters while the motor is operating at design duty conditions, including steady state full load amperes (FLA), voltage and power factor.
 - g. Results of the above tests shall show the all the equipment and wiring meets the requirements of these specifications before being accepted by the

engineer and owner. Should any of the above tests indicate defects in materials or workmanship, the faulty installation shall be repaired or replaced at once and the tests be re-conducted at contractor's expense.

- h. Operational Tests: the contractor shall note that certain other sections of these specifications require tests of the operation of various items of equipment. He shall familiarize himself with these requirements and where electrical controls are involved, in any of these tests, he shall furnish any services or materials required to make any electrical performance tests required.
- 3. All defects shall be repaired at once and tests re-conducted at contractor's expense.
- 4. For the purpose of these tests, normal and emergency conditions may be simulated during these tests if approved by the Engineer. The services of the manufacturer's factory trained service engineer shall be provided to inspect the installation of all equipment furnished under this division to assure that is installed in accordance with the manufacturer's instructions, assist with start up and instruct operating personnel in the operation and maintenance of the equipment.

B. Inspection

- 1. All phases of the work shall be inspected by a testing/inspection agency (Third party inspection), as specified in each section of the specifications.
- 2. An electrical certificate from the County inspection agency must be submitted to the owner prior to or with the final payment invoice. The electrical sub-contractor shall file with county permit department and pay all fees associated with such filing, at the start of construction so that adequate rough-in inspections can be made during the course of work.
- 3. Submit all inspection reports within 7 days from the inspection, specifically for all feeder installations, all panelboards, starters etc.

3.12 FIELD QUALITY CONTROL

A. Perform indicated tests to demonstrate workmanship, operation, and performance.

- 1. Conduct tests in presence of Owner or his Representative and, if required, inspectors of agencies having jurisdiction.
- 2. Arrange date of tests in advance with Owner, manufacturer and installer.
- 3. Give all inspectors minimum of one week notice.
- 4. Furnish all labor and materials required for period of test.

B. Repair or replace equipment and systems found inoperative or defective and retest.

- 1. If equipment or system fails retest, replace it with products which conform with Contract Documents.
- 2. Continue remedial measures and retests until satisfactory results are obtained.

C. Test equipment and systems as indicated for each item, unless otherwise recommended by manufacturer.

D. Coordinate work of this section with work of other sections to insure timely delivery and installation of work.

3.13 ADJUST AND CLEAN (SEE DIVISION 01)

- A. Inspect all equipment and put in good working order. Clean all exposed and concealed items.

END OF SECTION 260160

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 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.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. EPDM: Ethylene-propylene-diene monomer rubber.
- C. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

- A. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."

1.6 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 connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
 - 5. Design sufficient access and working space for repair and maintenance about all electrical equipment to permit ready and safe operation and maintenance of such equipment, as per OSHA 29 CFR 1910 Subpart D and 1910.303(g).
- B. Coordinate installation of required supporting devices and set sleeves in the existing cast-in-place concrete, masonry walls, and other existing structural components.

- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Panels."
- D. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to 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, manufacturers specified.

2.2 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 078413 "Penetration Firestopping."

2.3 SLEEVE SEALS

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

PART 3 EXECUTION

3.1 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 to raceways and piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, etc. 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 Section 078413 "Penetration Firestopping."
- C. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used.
- D. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- E. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 - 2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- F. 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.
- G. Cut sleeves to length for mounting flush with both surfaces of walls.
- H. Extend sleeves installed in floors 2 inches above finished floor level.
- I. Size pipe and sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed

- J. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- K. 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 Section 079200 "Joint Sealants" for materials and installation.
- L. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with Section 078413 "Penetration Firestopping."
- M. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

3.3 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.

3.4 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Section 078413 "Penetration Firestopping."

3.5 FIELD QUALITY CONTROL

- A. Inspect installed sleeve and sleeve-seal installations and associated firestopping for damage and faulty work.

END OF SECTION 260500

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene monomer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For testing agency.
- C. Field quality-control test reports: From a qualified testing and inspection agency engaged by the contractor.

1.5 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 Owner, and marked for intended use.
- C. Comply with NFPA 70.

PART 2 PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Southwire Company
 - 2. General Cable Corporation.
- B. Copper Conductors: Comply with NEMA WC 70. Aluminum conductors are not acceptable.
- C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN rated at 90 degrees C.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; EGS Electrical Group LLC.
 - 4. 3M; Electrical Products Division.
 - 5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-THWN, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.

- D. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- F. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- G. Class 2 Control Circuits: Type THHN-THWN, in raceway.
- H. MC Cable: MC Cable not allowed for this project.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. All wiring will be provided in the exposed raceways, unless otherwise indicated.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
- D. Install exposed raceways with cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- G. No MC Cables allowed for this project.

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors. No aluminum allowed.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Refer to Section 260500.

3.6 SLEEVE-SEAL INSTALLATION

- A. Refer to Section 260500.

3.7 FIRESTOPPING

- A. Refer to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor to engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Perform tests and inspections and prepare test reports.
- C. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- D. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control test reports.

1.4 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

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

2.2 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.

PART 3 EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Conductor Terminations and Connections:
 - 1. Connections to all receptacles: Connect to green grounding screw.

3.2 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. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
- C. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

3.3 INSTALLATION

- A. 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.
- B. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

3.4 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:

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Equipment supports.

- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

PART 2 PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - (1) Hilti Inc.
 - (2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - (3) MKT Fastening, LLC.
 - (4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - (1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - (2) Empire Tool and Manufacturing Co., Inc.
 - (3) Hilti Inc.
 - (4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - (5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 for steel shapes and plates.

PART 3 EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated from slotted steel support system, sized to enable capacity to be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - 6. To Light Steel: Sheet metal screws.
 - 7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 for site-fabricated metal supports.

- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touchup: Comply with requirements in Division 09 for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

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SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. IMC: Intermediate metal conduit.
- D. LFMC: Liquid-tight flexible metal conduit.
- E. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Custom enclosures and cabinets.
- C. Qualification Data: For professional engineer and testing agency.
- D. Source quality-control test reports.

1.5 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.

PART 2 PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Alflec Inc.
 - 3. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 4. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 5. Electri-Flex Co.
 - 6. O-Z Gedney; a unit of General Signal.
 - 7. Wheatland Tube Company.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. IMC: ANSI C80.6.
- D. EMT: ANSI C80.3.
- E. FMC: Zinc-coated steel.
- F. LFMC: Flexible steel conduit with PVC jacket.
- G. Fittings for Conduit (Including all Types and Flexible and Liquid-tight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Fittings for EMT: Compression type. Screw type not accepted.
- H. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 - 2. EGS/Appleton Electric.
 - 3. Erickson Electrical Equipment Company.
 - 4. Hoffman.
 - 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 - 6. RACO; a Hubbell Company.
 - 7. Thomas & Betts Corporation.
 - 8. Walker Systems, Inc.; Wiremold Company (The).
 - 9. 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, ferrous alloy, Type FD, with gasketed cover.

- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.
- F. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
- G. Cabinets:
 - 1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.

PART 3 EXECUTION

3.1 RACEWAY APPLICATION

- A. Comply with the following indoor applications, unless otherwise indicated:
 - 1. Exposed (used and located only 8 feet above finished floor) and not Subject to Physical Damage: EMT.
 - 2. Exposed (used and located within 8 feet above finished floor) and Subject to Severe Physical Damage: Rigid steel conduit
 - a. Mechanical rooms: EMT may be used in the mechanical rooms when located 8 feet above floor level provided that is not subject to physical damage such as near operable valve handles etc. In such cases where the raceways are subject to physical damage even above 8 feet above finished floor, such raceways shall be galvanized rigid steel raceways. All raceways within 8 feet shall be rigid steel conduits.
 - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 - 4. Damp or Wet Locations: Rigid steel conduit.
 - 5. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.
- B. Minimum Raceway Size: 3/4-inch (21-mm) trade size.
- C. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
- D. Do not install aluminum conduits. Aluminum raceways are not acceptable.

3.2 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- E. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- F. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- G. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- H. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
- I. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where otherwise required by NFPA 70.
- J. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 1. Use LFMC in damp or wet locations subject to severe physical damage.
 - 2. Use LFMC damp or wet locations not subject to severe physical damage.
- K. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Refer to Section 260500.

3.4 SLEEVE-SEAL INSTALLATION

- A. Refer to Section 260500.

3.5 FIRESTOPPING

- A. Refer to Section 078413 "Penetration Firestopping."

3.6 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.

END OF SECTION 260533

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SECTION 260553 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Identification for raceway and metal-clad cable.
 - 2. Identification for conductors and communication and control cable.
 - 3. Warning labels and signs.
 - 4. Instruction signs.
 - 5. Equipment identification labels.
 - 6. Miscellaneous identification products.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

1.5 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

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Color for Printed Legend:
 - 1. Power Circuits: Black letters on an orange field.
 - 2. Legend: Indicate system or service and voltage, if applicable.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch- (0.35-mm-) thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
- D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking nylon tie fastener.
- E. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.3 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. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).
- E. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.4 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) 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.

2.5 EQUIPMENT IDENTIFICATION LABELS

- A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with black letters on a white background. Minimum letter height shall be 3/8 inch (10 mm).
- B. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. Black letters on a white background. Minimum letter height shall be 3/8 inch (10 mm).
- C. Stenciled Legend: In nonfading, waterproof black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.6 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 (5 mm).

2. Tensile Strength: 50 lb (22.6 kg), minimum.
 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 4. Color: Black, except where used for color-coding.
- B. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.
1. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):
 - a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
 - (1) Primer: Interior concrete and masonry primer.
 - (2) Finish Coats: Interior semigloss alkyd enamel.
 2. Interior Concrete Unit Masonry:
 - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
 - (1) Block Filler: Concrete unit masonry block filler.
 - (2) Finish Coats: Interior semigloss acrylic enamel.
 3. Interior Gypsum Board:
 - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - (1) Primer: Interior gypsum board primer.
 - (2) Finish Coats: Interior semigloss acrylic enamel.
 4. Interior Ferrous Metal:
 - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - (1) Primer: Interior ferrous-metal primer.
 - (2) Finish Coats: Interior semigloss acrylic enamel.
 5. Interior Zinc-Coated Metal (except Raceways):
 - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - (1) Primer: Interior zinc-coated metal primer.
 - (2) Finish Coats: Interior semigloss acrylic enamel.
- C. 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

3.1 APPLICATION

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identify with orange self-adhesive vinyl tape applied in bands.
- B. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, snap-around, color-coding bands:
1. Fire Alarm System: Red.
 2. Fire-Suppression Supervisory and Control System: Red and yellow.
 3. Mechanical and Electrical Supervisory System: Green and blue.
 4. Telecommunication System: Green and yellow.
 5. Control Wiring: Green and red.
- C. Power-Circuit Conductor Identification: For secondary conductors No. 1/0 AWG and larger in pull- and junction-boxes use color-coding conductor tape. Identify

source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

- 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. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- G. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels with metal-backed, butyrate warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
 - 1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
 - a. Controls with external control power connections.
 - 2. 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.
- H. Instruction Signs:
 - 1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- I. 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, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 - 1. Labeling Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where 2 lines of text are required, use labels 2 inches (50 mm) high.

- b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
- 2. Equipment to Be Labeled for engraved laminated acrylic tags:
 - a. Panelboards, electrical cabinets, and enclosures.
 - b. Access doors and panels for concealed electrical items.
 - c. Disconnect switches.
 - d. Enclosed circuit breakers.
 - e. Motor starters.
 - f. Push-button stations.

3.2 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 non-adhesive 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 (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- G. Color-Coding for Phase Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - 1. Color shall be factory applied or, for sizes larger than No. 10 AWG
 - 2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White
 - 3. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

- I. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

END OF SECTION 260553

SECTION 260810 - INSPECTIONS, TESTING AND START-UP

PART 1 GENERAL

1.1 DESCRIPTION

- A. The intent of the inspection, testing, and check-out work specified herein is to insure that all electrical workmanship and equipment, whether Owner furnished or Contractor furnished, is installed and performs in accordance with the Contract Documents, manufacturer's instructions and all applicable codes and requirements. Also, it is intended to insure the following:
1. Equipment has not been subjected to damage during shipment or installation.
 2. Equipment is in accordance with the specifications.
 3. A bench mark is established for routine maintenance and troubleshooting.
 4. Successful start-up without last minute interruptions and delays.
 5. Each system component is installed satisfactorily and will perform its function reliably throughout the life of the plant.
- B. Testing requirements in other sections of this Specification are intended to compliment and not supersede nor be superseded by this Section.

1.2 RELATED SECTIONS

- A. Section 013300 for Submittal Procedures.
- B. Division 26 - Electrical Specifications.

1.3 REFERENCES

- A. American National Standards Institute (ANSI)
1. ANSI C2, National Electrical Safety Code
 2. ANSI Z244-1, American National Standard for Personnel Protection
- B. American Society of Testing and Materials (ASTM)
- C. Institute of Electrical and Electronic Engineers (IEEE)
- D. Insulated Cable Engineers Association (ICEA)
- E. International Electrical Testing Association (NETA)
- F. National Electrical Manufacturer's Association (NEMA)
- G. National Fire Protection Association (NFPA)
1. ANSI/NFPA 70, National Electrical Code
 2. ANSI/NFPA 70B, Electrical Equipment Maintenance
 3. ANSI/NFPA 70E, Standard for Electrical Safety in the Workplace

H. Occupational Safety and Health Administration (OSHA)

I. State and Local Codes and Ordinances

1.4 SUBMITTALS

A. Provide resumes for personnel conducting tests and evidence of the testing firm's qualifications, accreditation and experience.

B. Provide a list of test equipment to be utilized including the manufacturer's name, model number, serial number, accuracy, and last date of calibration.

C. Provide industry standards or guide specifications used in lieu of National Standards.

D. Provide testing procedures and schedules.

1.5 TESTING FIRM

A. The testing firm shall be a competent, independent electrical equipment testing laboratory or organization. The testing firm shall not be a subsidiary, division, nor a department of either the installing Contractor or the manufacturer of the equipment materials or systems being inspected and tested. The testing firm shall be a fully accredited member of the International Electrical Testing Association (NETA) and have the specialized experience and skill in the supervision and performance of all inspection and testing specified herein.

1.6 TEST INSTRUMENT CALIBRATION

A. The testing firm shall have a calibration program which assures that all applicable test instrumentation is maintained within rated accuracy.

B. The accuracy shall be directly traceable to the National Bureau of Standards.

C. Instruments shall be calibrated in accordance with the following frequency schedule:

1. Field instruments, analog: six (6) months.
2. Field instruments, digital: twelve (12) months.
3. Laboratory instruments: 12 months.
4. Leased specialty equipment: 12 months.

D. Calibration labels shall be visible on all equipment and shall have a date of calibration and due date. Calibration records shall be available for review by the Owner.

PART 2 PRODUCTS

Not Applicable

PART 3 EXECUTION

3.1 COORDINATION

- A. Provide all necessary supervision and labor, materials, tools, test instruments and other equipment or services required to inspect, test, adjust, set, calibrate, functionally and operationally check all work and equipment.
- B. Provide a set of contract documents to the testing firm providing the tests.
- C. Provide the testing firm a set of approved submittals and shop drawings for the equipment to be tested by the testing firm.
- D. Prepare procedures and schedules for all inspections, tests, settings and calibrations specified or otherwise required. The procedures must provide specific instructions for the checking and testing of each component in addition to the system functional checks. All procedures submitted shall include proposed job safety rules.
- E. Provide a suitable and stable source of electrical power to each test site. The testing firm shall specify the specific power requirements. The Owner shall approve all sources of electrical power for testing.
- F. Notify the Owner prior to the commencement of any testing.

3.2 INSPECTIONS AND TESTS

- A. Equipment purchased by the Contractor or purchased by the Owner but installed by the Contractor shall be inspected and tested to determine its condition.
- B. The inspections, tests and checks described herein shall not be considered as complete and all inclusive. Additional normal standard construction (and sometimes repetitive) checks and tests shall be provided as necessary throughout the project, prior to final acceptance by the Owner.
- C. At any stage of construction and when observed, any electrical equipment or system determined to be damaged, faulty, or requiring repairs shall be reported to the Owner. Corrective action may require prior approval.
- D. Perform routine insulation resistance, continuity and phase rotation tests for all distribution and utilization equipment prior to and in addition to tests performed by the testing firm specified herein.
- E. The testing firm shall provide visual and mechanical inspections of the following systems and equipment.
 - 1. Panelboards
 - 2. Low voltage wiring (600 volt and below)
 - 3. Molded case circuit breakers rated less than 400 amperes
 - 4. Motor controls & Controllers
 - 5. Variable Frequency Controllers
 - 6. Disconnect switches.

- F. All circuit breakers and protective devices shall be set and tested at the settings specified in the approved protective device coordination study. All fuses shall be selected and installed in accordance with the approved coordination study, where applicable.
- G. The rotation of all motors shall be checked and corrective action shall be taken where necessary to obtain correct rotation.
- H. Engagement of the testing firm in no way relieves the Contractor of the responsibility for the performance of the many and varied tests, checkouts, and inspections required during the various stages of construction.

3.3 CERTIFICATION

- A. Provide certified test reports. Test reports shall meet the criteria specified in OSHA Regulation Part 1907, "Accreditation of Testing Laboratories". The certification shall attest to the fact that the electrical installation has been installed and tested in accordance with the applicable National Standards or, where no National Standard exists, the applicable industry standard or guide specification for the equipment involved.
- B. The following information shall be included in the test reports.
 - 1. Description of equipment tested (manufacturer, model number, serial number).
 - 2. Description of test and standards used.
 - 3. Description of test equipment.
 - 4. Test results with pass/fail criteria.
 - 5. Conclusions and recommendations.
 - 6. Names of personnel conducting the test.
- C. The report shall be signed by a Registered Professional Engineer.
- D. Provide three (3) copies of the complete test report no later than fifteen (15) calendar days following completion of the tests.

END OF SECTION 260810

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Relay Panels.

1.3 DEFINITIONS

- A. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

- A. Product Data: For each type of panelboard, switching and 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. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 6. Include wiring diagrams for power, signal, and control wiring.
- C. Field Quality-Control Reports:
 - 1. Test procedures: Test results that comply with requirements.
 - 2. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Panelboard Schedules: For installation in panelboards.
- E. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. 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 that allows adjustments.

1.5 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. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1, "Panelboards."
- E. Comply with NFPA 70, "National Electrical Code."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations:
 1. Do not deliver or install panelboards until spaces are enclosed and weather-tight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 1. Ambient temperatures within limits specified.
 2. Altitude not exceeding 6600 feet.

1.8 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, encumbrances to workspace clearance

requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Keys: Two spares for each type of panelboard cabinet lock.
 - 2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP)
Types and shunt trip devices: Two spares for each panelboard.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Enclosures: Surface-mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - c. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 4. Coordinate with Drawings.
Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 - 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 - 6. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pre-treating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Same finish as panels and trim.
 - 7. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- B. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Ground and neutral buses in lighting and appliance panelboards are also referred to as "bars" in manufacturers' literature. Coordinate with Drawings.
 - 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 5. Extra-Capacity Neutral Bus: As suitable for nonlinear loads where indicated on the drawings.
- C. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Main and Neutral Lugs: Mechanical type.
 3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
 4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 5. Sub feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- D. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- E. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Series rated panelboards will not be accepted.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Square D; a brand of Schneider Electric.
 2. Siemens
 3. Eaton
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- E. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.

- b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
- c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
- d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
- e. Shunt Trip: 120 -V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
- f. Under-voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- C. Mount top of trim 78 inches above finished floor unless otherwise indicated.
- D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- E. Install overcurrent protective devices and controllers not already factory installed.
- F. Install filler plates in unused spaces.
- G. Comply with NECA 1, "Standard Practice for Good Workmanship in Electrical Construction."

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Panelboard directories shall be corrected and re-created after balancing the loads to meet the specifications requirements and shall match with the actual loads in the field. A copy of the panelboard schedule from the construction documents will not be acceptable.

3.4 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. 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. Panelboards will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to program, monitor, adjust, and operate the equipment. Refer to Section 017900 "Demonstration and Training."

3.6 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
 - 1. Fusible switches.
 - 2. Non-fusible switches.
 - 3. Molded-case circuit breakers.
 - 4. Enclosures.

1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.
- B. HD: Heavy duty.
- C. RMS: Root mean square.

1.4 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, 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. Manufacturer's field service report.

- F. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Sections, include the following:
 - 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - 2. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 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 and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items.

1.6 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, 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.

PART 2 PRODUCTS

2.1 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.

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Manufacturers:
 - 1. Square D/Group Schneider
 - 2. Eaton Corporation; Cutler-Hammer Products.
 - 3. Siemens

- 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. Non-fusible Switch, 600A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- D. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and neutral conductors.
 - 3. All disconnect switches used (in series with VFC) shall have auxiliary dry contacts in the disconnect switches and shall be wired to VFC. Provide control wires between VFC and disconnect switches to protect VFC.

2.3 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

- A. Manufacturers:
 - 1. Square D/Group Schneider
 - 2. Eaton Corporation; Cutler-Hammer Products.
 - 3. Siemens.
- B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

2.4 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
 - 1. Outdoor Locations: NEMA 250, Type 4
 - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.
- C. Comply with mounting and anchoring requirements specified in Section 260529 "Hangers and Supports for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 260553 "Identification for Electrical Systems."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.
- B. 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.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:
 - 1. Test mounting and anchorage devices according to requirements in Section 260529 "Hangers and Supports for Electrical Systems."
 - 2. 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.
 - 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - a. Instruments, Equipment and Reports:
 - (1) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of

deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.6 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 262816

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SECTION 262913 - ENCLOSED CONTROLLERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes ac, enclosed controllers rated 600 V and less, of the following types:
 - 1. Across-the-line, manual and magnetic controllers.

1.3 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each enclosed controller.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current rating of integrated unit.
 - d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
 - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around enclosed controllers where pipe and ducts are prohibited. Show enclosed controller layout and relationships between electrical components, and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- D. Qualification Data: For manufacturer and testing agency.
- E. Field quality-control test reports.

- F. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017800 "Operation and Maintenance Data," include the following:
 - 1. Routine maintenance requirements for enclosed controllers and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- G. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles (160 km) of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. 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.
- C. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.
- 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 NFPA 70.
- F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.6 COORDINATION

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.
- C. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.7 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. Indicating Lights: Two of each type installed.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Square D.
 - 2. Eaton Corporation; Cutler-Hammer Products.
 - 3. Siemens.

2.2 ACROSS-THE-LINE ENCLOSED CONTROLLERS

- A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."
 - 1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.
- B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated.

1. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
 2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
 3. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 20 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
- C. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch.
1. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

2.3 ENCLOSURES

- A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
1. Outdoor Locations: NEMA 250, Type 4 Stainless Steel
 2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4 Stainless Steel

2.4 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Control Relays: Auxiliary and adjustable time-delay relays.
- D. Elapsed Time Meters: Heavy duty with digital readout in hours.
- E. Phase-Failure and Under-voltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable under voltage setting.

2.5 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosed controllers before shipping.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances, and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

- A. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- B. Comply with mounting and anchoring requirements specified in Section 260529 "Hangers and Supports for Electrical Systems."

3.4 IDENTIFICATION

- A. Identify enclosed controller, components, and control wiring according to Section 260553 "Identification for Electrical Systems."

3.5 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
 - 2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation
 - 2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers
 - 3. Report results in writing.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS, Motor Control - Motor Starters. 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.

3.8 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.9 DEMONSTRATION

- A. Refer to Section 018200 "Demonstration and Training" for training requirements for Owner's maintenance personnel and building occupants.

END OF SECTION 262913

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Interior solid-state luminaires that use LED technology.
- 2. Lighting fixture supports.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire or both.
- G. Luminaire: Complete lighting unit, including LEDs engine, LED driver, reflector, and housing complete working unit ready to be installed.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Arrange in order of luminaire designation.
 - 2. Include data on features, accessories, and finishes.
 - 3. Include physical description and dimensions of luminaires.
 - 4. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
 - 5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project IES LM-79 and IES LM-80.

- a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
- B. Shop Drawings: For non-standard or custom luminaires.
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, all required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing laboratory providing photometric data for luminaires.
- B. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Product Certificates: For each type of luminaire.
- D. Product Test Reports: For each luminaire, for tests performed by a qualified testing agency.
- E. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable temporary protective covering before shipping.

1.9 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. Recessed Fixtures: Comply with NEMA LE 4.
- E. Bulb shape complying with ANSI C79.1.
- F. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- G. CRI of minimum 80. CCT of 3500K
- H. Rated lamp life of 50,000 hours.
- I. Internal driver.
- J. Nominal Operating Voltage: 120 V ac
- K. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
- L. Housings:
 - 1. Extruded-aluminum housing and heat sink.

2. Finish as indicated in the lighting fixture schedule

2.2 LINEAR INDUSTRIAL

- A. Manufacturers: Refer to lighting fixture schedule
- B. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Housing and heat sink rated to the following:
 1. Class 1, Division 2 Group(s) [A] [B] [C] [and] [D].
 2. NEMA 4X.
 3. IP 54.
 4. IP 66.
 5. Marine and wet locations.
 6. CSA C22.2 No 137.

2.3 SURFACE MOUNT, LINEAR

- A. Minimum 1500 lumens. Minimum allowable efficacy of 80 lumens per watt.
- B. Integral junction box with conduit fittings.

2.4 SURFACE MOUNT, NONLINEAR

- A. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.
- B. Integral junction box with conduit fittings.

2.5 MATERIALS

- A. Metal Parts:
 1. Free of burrs and sharp corners and edges.
 2. Sheet metal components shall be steel unless otherwise indicated.
 3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.
- C. Diffusers and Globes:
 1. prismatic acrylic and/or clear, UV-stabilized acrylic as indicated in the lighting fixture schedule
 2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 3. Glass: Annealed crystal glass unless otherwise indicated.
 4. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Finish: As indicated in the lighting fixture schedule

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage, and coating.
 - c. CCT and CRI for all luminaires.

2.6 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.7 LUMINAIRE FIXTURE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm)
- D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and re-lamping.
 - 3. Provide support for luminaire without causing deflection of ceiling or wall.
 - 4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.
- E. Suspended Luminaire Support:
 - 1. Pendants and Rods: Where longer than 48 inches brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
 - 3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and rod for suspension for each unit length of luminaire chassis, including one at each end.
 - 4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
- F. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 265119