

SECTION 15512 - CAST-IRON BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes packaged, factory-fabricated, gas-fired, cast-iron boilers, trim, and accessories for generating hot water.

1.3 SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other Work.
 - 1. Wiring Diagrams: Detail power, signal, and control wiring.
- C. Source quality-control test reports.
- D. Startup service reports.
- E. Operation and Maintenance Data: For cast-iron boilers to include in emergency, operation, and maintenance manuals.
- F. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of cast-iron boilers and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- 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. ASME Compliance: Fabricate and label cast-iron boilers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. ASHRAE/IESNA 90.1 Compliance: Cast-iron boilers shall have minimum efficiency according to Table 10-8.

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- E. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
- F. I=B=R Compliance: Cast-iron boilers shall be tested and rated according to HI's "Testing and Rating Standard for Heating Boilers," with I=B=R emblem on a nameplate affixed to boiler.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace controls and heat exchangers of cast-iron boilers that fail in materials or workmanship within specified warranty period.
- B. Warranty Period for Controls: Two years from date of Substantial Completion.
- C. Warranty Period for Heat Exchangers: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Hydrotherm, Inc./Mestek, Inc.
 - 2. Lennox Industries Inc.
 - 3. Smith Cast Iron Boilers.
 - 4. Weil-McLain; a United Dominion Company.

2.2 PACKAGED CAST-IRON BOILERS

- A. Description: Factory-fabricated, -assembled, and -tested cast-iron boiler with cast-iron sections sealed pressure-tight, set on an insulated steel base, and held together with tie rods; including insulated jacket and flue-gas vent connection.
- B. Maximum Pressure Rating: Water, 30 psig (210 kPa).
- C. Fabricate base and attachment to pressure vessel with reinforcement strong enough to resist boiler movement during a seismic event when boiler base is anchored to building structure.
- D. Boiler Characteristics and Capacities:
 - 1. Refer to boiler schedule on drawing.

2.3 COMPONENTS

- A. Cast-Iron Section Design: Wet leg, multiple pass, joined using high-temperature sealant to seal flue-gas passages not in contact with heating medium, tapered cast-iron push nipples, and held together with tie rods. Drain and blowdown tappings.
 - 1. Return injection tube to equalize water flow to all sections.
 - 2. Crown inspection tappings with brass plugs.
 - 3. Built-in air separator.
- B. Combustion Chamber: Equipped with flame observation ports, front and back. Seal flue-gas passages between cast-iron sections with fiber rope and high-temperature sealant.
- C. Casing:
 - 1. Jacket: Sheet metal, with snap-in or interlocking closures and powder-coated protective finish.
 - 2. Insulation: Minimum 1-inch- (25-mm-) thick fiberglass insulation surrounding the heat exchanger.
 - 3. Access: For cleaning between cast-iron sections.
 - 4. Draft Hood: Flue canopy and top flue connection shall be constructed of aluminized steel containing adjustable outlet damper assembly.
 - 5. Insulated base constructed of aluminized steel to permit boiler to be installed on combustible floor.
 - 6. Mounting base to secure boiler to concrete base.
 - 7. Control Cabinet: Sheet metal casing shall cover all controls, gas train, and burner.
- D. Draft Diverter: Separate galvanized-steel assembly.

2.4 ATMOSPHERIC GAS BURNER

- A. Burner Tubes and Orifices: Stainless steel for natural gas.
- B. Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
- C. Pilot: Intermittent-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

2.5 HOT-WATER BOILER TRIM

- A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."
- B. Aquastat Controllers: Operating and high limit.
- C. Safety Relief Valve: ASME rated. 30 psig (210 kPa).
- D. Boiler Air Vent: Automatic.

- E. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

2.6 BURNER OPERATING CONTROLS

- A. Description: To maintain safe operating conditions, burner safety controls limit the operation of burner.
 - 1. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
 - 2. Rollout Safety Switch: Factory mounted on boiler combustion chamber.

2.7 BOILER OPERATING CONTROLS

- A. Refer to Division 15 Section "HVAC Instrumentation and Controls."
- B. Boiler operating controls shall include the following devices and features:
 - 1. Control Transformer: 115 V.
 - 2. Motorized Vent Damper: Interlocked with burner to open before burner is operating. If damper fails to open, stop burner operation.
 - 3. Operating Pressure Control: Factory wired and mounted to cycle burner.
 - 4. Sequence of Operation: Electric, factory-fabricated, and field-installed panel to control burner firing rate to maintain a constant discharge water temperature.
- C. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control hot-water set point and display boiler status and alarms.

2.8 VENTING KITS

- A. Vent Damper: Motorized, 24-V ac, UL listed for use with standing pilot or intermittent ignition on atmospheric burner boiler equipped with draft hood. Interlock with burner.

2.9 SOURCE QUALITY CONTROL

- A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code: Section IV.
- B. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- C. Allow Owner access to source quality-control testing of cast-iron boilers. Notify Contracting Officer 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
 - 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Install boilers level on concrete base. Concrete base is specified in Division 15 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.
- B. Concrete Bases: Anchor boilers to concrete base.
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 5. Cast-in-place concrete materials and placement requirements are specified in Division 3.
- C. Install gas-fired boilers according to NFPA 54.
- D. Assemble and install boiler trim.
- E. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect gas piping full size to boiler gas-train inlet with union.
- C. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
- D. Install piping from safety relief valves to nearest floor drain.

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- E. Connect breeching full size to boiler outlet. Refer to Division 15 Section "Breechings, Chimneys, and Stacks" for venting materials.
- F. Install piping adjacent to boiler to allow service and maintenance.
- G. Ground equipment according to Division 16 Section "Grounding and Bonding."
- H. Connect wiring according to Division 16 Section "Conductors and Cables."
- I. 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.

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to test, inspect, and adjust boiler components and equipment installation and to perform startup service.
- B. Perform installation and startup checks according to manufacturer's written instructions.
- C. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
- D. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
- E. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen, and carbon monoxide in flue gas and to achieve combustion efficiency.
- G. Adjust initial temperature set points.
- H. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- I. Prepare written report that documents testing procedures and results.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cast-iron boilers. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 15512

SECTION 15550 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:

- 1. Listed double-wall vents.

1.3 SUBMITTALS

- A. Product Data: For the following:

- 1. Type B vents.

- B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.

- 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.

- C. Welding certificates.

- D. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

- B. Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

- C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified

warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

- B. Warranty Period: 10 years from date of Substantial Completion.

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, the manufacturers specified.

2.2 LISTED TYPE B VENTS

- A. Available Manufacturers:

1. Hart & Cooley, Inc.
2. Heat-Fab Inc.
3. Metal-Fab, Inc.
4. Selkirk Inc.; Selkirk Metalbestos and Air Mate.

- B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B; with neutral or negative flue pressure complying with NFPA 211 and suitable for certified gas-fired appliances.

- C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.

- D. Inner Shell: ASTM A 666, Type 430 stainless steel.

- E. Outer Jacket: Galvanized steel.

- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude 90 percent of rainfall.

2.3 GUYING AND BRACING MATERIALS

- A. Cable: Three galvanized, stranded wires of the following thickness:

1. For ID Sizes 4 to 15 Inches (100 to 381 mm): 5/16 inch (8 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF LISTED VENTS AND CHIMNEYS

- A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
- B. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
- D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
- E. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.
- F. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.
- G. Erect stacks plumb to finished tolerance of no more than 1 inch (25 mm) out of plumb from top to bottom.

3.3 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.
- B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.
- C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 15550

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SECTION 15710 - HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes shell-and-tube heat exchangers and plate heat exchangers for HVAC applications.

1.3 SUBMITTALS

- A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each type of product indicated. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- B. Maintenance Data: For heat exchangers to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."
- B. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Shell-and-Tube Heat Exchangers:
 - a. Amtrol, Inc.
 - b. Armstrong Fluid Handling; Div. of Armstrong International, Inc.
 - c. Baltimore Aircoil Co.

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- d. Dunham-Bush, Inc.
- e. ITT Fluid Handling; Div. of ITT Fluid Technology Corp.
- f. Patterson-Kelley Co.; Div. of Harsco Corp.
- g. Taco, Inc.

2.2 SHELL-AND-TUBE HEAT EXCHANGERS

- A. Configuration: Two pass, U-tube.
- B. Shell and Head Materials: Steel shell and cast-iron head.
- C. Tube and Tube Sheet Materials: Seamless, 3/4-inch (20-mm) OD copper tubes with steel tube sheets.
- D. Piping Connections: Threaded-shell and -head ports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HEAT EXCHANGER INSTALLATION

- A. Install heat exchangers according to manufacturer's written instructions.
- B. Install shell-and-tube heat exchangers on saddle supports or wall brackets, with provisions to drain shell.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.
- C. Install piping with threaded or flanged connections at heat exchangers.
- D. Install shutoff valves at heat exchanger inlet and outlet connections.
- E. Install relief valves on heat exchanger heated-fluid connection.

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3.4 CLEANING

- A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.5 COMMISSIONING

- A. Verify that heat exchangers are installed and connected according to the Contract Documents.
- B. Adjust flows and controls to deliver specified performance.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers as specified below:
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining heat exchangers.
 - 2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
 - 3. Schedule training with Owner, through Contracting Officer, with at least seven days' advance notice.

END OF SECTION 15710

SECTION 15767 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes propeller unit heaters.

1.3 SUBMITTALS

- A. Product Data: Include specialties and accessories for each unit type and configuration.
- B. Shop Drawings: Submit the following for each unit type and configuration:
 - 1. Plans, elevations, sections, and details.
 - 2. Details of anchorages and attachments to structure and to supported equipment.
 - 3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
 - 4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- C. Field Test Reports: Written reports of tests specified in Part 3 of this Section.
- D. Maintenance Data: For propeller unit heaters to include in maintenance manuals specified in Division 1. Include the following:
 - 1. Maintenance schedules and repair parts lists for motors, coils, integral controls, and filters.

1.4 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.

1.5 COORDINATION

- A. Coordinate layout and installation of propeller unit heaters and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Dunham-Bush, Inc.
2. Sterling.
3. Trane Company (The); North American Commercial Group.
4. U S A Coil & Air Inc.

2.2 UNIT HEATERS

- A. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with horizontal, adjustable louvers in blow-through configuration.

2.3 MATERIALS

- A. Casing: Galvanized steel, with removable panels.
- B. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer and manufacturer's standard paint applied to factory-assembled and -tested propeller unit heater before shipping.

2.4 COILS

- A. Hot-Water Coil: Copper tube, 0.031-inch (0.78-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 375 psig (2690 kPa) underwater.

2.5 FAN

- A. Propeller with aluminum blades directly connected to motor.

2.6 ACCESSORIES

- A. Horizontal Configuration: Louver fin diffuser.

2.7 CONTROLS

- A. Control Devices: Unit-mounted fan-speed switch and wall-mounting thermostat.

2.8 SOURCE QUALITY CONTROL

- A. Test propeller unit heater coils according to ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before propeller unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install propeller unit heaters level and plumb.
- B. Install propeller unit heaters to comply with NFPA 90A.
- C. Suspend propeller unit heaters from structure.
- D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Unless otherwise indicated, install shutoff valve and union or flange on each connection.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Ground equipment.
- E. 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.

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and report results in writing:
 - 1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safeties.

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- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

- A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. After installing units, clean propeller unit heaters internally according to manufacturer's written instructions.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 - 2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 15767

SECTION 15815 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes metal ducts for outside and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg (minus 500 to plus 2500 Pa). Metal ducts include the following:
 - 1. Rectangular ducts and fittings.
- B. Related Sections include the following:
 - 1. Division 15 Section "Duct Accessories" for dampers.

1.3 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

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 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

2.3 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
- B. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
- C. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.

2.4 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 - 1. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

2.5 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, offsets, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 - 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

- B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
 - 1. Available Manufacturers:
 - a. Ductmate Industries, Inc.
 - b. Nexus Inc.
 - c. Ward Industries, Inc.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
 - 1. Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa) 2-inch wg (500 Pa).
- B. All ducts shall be galvanized steel.

3.2 DUCT INSTALLATION

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install ducts with fewest possible joints.
- C. Install fabricated fittings for changes in directions, size, and shape and for connections.
- D. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches (300 mm), with a minimum of 3 screws in each coupling.
- E. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- H. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

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3.3 SEAM AND JOINT SEALING

- A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.
 - 1. For pressure classes lower than 2-inch wg (500 Pa), seal transverse joints.

3.4 HANGING AND SUPPORTING

- A. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

END OF SECTION 15815

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SECTION 15820 - DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Motorized control dampers.
- B. Related Sections include the following:
 - 1. Division 15 Section "HVAC Instrumentation and Controls" for electric damper actuators.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Motorized control dampers.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Motorized-control damper installations.
 - 2. Wiring Diagrams: Power, signal, and control wiring.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

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 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

2.3 MOTORIZED CONTROL DAMPERS

- A. Available Manufacturers:
 - 1. Greenheck.
 - 2. Penn Ventilation Company, Inc.
 - 3. Ruskin Company.
- B. General Description: AMCA-rated, parallel or opposed-blade design; minimum of 0.1084-inch- (2.8-mm-) thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- (1.61-mm-) thick, galvanized-steel damper blades with maximum blade width of 8 inches (203 mm).
 - 1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 - 2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
 - 3. Provide with closed-cell neoprene edging, rated for leakage at less than 10 cfm per sq. ft. (51 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (995 Pa) when damper is being held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

- A. Install motorized dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

3.2 ADJUSTING

- A. Adjust duct accessories for proper settings.

END OF SECTION 15820

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SECTION 15836 - AXIAL FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:

- 1. Propeller sidewall fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base air ratings on sea-level conditions.
- B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material gages and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
- C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
- D. Maintenance Data: For axial fans to include in maintenance manuals specified in Division 1.

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. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final locations, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

- A. Coordinate size and location of structural-steel support members.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Carnes Company HVAC.
 - 2. Cook, Loren Company.
 - 3. Greenheck Fan Corp.

2.2 MANUFACTURED UNITS

- A. Description: Fan wheel and housing, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.
- B. Housings: Galvanized steel with inlet bell and diffuser sections.
 - 1. Inlet and Outlet Connections: Outer mounting frame and companion flanges; inlet cone shall be welded to fan raceway.

- C. Wheels: Cast-aluminum, axial-flow type, with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.
- D. Fan Hub and Blade-Bearing Assemblies: Cast aluminum, machined and fitted with threaded bearing wells to receive blade-bearing assemblies.
 - 1. Blades: Replaceable, cast aluminum; factory mounted and balanced to hub assembly.
 - 2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- E. Shaft Bearings: Radial, self-aligning ball or roller bearings.
 - 1. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.
 - 2. Roller-Bearing Rating Life: ABMA 11, L_{10} of 100,000 hours.
 - 3. Extend lubrication lines to outside of casing and terminate with grease fittings.
- F. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - 1. Service Factor Based on Fan Motor: 1.4.
 - 2. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 - 3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - 4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - 5. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
 - 6. Motor Mount: Adjustable base.
- G. Accessories:
 - 1. Companion Flanges: Rolled-steel flanges.
 - 2. Inlet Screens: Wire-mesh screen on fans not connected to ductwork.

2.3 MOTORS

- A. Motor Construction: NEMA MG 1, general purpose, continuous duty, high efficiency, Design B.
- B. Enclosure Type: Open dripproof.

2.4 FACTORY FINISHES

- A. Sheet Metal Parts: Prime coat before final assembly.
- B. Exterior Surfaces: Baked-enamel finish coat after assembly.
- C. Coatings: Powder-baked enamel.

2.5 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install axial fans level and plumb.
- B. Support suspended units from structure using threaded steel rods.
- C. Install units with clearances for service and maintenance.
- D. Label fans according to requirements specified in Division 15 Section "Mechanical Identification."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."
- B. Ground equipment.
- C. 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.

3.3 FIELD QUALITY CONTROL

- A. Equipment Startup Checks:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.

3.5 CLEANING

- A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.
- B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

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3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain axial fans.
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
 - 2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 15836

SECTION 15900 - HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

1.3 SYSTEM DESCRIPTION

- A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

1.4 SEQUENCE OF OPERATION

A. Boiler Operation

1. An outdoor air temperature sensor set at 55°F (adjustable) shall start circulating pump P-2 and enable boiler (B-1) start circuitry.
2. Set boiler operating control temperature to 180°F (adjustable).
3. When outdoor air temperature rises to 60°F (adjustable), shut off boiler and circulating pump P-2.

B. Pump House Heating

1. On a call for heating from a wall-mounted thermostat set at 60°F (adjustable). The unit heater (UH-1 and UH-2) fan shall cycle to maintain space temperature. An aquastat shall not allow fan to run if hot water supply temperature is below 100°F (adjustable).
2. A space thermostat set at 35°F (adjustable) shall provide an audible and visual alarm at the low-temperature alarm panel.

C. Tank Heating

1. On a call for heating from a tank-mounted temperature sensor set at 42°F (adjustable), the circulating pump P-1 shall start. When tank water temperature rises to 45°F (adjustable), the pump P-1 shall shut off.

2. A low temperature tank-mounted sensor, set at 35°F (adjustable) shall provide an audible and visual alarm at the low-temperature alarm panel inside the building.
3. This wall-mounted panel shall have alarm indication, horn, test, and manual reset button. A remote visual alarm on the exterior of the pump house shall be provided. Tank-mounted sensors shall be suitable for outdoor application, NEMA 12, weather-tight.

D. Ventilation

1. On a call for cooling from a wall-mounted thermostat set at 95°F (adjustable), the exhaust fan EF-1 shall be energized and the motorized dampers at the intake louver and exhaust louver shall open. On a loss of power, the motorized dampers shall fail open.

E. Diesel Fire Pump Operation

1. When the diesel fire pump operates, the motorized damper at the intake louver shall open to provide combustion air. On a loss of power, the motorized damper shall fail open.

1.5 SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. Each control device labeled with setting or adjustable range of control.

- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
3. Details of control panel faces, including controls, instruments, and labeling.
4. Written description of sequence of operation.
5. Schedule of dampers including size, leakage, and flow characteristics.
6. Schedule of valves including leakage and flow characteristics.

- C. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:

1. Interconnection wiring diagrams with identified and numbered system components and devices.
2. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

3. Calibration records and list of set points.

- D. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- E. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is an authorized representative of the automatic control system manufacturer for both installation and maintenance of units required for this Project.
- B. Manufacturer Qualifications: A firm experienced in manufacturing automatic temperature-control systems similar to those indicated for this Project and with a record of successful in-service performance.
- C. 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.
- D. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.8 COORDINATION

- A. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Belimo Aircontrols (USA), Inc.
 - b. Erie Controls.
 - c. Honeywell, Inc.; Home & Building Control.
 - d. Johnson Controls, Inc.; Controls Group.
 - e. KMC Controls/Kreuter Manufacturing Company.
 - f. Landis & Staefa, Inc.

2.2 CONTROL PANELS

- A. Alarm Panels: Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted in hinged-cover enclosure.
 - 1. Alarm Condition: Indicating light flashes and horn sounds.
 - 2. Acknowledge Switch: Horn is silent and indicating light is steady.
 - 3. Second Alarm: Horn sounds and indicating light is steady.
 - 4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
 - 5. Contacts in alarm panel allow remote monitoring.

2.3 SENSORS

- A. Electronic Sensors: Vibration and corrosion resistant; for immersion, as required.
 - 1. Thermistor temperature sensors as follows:
 - a. Accuracy: Plus or minus 0.5 deg F (0.3 deg C) at calibration point.
 - b. Wire: Twisted, shielded-pair cable.
 - c. Insertion Elements for Liquids: Brass socket with minimum insertion length of 18 inches (64 mm).
 - 2. Resistance Temperature Detectors: Platinum.
 - a. Accuracy: Plus or minus 0.2 percent at calibration point.
 - b. Wire: Twisted, shielded-pair cable.
 - c. Insertion Elements for Liquids: Brass socket with minimum insertion length of 18 inches.

2.4 THERMOSTATS

- A. Combination Thermostat and Fan Switches: Line-voltage thermostat with two-, three-, or four-position, push-button or lever-operated fan switch.
 - 1. Label switches "FAN ON-AUTO-OFF." Provide unit for mounting on two-gang switch box.
- B. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater.
- C. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, integral manual on-off-auto selector switch.
 - 1. Equip thermostats, which control electric heating loads directly, with off position on dial wired to break ungrounded conductors.
 - 2. Dead Band: Maximum 2 deg F (1 deg C).

- D. Room Thermostat Cover Construction: Manufacturer's standard locking covers.
 - 1. Set-Point Adjustment: Exposed.
 - 2. Set-Point Indication: Exposed.
 - 3. Orientation: Vertical.
- E. Room thermostat accessories include the following:
 - 1. Insulating Bases: For thermostats located on exterior walls.
 - 2. Thermostat Guards: Metal wire, tamperproof.
- F. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

2.5 ACTUATORS

- A. Electronic Damper Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - 1. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. (86.8 kg-cm/sq. m) of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. (62 kg-cm/sq. m) of damper.
 - 2. Coupling: V-bolt and V-shaped, toothed cradle.
 - 3. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - 4. Fail-Safe Operation: Mechanical, spring-return mechanism to fail open.
 - 5. Power Requirements (Two-Position Spring Return): 24 or 120-V ac.
 - 6. Temperature Rating: Minus 22 to plus 122 deg F (minus 30 to plus 50 deg C).
 - 7. Run Time: 12 seconds open, 5 seconds closed.

2.6 DAMPERS

- A. Dampers: AMCA-rated, parallel or opposed-blade design; 0.1084-inch (2.8-mm) minimum, galvanized-steel frames with holes for duct mounting; damper blades shall not be less than 0.0635-inch (1.6-mm) galvanized steel with maximum blade width of 8 inches (203 mm).
 - 1. Blades shall be secured to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 - 2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
 - 3. For standard applications, include optional closed-cell neoprene edging.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.
- B. Verify that pipe- and equipment-mounted devices and wiring are installed before proceeding with installation.

3.2 INSTALLATION

- A. Install equipment level and plumb.
- B. Connect and configure equipment and software to achieve sequence of operation specified.
- C. Verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate all 60 inches (1524 mm) above the floor.
- D. Install guards on thermostats.
- E. Install automatic dampers according to Division 15 Section "Duct Accessories."
- F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- G. Install labels and nameplates to identify control components according to Division 15 Section "Basic Mechanical Materials and Methods."
- H. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."
- I. Install hydronic instrument wells and other accessories according to Division 15 Section "Hydronic Piping."

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Division 16.
- B. Install building wire and cable according to Division 16.
- C. Install signal and communication cable according to Division 16.
 - 1. Install exposed cable in raceway.
 - 2. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - 3. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

4. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to machine to allow service and maintenance.

B. Ground equipment.

1. 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.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.

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

C. Replace damaged or malfunctioning controls and equipment.

1. Start, test, and adjust control systems.

2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.

3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

3.6 DEMONSTRATION

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

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1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."

END OF SECTION 15900

SECTION 15950 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:
 - 1. Air Systems:
 - a. Constant-volume air systems.
 - 2. Hydronic Piping Systems:
 - a. Constant-flow systems.
 - 3. Verifying that automatic control devices are functioning properly.
 - 4. Reporting results of activities and procedures specified in this Section.

1.2 SUBMITTALS

- A. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- B. Warranties specified in this Section.

1.3 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.
- B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

1.4 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

- B. Perform TAB after pressure tests on water distribution systems have been satisfactorily completed.

1.5 WARRANTY

- A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
 - B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
 - 1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells and balancing valves and fittings are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 1 Section "Closeout Procedures."
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the

factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells and balancing valves and fittings are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as unit heaters, to verify that they are accessible and their controls are connected and functioning.
- L. Examine strainers for clean screens and proper perforations.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine equipment for installation and for properly operating safety interlocks and controls.
- P. Examine automatic temperature system components to verify the following:
 - 1. Dampers and other controlled devices are operated by the intended controller.
 - 2. Dampers are in the position indicated by the controller.
 - 3. Integrity of dampers for free and full operation and for tightness of fully closed and fully open positions.
 - 4. Thermostats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 - 5. Sensors are located to sense only the intended conditions.
 - 6. Sequence of operation for control modes is according to the Contract Documents.
 - 7. Controller set points are set at indicated values.
 - 8. Interlocked systems are operating.
- Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
 - 1. Permanent electrical power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic temperature-control systems are operational.
 - 4. Balancing valves are open.
 - 5. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
- B. Cut insulation, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions and similar controls and devices, to show final settings.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for fans.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. Determine the best locations for accurate duct airflow measurements.
- D. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- E. Verify that motor starters are equipped with properly sized thermal protection.
- F. Check dampers for proper position to achieve desired airflow path.
- G. Check for airflow blockages.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Obtain approval from Contracting Officer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
 - 2. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 - 1. Open all manual valves for maximum flow.
 - 2. Check expansion tank liquid level.
 - 3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
 - 4. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
 - 5. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
 - 1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 - 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 5 percent of design.
- B. Set calibrated balancing valves, if installed, at calculated presettings.
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 1. Determine the balancing station with the highest percentage over indicated flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 3. Record settings and mark balancing devices.
- F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

3.8 PROCEDURES FOR BOILERS

- A. If hydronic, measure entering- and leaving-water temperatures and water flow.

3.9 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:
 1. Entering- and leaving-water temperature.
 2. Water flow rate.
 3. Water pressure drop.
 4. Dry-bulb temperature of entering and leaving air.
 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 6. Airflow.
 7. Air pressure drop.

3.10 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.

- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the sequence of operation of control devices. Note the speed of response to input changes.
- G. Check the interaction of interlock and lockout systems.
- H. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
- I. Note operation of electric actuators using spring open for proper fail-safe operations.

3.11 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
 - 1. Exhaust Fans: Plus 5 to plus 10 percent.
 - 2. Heating-Water Flow Rate: 0 to minus 10 percent.

3.12 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
 - 1. Title page.
 - 2. Name and address of TAB firm.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.

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6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB firm who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer, type size, and fittings.
 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside- and exhaust-air dampers.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outside and exhaust airflows.
 2. Water flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Position of balancing devices.
- 3.13 ADDITIONAL TESTS
- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

END OF SECTION 15950

SECTION 16010 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The General Conditions, General requirements and Division 1 sections issued for this project shall be considered part of the electrical specifications, and the Contractor shall be bound by their requirements.
- B. It is the intent of this specification and accompanying drawings to describe and indicate the manufacture, erection and installation of the equipment and connections to the work specified herein and shown on the drawings for this project. It is not intended that the specifications and drawings describe and indicate each piece of equipment required for installation, for where items are required for satisfactory installation and are considered to be the accepted practice of the trade, they shall be considered to be both specified and indicated.
- C. It shall be understood that the Contractor as hereinafter mentioned shall be the Electrical Subcontractor, unless specifically noted otherwise.
- D. The Contractor shall furnish all labor and material necessary for the complete and satisfactory installation and operation of all electrical work for this contract.
- E. The Contractor shall assume the entire responsibility for the materials, workmanship, and satisfactory operation of the various electrical systems, and other work as specified herein and/or as shown on the drawings.
- F. The Contractor shall schedule and coordinate all work in close cooperation with all contractors working on this project.

1.2 WORK INCLUDED

- A. The Contractor shall provide materials, labor, equipment and appliances required to furnish and install a completely operational, coordinated and tested electrical system and related work, including but not limited to:
 - 1. Primary ductbank, manholes and transformer pad.
 - 2. Secondary power ducts, conduits, cables, fittings and grounding.
 - 3. Main distribution and panelboard systems.
 - 4. Tel/data raceways and wiring.
 - 5. Building power distribution system conduits and cables.
 - 6. Power, lighting and receptacle panelboards.
 - 7. Disconnect switches for specified equipment.
 - 8. Wiring devices, switches, receptacles and multi-outlet assemblies.
 - 9. Branch circuit conduit and wiring.
 - 10. Equipment power wiring and connections.

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11. Lighting fixtures and lamps systems.
12. Grounding systems.
13. Dry-type transformers and accessories.
14. Miscellaneous electrical equipment, devices, fittings, etc.
15. System tests with certified reports.
16. Operation and maintenance manuals.
17. As-built drawing preparation.
18. Electrical demolition requirements.
19. Fire suppression water tank ground grid.

1.3 RELATED WORK

- A. Division 15 - Mechanical.

1.4 WORK FURNISHED AND INSTALLED UNDER OTHER SECTIONS BUT WIRED UNDER THIS CONTRACT AS DEFINED ON CONTRACT DRAWINGS

- A. Electric motor loads, as shown on the Drawings.
- B. Unit heaters, boiler and electric heaters.

1.5 QUALITY ASSURANCE

- A. The requirements of the national, state and local codes establish the minimum acceptable quality of workmanship and materials, and work shall conform thereto, unless more stringent requirements are indicated or specified by the Contract Documents.
- B. Electrical equipment, installation, and workmanship shall comply with the latest edition of national, state and local codes, safety laws, and fire laws as applicable and establish minimum requirements. Special requirements which shall exceed these minimum requirements are indicated or specified by the Contract Documents.

1.6 PERMITS AND FEES

- A. This Contractor shall obtain all permits required for construction and/or building occupancy in compliance with Federal, State and local requirements for this work. The costs of these permits shall be paid by the Contractor.

1.7 REGULATORY REQUIREMENTS

- A. The installation, including any temporary services for construction, shall comply with state and local laws and regulations applying to electrical installations in the applicable City or Town, with applicable requirements of the National Electrical Code and its latest revisions and with the requirements of the Telephone Owner and Power Companies where such requirements do not conflict with the laws and regulations in effect.

1.8 DEFINITIONS

- A. The following definitions of terms and expressions used in this section are in addition to the listing given in Special Provisions.
 - 1. "Provide" shall mean "furnish and install," unless otherwise indicated.
 - 2. "Herein" shall mean the content of a particular section where this term appears.
 - 3. "Indicated" shall mean "indicated on contract drawings."
 - 4. "Concealed," where used in conjunction with conduit, junction boxes, outlet boxes and accessories, shall mean that they are hidden from sight as in trenches, chases, furred spaces, shafts or hung ceilings.
 - 5. "Exposed," where used in conjunction with conduit, junction boxes, outlet boxes and accessories, shall mean that they are not "concealed" as defined herein above.

1.9 MATERIALS AND WORKMANSHIP

- A. Materials shall be new and shall conform with the standard of the Underwriters' Laboratories, Inc. in every case where such a standard, listing or label has been established for the particular type of material in question.
- B. Names of manufacturers, catalog numbers, models or types, when used in this section and the included drawings, are intended to indicate the standards of type and quality of material.
- C. Where two or more units of the same class of equipment are required, these units shall be the product of a single manufacturer having a minimum of five years successful manufacturing of this equipment.
- D. Substitutions: Shall be requested through submittal procedure provided with General Requirements. All substitutions shall be of equal quality and operation and shall require the approval of the Contracting Officer.

1.10 DRAWINGS

- A. The drawings show the layout of the electrical system and indicate the approximate locations of outlets, apparatus and equipment. The runs of feeders and branches as indicated are schematic only. The exact routing of conduit shall be determined by the structural conditions and other obstructions. Field routing shall not be construed by the Contractor to mean that the design of the systems may be changed but refers only to physical runs of conduit between given points.
- B. Consult contract and reference drawings available at time of installation which may affect the location of any outlets, apparatus and equipment to avoid possible interference and permit full

coordination of work. The right to make any reasonable change in location of outlets, apparatus and equipment up to the time of roughing-in is reserved by the Contracting Officer.

- C. It shall be the responsibility of this Contractor to see that electrical equipment such as junction and pull boxes, panelboards, switches, controls and such other apparatus as may require maintenance and operation from time to time is made easily accessible. Although the equipment may be shown on the Drawings in certain locations, the construction may disclose the fact that such locations do not make its position readily accessible. In such cases, this Contractor shall call the attention of Contracting Officer to the condition before advancing the construction to a state where a change will reflect additional expenses.
- D. Contractor is particularly cautioned in the running of conduit on process equipment to avoid blocking removal of such equipment requiring future maintenance.

1.11 RECORD DRAWINGS

- A. Maintain at the job site a complete set of blueline prints of the electrical work on which shall be marked, clearly, neatly, accurately and promptly a record of the work done as the work progresses.
- B. Record drawings shall conform to General Requirements.

1.12 SUBMITTALS

- A. Submit shop drawings as required by these specifications and General Requirements.
- B. Submit shop drawings giving dimensions and details of electrical design requirements.
- C. Submit samples of plugs, receptacles, disconnect switches and other small parts as requested by the Contracting Officer.
- D. General bulletins or catalogs will not be accepted as shop drawings unless the equipment on which approval is to be obtained is specifically marked and information pertaining to the item, including dimensions where required for installation, is included. These types of documents shall be certified as planned for construction by the Contractor.
- E. Submit manufacturers notarized certificates of compliance for cable and other electric equipment.
- F. Submit copies of electrical test reports.

1.13 GUARANTEE

- A. The Contractor shall guarantee the electrical systems, including fixtures, to be free from short circuits, open circuits, loose connections, over-heating and such other defects.

1.14 EQUIPMENT AND SCAFFOLDING

- A. The Contractor performing work under this section shall be responsible for furnishing tools and equipment, scaffolding and other temporary construction facilities required for the execution of the work in a safe and legal manner.

1.15 TEMPORARY POWER AND LIGHT

- A. Temporary service for construction will be provided by the Contractor.
- B. Each Contractor shall provide and maintain, at its own expense, extension cords, lighting, appurtenances and accessories for lights or power tools required in addition to and beyond the temporary service provided.
- C. The cost of electrical energy used for temporary power and lighting for the work of Contractor shall be borne by the Contractor, as indicated in the General Requirements.
- D. Upon completion of the work and before final acceptance of the entire project, each Contractor shall remove, at his own expense, wiring appurtenances and accessories used in the performance of its respective work to the satisfaction of the Contracting Officer. The temporary service area shall be cleaned and restored to acceptable condition by the Contractor.

1.16 INSPECTION AND TESTS

- A. Provide tests as directed under the individual Sections of Division 16.
- B. Connections at cabinets, switches, circuit breakers and splices must be made prior to the time of final inspection and testing. Circuits shall be continuous from service switches to each outlet. Each system shall test free from short circuits and ground and shall have an insulation resistance between conductors and ground based on maximum load not less than requirements of the latest edition of the National Electrical Code.
- C. Voltages shall be tested at the line side of the main breaker with switches or circuit breakers in the open position.
- D. This Contractor shall be responsible for correct voltages, tap settings and correct phase designations on the electrical equipment.
- E. Circuit breakers shall be tested for instantaneous and time delay trip. Breakers shall be tested at 300 percent overload. Certification by the manufacturer that the equipment furnished will conform to these requirements will be acceptable.
- F. The grounding installation shall be tested and the resistance between ground and absolute earth shall not exceed 25 ohms and shall be measured by the Contractor before the equipment is placed in operation.

- G. Testing equipment necessary to satisfactorily conduct the tests shall be provided. The tests shall be made in the presence of the Engineer at no additional expense to the Owner.
- H. Lighting fixtures and systems shall be tested with specified lamps in place, for a period not less than twenty hours.
- I. Failure or defects in workmanship or materials revealed by tests or inspection shall be corrected promptly and tests shall be reconducted by the Contractor. Defective material shall be replaced promptly with new and unused material at no additional expense. Insofar as practical, a normal full load test shall be made on the power and lighting systems.
- J. The Contractor shall measure and record minimum and maximum voltages, measure and record voltage between phase wires and neutral.
- K. Copies of all test reports shall be submitted to the Engineer per the procedure described in General Requirements for acceptance and approval.

1.17 CUTTING AND PATCHING

- A. The Contractor shall arrange to have the conduit, panelboards, boxes and such other pertinent parts set in place ahead of the construction work wherever possible to eliminate the need for cutting and patching. Cutting and patching shall be done as specified herein.

1.18 ELECTRICAL CHARACTERISTICS

- A. Building power distribution design may be 277/480 volts, 3-phase, 4-wire and/or 120/208 volts, 3-phase, 4-wire, 60 hertz, as required.
- B. Power system for convenience outlets, appliances, and incandescent lighting - 120/208 volts, 3-phase, 4-wire, 60 hertz, as required.
- C. Motors 1/2 horsepower to 40 horsepower - 480 volts, 3-phase, 3-wire.
- D. Motors less than 1/2 horsepower - 120 volts, single-phase, 2-wire, unless otherwise indicated on Drawings.
- E. Fluorescent, and metal halide lighting - 277 volts, single-phase, 2-wire, unless otherwise indicated on the Drawings.
- F. Provision shall be made for harmonic effects in all electrical systems.

1.19 COORDINATION

- A. The Electrical Contractor shall be responsible for fully coordinating the various parts of the work included under this Contract, and such other disciplines work as it may affect the completion of this Contract, throughout the various phases of construction and before the ordering or fabrication of the various parts of the work, so as to insure compliance with the

drawings and specifications, and as necessary to provide the installations complete and in satisfactory operating condition.

- B. Mechanical and Electrical Coordination: Power wiring and conduit are included under this Contract. The electrical components of mechanical equipment, such as motors, control or pushbutton stations, float or pressure switches, solenoid valves, other devices functioning to control mechanical equipment, and control wiring and conduit are provided under other Divisions.

1.20 OPERATION AND MAINTENANCE MANUAL

- A. The Contractor shall furnish an operation and maintenance manual for each electrical system and for each piece of equipment furnished under his contract in accordance with Division 1 requirements.
- B. The manual shall include the names, addresses, and telephone numbers of each subcontractor installing equipment and system, and of the local representatives for each item of equipment and each system.
- C. The manual shall include, but not be limited to, the following: a system layout showing circuits, devices and controls; wiring and control diagrams with data to explain detailed operation and control of each component; a control sequence describing start-up, operation and shut-down; a detailed description of the function of each principal component of the system; the procedure for starting; the procedure for operating; shut-down instructions; lubrication schedule including type, grade, temperature range, and frequency; safety precautions, diagrams, and illustrations; test procedures; performance data; and parts list with identifying drawings. The parts list for equipment shall indicate the source of supply, recommended spare parts, and the service organization which is reasonably convenient to the building site within a fifty-mile radius.
- D. The manual shall include complete instructions for equipment, controls, and accessories as provided.

1.21 DELIVERY, STORAGE AND HANDLING

- A. Deliver material in manufacturers' original unopened protective packaging.
- B. Store materials in original packaging in a manner to prevent soiling, physical damage, wetting or corrosion prior to installation.
- C. Handle in a careful manner to prevent damage to finished surfaces.
- D. Where possible, maintain protective coverings until installation is complete and remove such covers as part of final clean-up.
- E. Touch up any damage to finishes to match adjacent surfaces to the satisfaction of the Engineer.

- F. The Contractor shall be responsible for replacing, in kind, all material and equipment that is damaged due to handling or storage, at no cost to the Owner.

1.22 WARNING SIGNS

- A. Warning signs for the enclosures of electrical transformers and switchgear having a nominal rating exceeding 600 volts shall be baked enamel on metal for indoor or outdoor use with legend "DANGER HIGH VOLTAGE" in nominal 3-inch high letters conforming to ANSI Z35.1.

PART 2 - PRODUCTS

2.1 MATERIAL AND EQUIPMENT TO BE FURNISHED

- A. Equipment and materials furnished shall be new and unused, prior to this installation, first grade commercial quality and shall be essentially the standard cataloged products of a manufacturer regularly engaged in the manufacture of the products for a successful minimum of five years. Rebuilt or remanufactured equipment will not be permitted.

PART 3 - EXECUTION

3.1 MEASUREMENTS

- A. Before ordering material or performing work, the Contractor shall verify such measurements as may be required for the proper fitting of his work to other adjoining work. Contractor shall be responsible for the correctness of the dimensions and shall satisfactorily correct, without extra charge to the Owner, work which does not fit, by furnishing new work if required for the purpose. No extra charge will be allowed for minor differences between actual dimensions and the measurements indicated on the drawings.

3.2 LOCATION OF ELECTRICAL EQUIPMENT

- A. The locations and dimensions of electrical equipment shown on plans shall be considered as approximate and diagrammatic only. The Contractor shall determine the exact locations, subject to the approval of the Engineer to meet field conditions, avoid interference with other equipment and service or for other sufficient reasons. The right to make any reasonable change in location of equipment before installation is reserved by the Contracting Officer and such changes shall be made without additional expense to the Owner.
- B. When the construction discloses the fact that certain equipment locations are not feasible, the Contractor shall notify the Contracting Officer before advancing with the installation and construction to a stage where change will reflect additional expense to the Owner.

3.3 PROTECTION OF ELECTRICAL EQUIPMENT

- A. The Contractor shall protect at his expense, materials and equipment that are subject to injury during the course of construction. Such protection shall include and is not limited to the capping or plugging of conduit and outlet boxes and the sealing of cables. The Contractor shall also accept responsibility for damage done to his work until his work has been accepted by the Owner. The Contractor shall repair damage which may occur to his operation during construction at no extra cost to the Owner, except where such damages are caused by the Owner to equipment and installations which were properly protected against damage during construction by the Contractor.

3.4 NAMEPLATE MOUNTING

- A. Nameplates shall be mounted on electrical equipment installed under these specifications, including distribution panels, starters, transformers, switches, pushbuttons, selector switches, and remote controls. They shall be securely fastened using stainless steel screws and centered directly over or on the instruments and devices, or as shown on the drawings.

3.5 WARNING SIGN MOUNTING

- A. Provide warning signs per NEC with the legend "DANGER HIGH VOLTAGE" for the enclosures of electrical transformers and switchgear having a nominal rating exceeding 600 volts. When such equipment is guarded by a fence, mount signs on the fence. Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

3.6 FITTING, CUTTING AND PATCHING

- A. The Contractor shall do cutting and fitting of his work, and of work that may be required to make the several parts come together properly, and fit his work to receive or be received by the work of other contractors as shown upon, or reasonably implied by, the drawings and specifications. Cost of cutting and fitting caused by defective or ill-timed work shall be borne by the party responsible therefore.
- B. The Contractor shall properly complete, patch and finish up his work after cutting and fitting. Unless otherwise specified, the Contractor shall perform and pay for cutting and patching required throughout the project for completion of the work in accordance with the plans and specifications.
- C. Surface damaged by notching, drilling, welding or other process during the installation of the electrical work shall be repaired and painted without cost to the Owner, and to the satisfaction of the Contracting Officer.

3.7 LOCATION OF EQUIPMENT

- A. Unless otherwise shown on the Contract Drawings, the location of outlets or devices, from finished floor to center of plate or device, shall be as follows:

1. Lighting switches: 48 inches.
 2. Receptacles: 18 inches.
- B. Unless otherwise shown on the Contract Drawings, the location of equipment, from finished floor to top of enclosures shall not exceed 6 feet, 6 inches. Equipment installations shall meet all National Electric and Safety Codes.

3.8 DISSIMILAR METALS

- A. Dissimilar metals shall mean those metal which are incompatible with one another in the presence of moisture, (i.e., copper and aluminum), as determined from their relative positions in the electrochemical series, or from test data. Where dissimilar metals come in contact, coat the joint both inside and out with approved material so as to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.
- B. Transitions in raceways, from one metal to a dissimilar metal (i.e., copper to aluminum) shall only be made at boxes or other enclosures, except where shown on the Contract Drawings. Transition between metals shall be made using a bi-metallic plated connection.

3.9 FINAL FIELD TESTS

- A. The entire electrical installation shall be inspected prior to final acceptance testing, thoroughly cleaned, and damaged finishes touched up after final completion and prior to final acceptance testing being performed. Not less than 30 days prior to the testing, furnish a test plan, to the Contracting Officer for review, outlining all aspects of the testing, including tests to be performed and the expected results.
- B. Perform the following field test in the presence of the Contracting Officer to demonstrate the reliability of the electrical installation. Give the Contracting Officer a minimum of one week advance notice of such tests.

Operate all electrical systems and equipment for a period of 24 hours, unless in the opinion of the Contracting Officer, a different test period is required, to prove the operation and performance of a system and its equipment.

Should the foregoing test reveal any defects, promptly correct such defects and re-run the tests until the entire installation conforms to the requirements of these Specifications and the Contract Drawings.

- C. Tests requiring certified reports and those requiring factory or field inspection shall be conducted and reported to the Contracting Officer in conformance with standards herein specified.

3.10 SAFETY MEASURES TO BE TAKEN

- A. The Contractor will be solely and completely responsible for conditions of the job site, including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal working hours. No construction observations of the Contractor's performance is not intended to include review of the adequacy of the Contractor's safety measures, in, on or near the construction site. It shall be the Contractor's responsibility to comply with "Safety and Health Regulations for Construction," Volume 36, No. 75, Part 11 of the Federal Register by the U.S. Department of Labor and the National Electric Safety Code. Contractor shall be responsible for providing such safety measures and shall consult with the state or federal safety inspector for interpretation whenever in doubt as to whether safe conditions do or do not exist of whether he is or is not in compliance with state or federal regulations.

3.11 WORK RESPONSIBILITIES

- A. Drawings indicate diagrammatically desired locations or arrangement of conduit runs and outlets equipment. Proper judgment shall be exercised in executing Work so as to secure best possible installation in available space and to overcome local difficulties due to space limitations or interference with structural conditions. Contractor shall be responsible for correct placing of Work and proper location and connection of Work in relation to Work of other trades. Advise appropriate trade as to locations of access panels.

3.12 WARRANTY

- A. The Contractor shall be responsible for all work installed under this specification. He shall make good, repair or replace, at his own expense as may be necessary, any defective work, materials or parts which may show themselves within one year after final acceptance, two years for ballasts with installation, if in the opinion of the Contracting Officer said defect is due to imperfection in material, design or workmanship. Incandescent lamps are not warranted, but all shall be operating at time of final acceptance.

3.13 RUBBER MATTING

- A. Provide continuous insulated rubber matting not less than 36 inches wide and not less than one-quarter inch thick in one piece in front of:
 - 1. Main Distribution Area.
- B. Matting shall conform to ASTM D178, Type 2.

END OF SECTION 16010

SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Concrete equipment bases.
 - 2. Electrical demolition.
 - 3. Cutting and patching for electrical construction.
 - 4. Touchup painting.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. IMC: Intermediate metal conduit.
- D. LFMC: Liquidtight flexible metal conduit.
- E. RNC: Rigid nonmetallic conduit.
- F. RSC: Rigid steel conduit.

1.4 SUBMITTALS

- A. Product Data: For electricity-metering equipment.
- B. Shop Drawings: Dimensioned plans and sections or elevation layouts of electricity-metering equipment.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

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.

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- B. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
 - 1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- C. Coordinate electrical service connections to components.
- D. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.

PART 2 - PRODUCTS

2.1 CONCRETE BASES

- A. Concrete Forms and Reinforcement Materials: As specified in Division 3 Section "Cast-in-Place Concrete."

2.2 TOUCHUP PAINT

- A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.
- B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

- A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.
- B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 SUPPORT INSTALLATION

- A. Install support devices to securely and permanently fasten and support electrical components.
- B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.
- C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
- D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.
- E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.
- F. Install 1/4-inch- (6-mm-) diameter or larger threaded steel hanger rods, unless otherwise indicated.
- G. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch (38-mm) and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.
- H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.
- I. Simultaneously install vertical conductor supports with conductors.
- J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches (610 mm) from the box.
- K. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.
- L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.
- M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:
 - 1. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.

2. New Concrete: Concrete inserts with machine screws and bolts.
3. Existing Concrete: Expansion bolts.
4. Instead of expansion bolts, threaded studs driven by a powder charge and provided with lock washers may be used in existing concrete.
5. Steel: Welded threaded studs or spring-tension clamps on steel.
 - a. Field Welding: Comply with AWS D1.1.
6. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
7. Light Steel: Sheet-metal screws.
8. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

3.3 FIRESTOPPING

- A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping."

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. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete."

3.5 DEMOLITION

- A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.
- B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.
- C. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches (50 mm) below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.
- D. Remove demolished material from Project site.
- E. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

- F. Lamp disposal shall comply with State of Connecticut, Dept. of Environmental Protection requirements. Provide proper paper work to government to show disposal requirement where met.
- G. Provide blank cover plates on existing boxes made exposed by demolition work, where boxes are to remain.
- H. Coordinate all power outages with Government.

3.6 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.
- B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.7 FIELD QUALITY CONTROL

- A. Inspect installed components for damage and faulty work, including the following:
 - 1. Raceways.
 - 2. Building wire and connectors.
 - 3. Supporting devices for electrical components.
 - 4. Electrical identification.
 - 5. Electricity-metering components.
 - 6. Concrete bases.
 - 7. Electrical demolition.
 - 8. Cutting and patching for electrical construction.
 - 9. Touchup painting.

3.8 REFINISHING AND TOUCHUP PAINTING

- A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 9 Section "Painting."
 - 1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
 - 2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
 - 3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

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3.9 CLEANING AND PROTECTION

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION 16050

SECTION 16060 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- C. Field Test Reports: Submit written test reports to include 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.

1.4 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.
 - 1. Comply with UL 467.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Grounding Conductors, Cables, Connectors, and Rods:
 - a. Apache Grounding/Erico Inc.
 - b. Boggs, Inc.

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- c. Chance/Hubbell.
- d. Copperweld Corp.
- e. Dossert Corp.
- f. Erico Inc.; Electrical Products Group.
- g. Framatome Connectors/Burndy Electrical.
- h. Galvan Industries, Inc.
- i. Harger Lightning Protection, Inc.
- j. Hastings Fiber Glass Products, Inc.
- k. Heary Brothers Lightning Protection Co.
- l. Ideal Industries, Inc.
- m. ILSCO.
- n. Kearney/Cooper Power Systems.
- o. Korns: C. C. Korns Co.; Division of Robroy Industries.
- p. Lightning Master Corp.
- q. Lyncole XIT Grounding.
- r. O-Z/Gedney Co.; a business of the EGS Electrical Group.
- s. Raco, Inc.; Division of Hubbell.
- t. Robbins Lightning, Inc.
- u. Salisbury: W. H. Salisbury & Co.
- v. Superior Grounding Systems, Inc.
- w. Thomas & Betts, Electrical.

2.2 GROUNDING CONDUCTORS

- A. For insulated conductors, comply with Division 16 Section "Conductors and Cables."
- B. Material: Aluminum, copper-clad aluminum, and copper.
- C. Equipment Grounding Conductors: Insulated with green-colored insulation.
- D. Grounding Electrode Conductors: Stranded cable.
- E. Bare Copper Conductors: Comply with the following:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Assembly of Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.

2.3 CONNECTOR PRODUCTS

- A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.
- B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B. In raceways, use insulated equipment grounding conductors.
- C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.
- D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

3.2 EQUIPMENT GROUNDING CONDUCTORS

- A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
- B. Install equipment grounding conductors in all feeders and circuits.
- C. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:
 - 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.
 - 7. Armored and metal-clad cable runs.

3.3 CONNECTIONS

- A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
 - 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 - 4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.

5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- B. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- C. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
- D. Tighten screws and bolts for grounding and bonding 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.
- E. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing:
 1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
 2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.
 3. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
 - a. Equipment Rated 500 kVA and Less: 10 ohms.
 - b. Equipment Rated 500 to 1000 kVA: 5 ohms.
 - c. Equipment Rated More Than 1000 kVA: 3 ohms.
 - d. Substations and Pad-Mounted Switching Equipment: 5 ohms.
 - e. Manhole Grounds: 10 ohms.

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4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 16060

SECTION 16071 - SEISMIC CONTROLS FOR ELECTRICAL WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes seismic restraints and other earthquake-damage-reduction measures for electrical components. It complements optional seismic construction requirements in the various electrical component Sections.

1.3 DEFINITIONS

- A. BOCA: BOCA National Building Code.
- B. SBC: Standard Building Code.
- C. UBC: Uniform Building Code.
- D. Seismic Restraint: A fixed device (a seismic brace, an anchor bolt or stud, or a fastening assembly) used to prevent vertical or horizontal movement, or both vertical and horizontal movement, of an electrical system component during an earthquake.
- E. Mobile Structural Element: A part of the building structure such as a slab, floor structure, roof structure, or wall that may move independent of other mobile structural elements during an earthquake.

1.4 SUBMITTALS

- A. Product Data: Illustrate and indicate types, styles, materials, strength, fastening provisions, and finish for each type and size of seismic restraint component used.
 - 1. Anchor Bolts and Studs: Tabulate types and sizes, complete with report numbers and rated strength in tension and shear as evaluated by ICBO Evaluation Service an agency approved by authorities having jurisdiction.
- B. Shop Drawings: Indicate materials, and show designs and calculations signed and sealed by a professional engineer.
 - 1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - 2. Details: Detail fabrication and arrangement. Detail attachment of restraints to both structural and restrained items. Show attachment locations, methods, and spacings.

identifying components and listing their strengths. Indicate direction and value of forces transmitted to the structure during seismic events.

- C. Coordination Drawings: Plans and sections drawn to scale and coordinating seismic bracing for electrical components with other systems and equipment, including other seismic restraints, in the vicinity.
- D. Product Certificates: Signed by manufacturers of seismic restraints certifying that products furnished comply with requirements.
- E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- F. Material Test Reports: From a qualified testing agency indicating and interpreting test results of seismic control devices for compliance with requirements indicated.

1.5 QUALITY ASSURANCE

- A. Comply with seismic restraint requirements in BOCA California Building Code/Code of Regulations of OSHPD SBC UBC, unless requirements in this Section are more stringent.
- B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing seismic engineering services, including the design of seismic restraints, that are similar to those indicated for this Project.
- C. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated.

1.6 PROJECT CONDITIONS

- A. Project Seismic Zone and Zone Factor as Defined in UBC: Zone 2A, Zone Factor 0.15.
- B. Occupancy Category as Defined in UBC: I.
- C. Acceleration Factor: 0.2G.

1.7 COORDINATION

- A. Coordinate layout and installation of seismic bracing with building structural system and architectural features, and with mechanical, fire-protection, electrical, and other building features in the vicinity.
- B. Coordinate concrete bases with building structural system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
 2. B-Line Systems, Inc.
 3. Erico, Inc.
 4. GS Metals Corp.
 5. Loos & Company, Inc.
 6. Mason Industries, Inc,
 7. Powerstrut.
 8. Thomas & Betts Corp.
 9. Unistrut Corporation.

2.2 MATERIALS

- A. Use the following materials for restraints:
1. Indoor Dry Locations: Steel, zinc plated.
 2. Outdoors and Damp Locations: Galvanized steel.
 3. Corrosive Locations: Stainless steel.

2.3 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

- A. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.
- B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type.
- C. Concrete Inserts: Steel-channel type.
- D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.
- E. Welding Lugs: Comply with MSS SP-69, Type 57.
- F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.
- G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

- H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.4 SEISMIC BRACING COMPONENTS

- A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch (41-by-41-mm) cross section, formed from 0.1046-inch- (2.7-mm-) thick steel, with 9/16-by-7/8-inch (14-by-22-mm) slots at a maximum of 2 inches (50 mm) o.c. in webs, and flange edges turned toward web.
 - 1. Materials for Channel: ASTM A 570, GR 33.
 - 2. Materials for Fittings and Accessories: ASTM A 575, ASTM A 576, or ASTM A 36.
 - 3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.
 - 4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.
- B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.
- C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.
 - 1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
 - 2. Wire Rope Cable: Comply with ASTM 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.
- D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install seismic restraints according to applicable codes and regulations and as approved by authorities having jurisdiction, unless more stringent requirements are indicated.

3.2 STRUCTURAL ATTACHMENTS

- A. Use bolted connections with steel brackets, slotted channel, and slotted-channel fittings to spread structural loads and reduce stresses.
- B. Attachments to New Concrete: Bolt to channel-type concrete inserts or use expansion anchors.
- C. Attachments to Existing Concrete: Use expansion anchors.

- D. Holes for Expansion Anchors in Concrete: Drill at locations and to depths that avoid reinforcing bars.
- E. Attachments to Solid Concrete Masonry Unit Walls: Use expansion anchors.
- F. Attachments to Hollow Walls: Bolt to slotted steel channels fastened to wall with expansion anchors.
- G. Attachments to Steel: Bolt to clamps on flanges of beams or on upper truss chords of bar joists.

3.3 ELECTRICAL EQUIPMENT ANCHORAGE

- A. Anchor rigidly to a single mobile structural element or to a concrete base that is structurally tied to a single mobile structural element.
- B. Anchor panelboards, motor-control centers, motor controls, switchboards, switchgear, transformers, unit substations, fused power-circuit devices, transfer switches, busways, battery racks, static uninterruptible power units, power conditioners, capacitor units, communication system components, and electronic signal processing, control, and distribution units as follows:
 - 1. Size concrete bases so expansion anchors will be a minimum of 10 bolt diameters from the edge of the concrete base.
 - 2. Concrete Bases for Floor-Mounted Equipment: Use female expansion anchors and install studs and nuts after equipment is positioned.
 - 3. Bushings for Floor-Mounted Equipment Anchors: Install to allow for resilient media between anchor bolt or stud and mounting hole in concrete.
 - 4. Anchor Bolt Bushing Assemblies for Wall-Mounted Equipment: Install to allow for resilient media where equipment or equipment-mounting channels are attached to wall.
 - 5. Torque bolts and nuts on studs to values recommended by equipment manufacturer.

3.4 SEISMIC BRACING INSTALLATION

- A. Install bracing according to spacings and strengths indicated by approved analysis.
- B. Expansion and Contraction: Install to allow for thermal movement of braced components.
- C. Cable Braces: Install with maximum cable slack recommended by manufacturer.
- D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to the structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Make flexible connections in raceways, cables, wireways, cable trays, and busways where they cross expansion and seismic control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate at electrical equipment anchored to a different mobile structural element from the one supporting them.

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3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform the following field quality-control testing:
- B. Testing: Test pull-out resistance of seismic anchorage devices.
 - 1. Provide necessary test equipment required for reliable testing.
 - 2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 3. Schedule test with Contracting Officer, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
 - 4. Obtain Architect's approval before transmitting test loads to the structure. Provide temporary load-spreading members.
 - 5. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - 6. Test to 90 percent of rated proof load of device.
 - 7. If a device fails the test, modify all installations of same type and retest until satisfactory results are achieved.
 - 8. Record test results.

END OF SECTION 16071

SECTION 16075 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Schedule of Nomenclature: An index of electrical equipment and system components used in identification signs and labels.
- C. Samples: For each type of label and sign to illustrate color, lettering style, and graphic features of identification products.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

PART 2 - PRODUCTS

2.1 CABLE LABELS

- A. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
 - 1. Color: Black letters on orange field.
 - 2. Legend: Indicates voltage voltage and service.
- B. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend overlaminated with a clear, weather- and chemical-resistant coating.

- C. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.
- D. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide (0.08 mm thick by 25 to 51 mm wide).

2.2 NAMEPLATES AND SIGNS

- A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.
- B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, 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.
- C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.
- D. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength: 50 lb (22.3 kg) minimum.
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: According to color-coding.
- B. Paint: Formulated for the type of surface and intended use.
 - 1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
 - 2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
 - 3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
 - 4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
- C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before applying.
- E. Install painted identification according to manufacturer's written instructions and as follows:
 - 1. Clean surfaces of dust, loose material, and oily films before painting.
 - 2. Prime surfaces using type of primer specified for surface.
 - 3. Apply one intermediate and one finish coat of enamel.
- F. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.
- G. Circuit Identification Labels on Boxes: Install labels externally.
 - 1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
 - 2. Concealed Boxes: Plasticized card-stock tags.
 - 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- H. Color-Coding of Secondary Phase Conductors: Use the following colors for service feeder and branch-circuit phase conductors:
 - 1. 208/120-V Conductors:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - 2. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:

- a. Colored, pressure-sensitive plastic tape in half-lapped turns for a 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. Use 1-inch- (25-mm-) wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
 - b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches (76 mm) from the terminal and spaced 3 inches (76 mm) apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.
- I. Power-Circuit Identification: Metal tags or aluminum, wraparound marker bands for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms.
1. Legend: 1/4-inch- (6.4-mm-) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
 2. Tag Fasteners: Nylon cable ties.
 3. Band Fasteners: Integral ears.
- J. Apply identification to conductors as follows:
1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
 2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
 3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.
- K. Apply warning, caution, and instruction signs as follows:
1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
 2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- (9-mm-) high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- L. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high lettering on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment using mechanical fasteners:
1. Panelboards, electrical cabinets, and enclosures.

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2. Access doors and panels for concealed electrical items.
3. Electrical switchgear and switchboards.
4. Emergency system boxes and enclosures.
5. Disconnect switches.
6. Enclosed circuit breakers.
7. Motor starters.
8. Power transfer equipment.
9. Contactors.
10. Remote-controlled switches.

END OF SECTION 16075

SECTION 16120 - CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

1.3 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 inspecting agency engaged by Contractor.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 CONDUCTORS AND CABLES

A. Available Manufacturers:

1. Alcan Aluminum Corporation; Alcan Cable Div.
2. American Insulated Wire Corp.; a Leviton Company.
3. General Cable Corporation.
4. Senator Wire & Cable Company.
5. Southwire Company.

B. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.

C. Conductor Material: Copper Copper, stranded conductor solid conductor for No. 10 AWG and smaller, stranded for No. 8 AWG and larger.

D. Conductor Insulation Types: Type THW, THHN-THWN, XHHW, UF, USE and SO complying with NEMA WC 5 or 7.

E. Multiconductor Cable: Type MC Metal-clad cable, and Type SO with ground wire.

2.3 CONNECTORS AND SPLICES

A. Available Manufacturers:

1. AFC Cable Systems, Inc.
2. AMP Incorporated/Tyco International.
3. Hubbell/Anderson.
4. O-Z/Gedney; EGS Electrical Group LLC.
5. 3M Company; Electrical Products Division.

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 AND INSULATION APPLICATIONS

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

- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and 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. Branch Circuits Concealed in Concrete and below Slabs-on-Grade: Type THHN-THWN, single conductors in raceway.

3.2 INSTALLATION

- A. Conceal cables in finished walls, ceilings, and floors, 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 conduits parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support conduits according to Division 16 Section "Basic Electrical Materials and Methods."
- F. Seal around conduits penetrating fire-rated elements according to Division 7 Section "Through-Penetration Firestop Systems."
- G. Identify and color-code conductors and cables according to Division 16 Section "Basic Electrical Materials and Methods Electrical Identification."

3.3 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 unspliced conductors.
 - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

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3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.

- B. 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.

END OF SECTION 16120

SECTION 16130 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections include the following:
 - 1. Division 7 Section "Through-Penetration Firestop Systems" for firestopping materials and installation at penetrations through walls, ceilings, and other fire-rated elements.
 - 2. Division 16 Section "Basic Electrical Materials and Methods" for supports, anchors, and identification products.
 - 3. Division 16 Section "Seismic Controls for Electrical Work" for seismic restraints and bracing of raceways, boxes, enclosures, and cabinets.
 - 4. Division 16 Section "Wiring Devices" for devices installed in boxes and for floor-box service fittings.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. IMC: Intermediate metal conduit.
- D. LFMC: Liquidtight flexible metal conduit.
- E. RSC: Rigid steel conduit.

1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: Show fabrication and installation details of components for raceways, fittings, boxes, enclosures, and cabinets.
- C. Shop Drawings: Signed and sealed by a qualified professional engineer.
 - 1. Design Calculations: Calculate requirements for selecting seismic restraints.

2. Detail assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- D. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
1. Ceiling suspension assembly members.
 2. Method of attaching hangers to building structure.
 3. Size and location of initial access modules for acoustical tile.
 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- E. Manufacturer Seismic Qualification Certification: Submit certification that enclosures, cabinets, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

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.

1.6 COORDINATION

- A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 METAL CONDUIT AND TUBING

A. Available Manufacturers:

1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Anamet Electrical, Inc.; Anaconda Metal Hose.
4. Electri-Flex Co.
5. Grinnell Co./Tyco International; Allied Tube and Conduit Div.
6. LTV Steel Tubular Products Company.
7. Manhattan/CDT/Cole-Flex.
8. O-Z Gedney; Unit of General Signal.
9. Wheatland Tube Co.

B. Rigid Steel Conduit: ANSI C80.1.

C. Aluminum Rigid Conduit: ANSI C80.5.

D. IMC: ANSI C80.6.

E. Plastic-Coated Steel Conduit and Fittings: NEMA RN 1.

F. Plastic-Coated IMC and Fittings: NEMA RN 1.

G. EMT and Fittings: ANSI C80.3.

1. Fittings: Set-screw type.

H. FMC: Aluminum.

I. LFMC: Flexible steel conduit with PVC jacket.

J. Fittings: NEMA FB 1; compatible with conduit and tubing materials.

2.3 METAL WIREWAYS

A. Available Manufacturers:

1. Hoffman.
2. Square D.

- B. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
- E. Wireway Covers: Hinged type Screw-cover type.
- F. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

- A. Surface Non-Metal Raceways: Two compartment non-metallic with snap-on covers and all accessories.
 - 1. Available Manufacturers:
 - a. Panduit.
 - b. Thomas & Betts Corporation.
 - c. Walker Systems, Inc.; Wiremold Company (The).
- B. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways.
- C. Raceway shall be two-piece design with base and divider. Approximate size shall be 4.75" x 1.75" deep with an approximate thickness of .10". Cover shall be non-metallic snap-on type. Device brackets shall be offset from raceway. All "T" fittings, end caps and accessories shall be furnished as required.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. Available Manufacturers:
 - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 - 2. Emerson/General Signal; Appleton Electric Company.
 - 3. Erickson Electrical Equipment Co.
 - 4. Hoffman.
 - 5. Hubbell, Inc.; Killark Electric Manufacturing Co.
 - 6. O-Z/Gedney; Unit of General Signal.
 - 7. RACO; Division of Hubbell, Inc.
 - 8. Robroy Industries, Inc.; Enclosure Division.
 - 9. Scott Fetzer Co.; Adalet-PLM Division.
 - 10. Spring City Electrical Manufacturing Co.
 - 11. Thomas & Betts Corporation.
 - 12. Walker Systems, Inc.; Wiremold Company (The).

13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
 - B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
 - C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.
 - D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
 - E. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
 - F. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2.6 FACTORY FINISHES

- A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard color paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Indoors:
 1. Exposed: EMT or RNC.
 2. Concealed: EMT ENT or RNC.
 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 as follows:
 - a. Damp or Wet Locations: NEMA 250, Type 4, nonmetallic.
- B. Minimum Raceway Size: 3/4-inch trade size (DN 21).
- C. Raceway Fittings: Compatible with raceways and suitable for use and location.

3.2 INSTALLATION

- A. 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.
- B. Complete raceway installation before starting conductor installation.
- C. Support raceways as specified in Division 16 Section "Basic Electrical Materials and Methods."

- D. Install temporary closures to prevent foreign matter from entering raceways.
- E. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.
- F. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
 - 1. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
- H. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
 - 1. Run parallel or banked raceways together on common supports.
 - 2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- I. Join raceways with fittings designed and approved for that purpose and make joints tight.
 - 1. Use insulating bushings to protect conductors.
- J. Tighten setscrews of threadless fittings with suitable tools.
- K. Terminations:
 - 1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
 - 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
- L. 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.
- M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-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.

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2. Where otherwise required by NFPA 70.

- N. Flexible Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.
- O. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.
- P. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.3 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.4 CLEANING

- A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 16130

SECTION 16140 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes receptacles, connectors, switches, and finish plates.

1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.

1.4 SUBMITTALS

- A. Product Data: For each product specified.
- B. Shop Drawings: Legends for receptacles and switch plates.
- C. Samples: For devices and device plates for color selection and evaluation of technical features.
- D. Maintenance Data: For materials and products to include in maintenance manuals specified in Division 1.

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.
- B. Comply with NEMA WD 1.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Wiring Devices:
 - a. Bryant Electric, Inc.
 - b. Eagle Electric Manufacturing Co., Inc.
 - c. GE Company; GE Wiring Devices.
 - d. Hubbell, Inc.; Wiring Devices Div.
 - e. Killark Electric Manufacturing Co.
 - f. Leviton Manufacturing Co., Inc.
 - g. Pass & Seymour/Legrand; Wiring Devices Div.
 - h. Pyle-National, Inc.; an Amphenol Co.
 2. Multioutlet Assemblies:
 - a. Panduit.
 - b. Wiremold.

2.2 RECEPTACLES

- A. Straight-Blade and Locking Receptacles: Heavy-Duty grade.
- B. GFCI Receptacles: Feed-through type, with integral NEMA WD 6, Configuration 5-20R duplex receptacle arranged to protect connected downstream receptacles on same circuit. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.
- C. TVSS Receptacles: Duplex type, NEMA WD 6, Configuration 5-20R, with integral TVSS in line to ground, line to neutral, and neutral to ground.
1. TVSS Components: Multiple metal-oxide varistors; rated a nominal clamp level of 500 transient-suppression voltage and minimum single transient pulse energy dissipation of 140 J line to neutral, and 70 J line to ground and neutral to ground.
 2. Active TVSS Indication: Light visible in face of device to indicate device as "active" or "no longer active."
 3. Identification: Distinctive marking on face of device denotes TVSS-type unit.
- D. Industrial Heavy-Duty Receptacle: Comply with IEC 309-1.

2.3 SWITCHES

- A. Snap Switches: Heavy-duty, quiet type.

2.4 WALL PLATES

- A. Single and combination types match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: 0.04-inch- (1-mm-) thick, Type 302, satin-finished stainless steel.
 - 3. Material for Unfinished Spaces: Galvanized steel.

2.5 FINISHES

- A. Color: Ivory, unless otherwise indicated or required by Code.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install devices and assemblies plumb and secure.
- B. Install wall plates when painting is complete.
- C. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- D. Protect devices and assemblies during painting.
- E. Adjust locations at which floor service outlets and telephone/power service poles are installed to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

- A. Comply with Division 16 Section "Electrical Identification."
- B. Comply with Division 16 Section "Basic Electrical Materials and Methods."
 - 1. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.
 - 2. Receptacles: Identify panelboard and circuit number from which served. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on face of plate and durable wire markers or tags within outlet boxes.

3.3 CONNECTIONS

- A. Connect wiring device grounding terminal to outlet box with bonding jumper.

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

3.4 FIELD QUALITY CONTROL

- A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.
- B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- C. Replace damaged or defective components.

3.5 CLEANING

- A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 16140

SECTION 16410 - 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 Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:
 - 1. Service disconnecting means.
 - 2. Feeder and branch-circuit protection.
 - 3. Motor and equipment disconnecting means.
- B. Related Sections include the following:
 - 1. Division 16 Section "Wiring Devices" for attachment plugs, receptacles, and toggle switches used for disconnecting means.

1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.
- B. RMS: Root mean square.
- C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

- A. Product Data: For each type of switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each switch and circuit breaker.
 - 1. 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. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Current and voltage ratings.
 - c. Short-circuit current rating.
 - d. UL listing for series rating of installed devices.

- e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:
 1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.
- E. Field Test Reports: Submit written test reports and include 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.
- F. Manufacturer's field service report.
- G. Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:
 1. Routine maintenance requirements for components.
 2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
 3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Testing agency that is a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or 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 NEMA AB 1 and NEMA KS 1.
- D. Comply with NFPA 70.
- E. 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. Comply with indicated maximum dimensions.

1.6 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 2. Altitude: Not exceeding 6600 feet (2000 m).

1.7 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. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Fusible Switches:
 - a. Eaton Corp.; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Control Division.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D Co.
 2. Molded-Case Circuit Breakers:

Fire Suppression System, Building No. 1
Bradley Air National Guard Base
East Granby, CT
Project No. CEKT962043

- a. Eaton Corp.; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Control Division.
 - c. Klockner-Moeller.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D Co.
3. Combination Circuit Breaker and Ground-Fault Trip:
- a. Eaton Corp.; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Control Division.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D Co.
4. Molded-Case, Current-Limiting Circuit Breakers:
- a. Eaton Corp.; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Control Division.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D Co.

2.2 ENCLOSED SWITCHES

- A. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle.
- B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks, and interlocked with cover in closed position.

2.3 ENCLOSED CIRCUIT BREAKERS

- A. 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.
 3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. GFCI Circuit Breakers: Single- and two-pole configurations with 5 30-mA trip sensitivity.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Mechanical style suitable for number, size, trip ratings, and material of conductors.
 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
 3. Ground-Fault Protection: Integrally mounted Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system.
 5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 75 percent of rated voltage.
 6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
 7. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

2.4 ENCLOSURES

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

2.5 FACTORY FINISHES

- A. Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard gray paint applied to factory-assembled and -tested enclosures before shipping.

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.

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

3.2 INSTALLATION

- A. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."
- B. 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 Division 16 Section "Basic Electrical Materials and Methods."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

- A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.
- B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.
- C. 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.

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
 2. Test continuity of each line- and load-side circuit.
- B. Testing Agency: Engage a qualified independent testing agency to perform specified testing.
- C. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

- D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switches and circuit breakers checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

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

3.7 CLEANING

- A. On completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16410

SECTION 16441 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes service, distribution and freestanding circuit breakers, switchboards rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 16 Section "Seismic Controls for Electrical Work."

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. RFI: Radio-frequency interference.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw.
- F. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, TVSS device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment, existing equipment and existing conduits. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of switchboards and overcurrent protective devices.