

SECTION – 15625 - REHABILITATION OF EXISTING WATER COOLED CHILLER & COOLING TOWER

8. Refrigerant charge is sufficient and chiller has been leak tested.
 9. Chillers' Refrigerant pressure relief is vented to outside.
 10. Thermometers and pressure gages are installed.
 11. Controls and safety interlocks are connected.
 12. Pumps are installed, connected, and operational.
 13. Makeup water is connected.
 14. Isolation valves are open
- D. Check and record performance of chiller protection devices.
- E. Check and record performance of chilled- and condenser-water flow and low-temperature interlocks.
- F. Operate chiller for run-in period as recommended by manufacturer.
- G. Check static deflection of vibration isolators, including deflection during chiller startup and shutdown.
- H. Check refrigerant charge. Check oil level.

3.9 COOLING TOWER COMMISSIONING

- A. Complete installation and startup checks according to manufacturer's written instructions and do the following:
1. Clean entire unit and wash basins.
 2. Ensure new accessories are properly installed.
 3. Check makeup water float.
 4. Check clearances for airflow and for tower servicing.
 5. Check for vibration isolation and structural support.
- B. Obtain wet-bulb, tower-size, and performance selection tables from manufacturer.
- C. Lubricate bearings on fans and shaft as recommended by manufacturer.
- D. Ensure fan wheels rotate in correct direction without vibration or binding.
- E. Adjust belts to proper alignment and tension.
- F. Start cooling-tower and condenser-water pumps. Follow manufacturers written starting procedures.
- G. Check water level in tower basin and equalizing piping.
- H. Check operation of tower basin, makeup line, automatic freeze protect dump, and controlling device.
- I. Check operation of basin immersion heater and control thermostat.

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- J. Ensure system chemical treatment is working, and measure chemical treatment levels. Check operation of tower basin automatic blow-down, and controlling device.
- K. Verify that tower discharge is not recirculating into air intakes.

3.10 DEMONSTRATION

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

END OF SECTION

SECTION 15767

ELECTRIC PROPELLER UNIT HEATER

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 electric heating propeller unit heaters for mechanical rooms' freeze protection.
- B. Related Sections include the following:
 - 1. Division 15 Section "Mechanical General Requirements".
 - 2. Division 15 Section "Testing, Adjusting, and Balancing"
 - 3. Division 16, for power requirements.

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. 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.

- B. Units shall be listed and labeled under ANSI/UL Standard and OSHA Certified.

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, duct work, fire-suppression-system components, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following: Basis of Design Reznor EGEA-7.
 - 1. Thomas & Bett Corp.; Reznor EEGA-7
 - 2. Trane Company (The); Commercial Systems Group
 - 3. Carrier Corp.; Carrier Air Conditioning Div.
 - 4. Snyder General Corp.; McQuay Commercial Products Group.
 - 5. Qmark

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 with thermostatic control.

2.3 MATERIALS

- A. Casing: Two-piece with “picture frame” front formed into wraparound sides, top and bottom. Adjustable horizontal louvers are standard. 18 gauge back panel with deep-draw fan orifice. Steel supply and return pipe tap connectors bolted to back.
- B. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer and manufacturer’s standard applied to factory-assembled and -tested propeller unit heater before shipping.

2.4 ELECTRIC-RESISTANCE HEATING ELEMENTS

- A. Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium-oxide insulating refractory and sealed in high-mass steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.
 - 1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for overtemperature protection of heaters.

2. Wiring Terminations: Match conductor materials and sizes indicated.

2.5 FANS

- A. Propeller with aluminum blades directly connected to motor and factory balanced

2.6 FAN MOTORS

- A. Motors, 1/6 hp and smaller: Multi-speed motor with integral thermal-overload protection and sleeve bearing. : Size 1/6 through 3/4 hp shall be ball bearing.

2.7 ACCESSORIES

- A. Horizontal Configuration: Louver fin diffuser.
- B. Wall or ceiling mounting brackets.
- C. Dedicated wall mounted Thermostat with base.
- D. Summer Fan Switch Kit - Field installable for circulating warm stratified air.

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 heater 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 heater(s) level and plumb.
- B. Install propeller unit heater(s) to comply with NFPA 90A.
- C. Suspend propeller unit heater(s) from structure with rubber-in-shear vibration isolators (rubber hangers).

- D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

- A. Ground equipment.
- B. 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.
- 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.

END OF SECTION

SECTION 15775
ELECTRIC HEATING 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 heating cables for the following applications:
 - 1. Indoor & Outdoor domestic cold water piping freeze protection electric heat tracing cables.
- B. Related Sections include the following:
 - 1. Division 15 Section "Mechanical General Requirements".
 - 2. Division 15 Section "Pipe Insulation".
 - 3. Division 15 Section "Domestic Water Piping".
 - 4. Division 15 Section "Hydronic Piping".
 - 5. Division 16, for power requirements.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- C. Maintenance Data: For electric heating cables to include in maintenance manuals specified in Division 1.
- D. Warranties: Special warranties specified in this Section.

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 electric heating cables and system components with other construction.

1.6 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following: The heating cable shall be XL-Trace cable as manufactured by Raychem Corporation.
 - 1. Raychem Corporation; XL-Trace (H611)
 - 2. Accutron Heat Tracing Systems.
 - 3. Chromalox; Wiegard Industrial Division; Emerson Electric Company.
 - 4. Thermon Manufacturing Co.

2.2 HEATING CABLES

- A. Heat-Tracing Cables: Self-regulating, electric heating cables suitable for freeze protection of metal or plastic piping.
 - 1. Cables: Pair of parallel No. 16 AWG tinned-copper bus wires embedded in cross-linked conductive polymer core, which varies power output in response to temperature along its length.
 - 2. Cable shall be capable of crossing over itself without overheating.
 - 3. Heat Output: At least 90 percent of rating over a temperature range from 40 to 150 deg F pipe temperature.
 - 4. The heating cable shall operate on line voltages of 277 volts without the use of transformers.
 - 5. The required heating cable output rating shall be 6 watts per foot at 50°F. (Heating cable selection is based on 1 inch fiberglass insulation on metal piping.)
 - 6. Cable Cover: Fabricated of cross-linked, modified, polyolefin dielectric jacket; tinned-copper braid; and polyolefin outer jacket with ultraviolet inhibitor.

2.3 CONTROLS

- A. Thermostatic Control–Line Sensing Pipe Thermostat: Unit with adjustable temperature range from 35 to 50 deg F snap action; open-on-rise, single-pole switch with 25-A rating; and remote bulb for directly sensing pipe-wall temperature.

2.4 ACCESSORIES

- A. All heating-cable components shall be UL Listed, CSA Certified, or FM Approved for use as part of the system to provide (choose one: pipe freeze protection, flow maintenance). Component enclosures shall be rated NEMA 4X to prevent water ingress and corrosion. Installation shall not require the installing contractor to cut into the heating-cable core to expose the bus wires. Connection systems that require the installing contractor to strip the bus wires or that use crimps or terminal blocks, shall not be acceptable. All components that make an electrical connection shall be reenterable for servicing. No component shall use silicone to seal the electrical connections. An exception will be made in areas where a conduit transition is required.
- B. Cable Installation Accessories: Tapes, cable ties, warning labels, end seals and splices, and installation clips.

PART 3 - EXECUTION

General: Division 15 contractor shall purchase material, and is responsible for entire system, including testing before and after insulation. Installation, including all splices, tees and end terminations, shall be performed by division 15 contractor, with the exception of any power connections, which shall be installed and connected to power by division 16 contractor.

3.1 EXAMINATION

- A. Examine surfaces and substrates to receive heating cables for compliance with requirements for installation, tolerances, and other conditions affecting performance.
 - 1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
 - 2. Ensure pipe testing is complete.
 - 3. Ensure surfaces and substrates are level and plumb.
- B. Test cables for electrical continuity before installing.
- C. Test cables for insulation resistance before installing.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Heat Trace all plumbing and hydronic piping installed above grade and subject to freezing.
- B. Cut cable to length required.

- C. Install heater-to-cold lead connections in accessible locations. Do not embed in concrete or plaster.
- D. Avoid crossing expansion, construction, or control joints with heating cables. Provide sufficient slack conductor in expansion loop.
- E. Heat trace shall be strapped to the piping under the insulation and such piping shall be labeled for this condition.
- F. Power connection, end seal, splice, and tee kit components shall be applied in the field.
- G. Heating cable circuit shall be protected by a ground-fault device for equipment protection. This requirement is in accordance with section 427-22 of the NEC.
- H. System must be installed per manufacturer's recommendations.
- I. Apply the heating cable linearly on the pipe after piping has been successfully pressure-tested. Secure the heating cable to piping with cable ties or fiberglass tape.
- J. Apply "Electric Traced" labels to the outside of the thermal insulation.

3.3 CONNECTIONS

- A. Electrical installation requirements are specified in Division 16 Sections. Drawings indicate general arrangement of wiring, conduit, and specialties.
- B. Connect heating cables and other components to wiring systems.
- C. 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.

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform tests after installation but before application of coverings, such as insulation, plaster, or concrete.
 - 1. Test cables for electrical continuity before energizing.
 - 2. Test cables for insulation resistance before energizing. Test using a 2500-Vdc Megger, Minimum insulation resistance shall be 20 megohms or greater. Remove cables if measured resistance is less.
 - 3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
- B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation.

- C. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.
- D. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 PROTECTION

- A. Protect installed heating cables, including leads, from damage before substantial completion.

END OF SECTION

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 rectangular, round, and flat-oval metal ducts and plenums for heating, ventilating, and air-conditioning systems in pressure classes from minus 2- to plus 5-inch wg.
- B. Related Sections include the following:
 - 1. Division 7 Section "Joint Sealants" for fire-resistant sealants for use around duct penetrations and fire-damper installations in fire-rated floors, partitions, and walls.
 - 2. Division 8 Section "Access Doors" for wall and ceiling-mounted access doors for access to concealed ducts.
 - 3. Division 10 Section "Louvers and Vents" for intake and relief louvers and vents connected to ducts and installed in exterior walls.
 - 4. Division 15 Section "Duct Insulation".
 - 5. Division 15 Section "Duct Accessories" for dampers, sound-control devices, duct-mounted access doors and panels, turning vanes, and flexible ducts.
 - 6. Division 15 Section "Diffusers, Registers, and Grilles."
 - 7. Division 15 Section "Building Management System" for automatic volume-control dampers and operators.
 - 8. Division 15 Section "Testing, Adjusting, and Balancing" for air balancing and final adjusting of manual-volume dampers.

1.3 DEFINITIONS

- A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C 168. In this Section, these values are the result of the formula $\text{Btu} \times \text{in}/\text{h} \times \text{sq. ft.} \times \text{deg F}$ at the temperature differences specified. Values are expressed in Btu.
 - 1. Example: Apparent Thermal Conductivity (k-Value): 0.26 or 0.037.

1.4 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select and size air-moving and -distribution equipment and other components of air system. 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.

1.5 SUBMITTALS

- A. Product Data: For duct liner and sealing materials.
- B. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
 - 1. Ceiling suspension assembly equipment Variable Air Volume w/reheat hot water coils.
 - 2. Overall primary double line duct layout.
 - 3. Coordination with ceiling mounted items, including ceiling mounted equipment, light fixtures, diffusers, grilles, sprinkler heads, access panels, and special moldings.
- C. Submit as built drawings showing all fire dampers, balancing dampers, splitter dampers, VAV boxes, smoke dampers and other equipment in duct work served by the individual AHUs.
 - 1. Ductwork Shop Drawings including:
 - a. Overall primary double line duct layout.
 - b. Dimensions, elevations, and sections as required showing clearances, methods of support, and details of installation.
 - c. Locations of auxiliary equipment.
 - d. Dimensions of each duct section.

1.6 QUALITY ASSURANCE

- A. Welding Standards: Qualify welding procedures and welding personnel to perform welding processes for this Project according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports; AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members; and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. The project entails an open space layout; coordination for esthetic is of outmost importance. Coordinate exposed duct runs with architectural structure, ceiling-mounted items, including lighting fixtures, speakers, sprinkler heads, access panels, louvers, windows and special moldings.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver sealant and firestopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multicomponent materials.
- B. Store and handle sealant and firestopping materials according to manufacturer's written recommendations.

- C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

- A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, G90 coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.
- B. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts.
- C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 DUCT LINER

- A. General: Comply with NFPA 90A or NFPA 90B and NAIMA's "Fibrous Glass Duct Liner Standard."
- B. Materials: ASTM C 1071 with coated surface exposed to airstream to prevent erosion of glass fibers.
 - 1. Thickness: 1-1/2 inches.
 - 2. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - 3. Fire-Hazard Classification: Maximum flame-spread rating of 25 and smoke-developed rating of 50, when tested according to ASTM C 411.
 - 4. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and ASTM C 916.
 - 5. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
 - a. Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
 - b. Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
 - c. Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

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.
 - 1. Joint and Seam Tape: 2 inches wide; glass-fiber fabric reinforced.

2. Tape Sealing System: Woven-fiber tape impregnated with a gypsum mineral compound and a modified acrylic/silicone activator to react exothermically with tape to form a hard, durable, airtight seal.
3. Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant, formulated with a minimum of 75 percent solids.
4. Flanged Joint Mastics: One-part, acid-curing, silicone, elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

2.4 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for building materials.
 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- B. Hanger Materials: Galvanized, sheet steel or round, threaded steel rod.
 1. Hangers Installed in exposed areas shall be all-thread rod or galvanized rods with threads painted after installation. Hangers for round exposed duct shall be pipe U bolt type hangers.
 2. Straps and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for sheet steel 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.
- D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
 1. Supports for Galvanized-Steel Ducts: Galvanized steel shapes and plates.

2.5 RECTANGULAR DUCT FABRICATION

- A. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction with galvanized, sheet steel, according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Comply 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 classification.
 2. Materials: Free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.
- B. Static-Pressure Classifications: Unless otherwise indicated, construct ducts to the following:
 1. Primary Supply Duct: 5-inch wg.
 2. Secondary Supply Duct: 3-inch wg.
 3. Supply Ducts: 3-inch wg.

4. Return Ducts: 2-inch wg. negative pressure.
 5. Exhaust Ducts: 2-inch wg. negative pressure.
- C. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of unbraced panel area.

2.6 SHOP APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Adhere a single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness are prohibited.
- B. Apply adhesive to liner facing in direction of airflow not receiving metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.
- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liners in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
- G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profile or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 1. Fan discharge.
 2. Intervals of lined duct preceding unlined duct.
 3. Upstream edges of transverse joints in ducts.
- I. Terminate liner with duct buildouts installed in ducts to attach dampers, turning vane assemblies, and other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct wall with bolts, screws, rivets, or welds. Terminate liner at fire dampers at connection to fire-damper sleeve.

2.7 ROUND AND OVAL DUCT FABRICATION

- A. Round Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Double-Wall (Insulated) Ducts: Factory fabricated double-wall (insulated) ducts with an outer shell and perforated inner liner. Dimensions indicated on internally insulated ducts are inside dimensions.

1. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
2. Outer Shell: Base outer-shell metal thickness on actual outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner shell and insulation, and in metal thickness specified for single-wall duct.
3. Insulation: 2-inch- thick fibrous-glass insulation, unless otherwise indicated. Terminate insulation where internally insulated duct connects to single-wall duct or uninsulated components. Terminate insulation and reduce outer duct diameter to inner liner diameter.
4. Perforated Inner Liner: Fabricate round inner liners with sheet metal having 3/32-inch-diameter perforations, with an overall open area of 23 percent. Use the following sheet metal thicknesses and seam construction:
 - a. Ducts 3 to 8 Inches in Diameter: 0.019 inch with standard spiral seam construction.
 - b. Ducts 9 to 42 Inches in Diameter: 0.019 inch with single-rib spiral seam construction.
 - c. Ducts 44 to 60 Inches in Diameter: 0.022 inch with single-rib spiral seam construction.
5. Maintain concentricity of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.

2.8 ROUND SUPPLY AND EXHAUST FITTING FABRICATION

- A. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal seam straight duct.
- B. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.
- C. Elbows: Fabricate in die-formed, gored, pleated, or mitered construction. Fabricate bend radius of die-formed, gored, and pleated elbows one and one-half times elbow diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg :
 - a. Ducts 3 to 26 Inches in Diameter: 0.028 inch.
 - b. Ducts 27 to 36 Inches in Diameter: 0.034 inch .
 - c. Ducts 37 to 50 Inches in Diameter: 0.040 inch .
 - d. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
 3. 90-Degree, Two-Piece, Mitered Elbows: Use only for supply systems, or exhaust systems for material-handling classes A and B; and only where space restrictions do not permit using 1.5 bend radius elbows. Fabricate with single-thickness turning vanes.
 4. Round Elbows, 8 Inches and Smaller: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate

- nonstandard bend-angle configuration or nonstandard diameter elbows with gored construction.
5. Round Elbows, 9 through 14 Inches: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees, unless space restrictions require a mitered elbow. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with gored construction.
 6. Round Elbows, Larger than 14 Inches, and All Flat-Oval Elbows: Fabricate gored elbows, unless space restrictions require a mitered elbow.
 7. Die-Formed Elbows for Sizes through 8 Inches and All Pressures: 0.040 inch thick with two-piece welded construction.
 8. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
- D. Double-Wall (Insulated) Fittings: Fabricate double-wall (insulated) fittings with an outer shell and an inner liner. Dimensions indicated on internally insulated ducts are inside dimensions.
1. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 2. Outer Shell: Base outer-shell metal thickness on actual outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner shell and insulation. Use the same metal thicknesses for outer duct as for uninsulated fittings.
 3. Insulation: 2-inch- thick fibrous-glass insulation, unless otherwise indicated. Terminate insulation where internally insulated duct connects to single-wall duct or uninsulated components. Terminate insulation and reduce outer duct diameter to nominal single-wall size.
 4. Perforated Inner Liner: Fabricate round and flat-oval inner liners with sheet metal having 3/32-inch- diameter perforations, with an overall open area of 23 percent. Use the following sheet metal thicknesses:
 - a. Ducts 3 to 34 Inches in Diameter: 0.028 inch.
 - b. Ducts 35 to 58 Inches in Diameter: 0.034 inch.
 5. Maintain concentricity of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION, GENERAL

- A. Duct installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts, fittings, and accessories.
- B. Construct and install each duct system for the specific duct pressure classification indicated.
- C. Install round ducts in lengths not less than 12 feet, unless interrupted by fittings.
- D. Install ducts with fewest possible joints.
- E. Install fabricated fittings for changes in directions, changes in size and shape, and connections.
- F. Install couplings tight to duct wall surface with a minimum of projections into duct.

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- G. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.
 - H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
 - I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
 - J. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.
 - K. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
 - L. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
 - M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 2 inches.
 - N. Fire-Rated Partition Penetrations: Where ducts pass through interior partition walls, install appropriately rated fire damper, sleeve, and firestopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Firestopping."
- 3.2 SEAM AND JOINT SEALING
- A. General: Seal duct seams and joints according to the duct pressure class indicated and as described in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
 - B. Pressure Classification Less than 2-Inch wg : Transverse joints.
 - C. Seal externally insulated ducts before insulation installation.
 - D. Existing duct to remain shall be sealed externally and reinsulated.
- 3.3 HANGING AND SUPPORTING
- A. Install rigid round and rectangular metal duct with support systems indicated in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
 - B. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
 - C. Support vertical ducts at a maximum interval of 16 feet and at each floor.
 - D. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure load.

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- E. Install concrete inserts before placing concrete.
- F. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3.4 CONNECTIONS

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

3.5 FIELD QUALITY CONTROL

- A. Disassemble, reassemble, and seal segments of systems as required to accommodate leakage testing and as required for compliance with test requirements.
- B. Conduct tests, in presence of Owner Representative (Architect), at static pressures equal to maximum design pressure of system or section being tested. If pressure classifications are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
- C. Determine leakage from entire system or section of system by relating leakage to surface area of test section.
- D. Maximum Allowable Leakage: Comply with requirements for Leakage Classification 3 for round and flat-oval ducts, Leakage Classification 12 for rectangular ducts in pressure classifications less than and equal to 2-inch wg (both positive and negative pressures), and Leakage Classification 6 for pressure classifications from 2- to 10-inch wg
- E. Remake leaking joints until leakage is less than maximum allowable.

3.6 ADJUSTING

- A. Adjust volume-control dampers in ducts, outlets, and inlets to achieve design airflow.
- B. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for detailed procedures.

3.7 CLEANING

- A. During construction Vacuum existing duct to remain to remove dust and debris.
- B. After completing system installation, including outlet fittings and devices, inspect the system. Vacuum ducts before final acceptance to remove dust and debris.

END OF SECTION

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. Backdraft dampers.
2. Manual-volume dampers.
3. Fire and smoke dampers.
4. Duct silencers.
5. Turning vanes.
6. Duct-mounted access doors and panels.
7. Flexible ducts.
8. Flexible connectors.
9. Duct accessory hardware.

- B. Related Sections include the following:

1. Division 8 Section "Access Doors" for wall- and ceiling-mounted access doors and panels.
2. Division 10 Section "Louvers and Vents" for intake and relief louvers and vents connected to ducts and installed in exterior walls.
3. Division 15 Section "Diffusers, Registers, and Grilles."
4. Division 15 Section "Building Management System" for electric damper actuators.
5. Division 16 Section "Fire Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 SUBMITTALS

- A. Product Data: For the following:

1. Backdraft dampers.
2. Manual-volume dampers.
3. Fire and smoke dampers.
4. Duct silencers.
5. Duct-mounted access doors and panels.
6. Flexible ducts.
7. Turning Vanes.

- B. Product Certificates: Submit certified test data on dynamic insertion loss; self-noise power levels; and airflow performance data, static-pressure loss, dimensions, and weights.

1.4 QUALITY ASSURANCE

- A. NFPA Compliance: Comply with the following NFPA standards:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

- A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, G90 coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.
- B. Extruded Aluminum: ASTM B 221, Alloy 6063, Temper T6.
- C. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT DAMPERS

- A. Description: Suitable for horizontal or vertical installations.
- B. Frame: 0.052-inch- (1.3-mm-) thick, galvanized, sheet steel, with welded corners.
- C. Blades: 0.025-inch- thick, roll-formed aluminum.
- D. Blade Seals: Neoprene.
- E. Blade Axles: Galvanized steel.
- F. Tie Bars and Brackets: Galvanized steel.
- G. Return Spring: Adjustable tension.

2.3 MANUAL-VOLUME DAMPERS

- A. General: Factory fabricated with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classifications of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
 - B. Standard Volume Dampers: single-blade design as indicated, standard leakage rating, and suitable for horizontal or vertical applications.
 1. Steel Frames: Hat-shaped, galvanized, sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
 2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized, sheet steel.
 3. Blade Axles: Galvanized steel.
 4. Tie Bars and Brackets: Galvanized steel.
 - C. Low-Leakage Volume Dampers: Multiple-opposed-blade design as indicated, low-leakage rating, and suitable for horizontal or vertical applications.
 1. Steel Frames: Hat-shaped, galvanized, sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
 2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized, sheet steel.
 3. Blade Seals: Neoprene.
 4. Blade Axles: Galvanized steel.
 5. Tie Bars and Brackets: Galvanized steel.
 - D. High-Performance Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
 1. Steel Frames: Hat-shaped, galvanized steel channels, minimum of 0.064 inch (1.62 mm) thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
 2. Steel Blades: 0.052-inch- thick, galvanized, sheet steel; airfoil shaped.
 3. Blade Seals: Dual-durometer vinyl on blade edges; metallic compression on jambs.
 4. Blade Axles: Galvanized steel.
 5. Tie Bars and Brackets: Galvanized steel.
 - E. Jackshaft: 1-inch-diameter galvanized steel pipe rotating within a pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 1. Length and Number of Mountings: Appropriate to connect linkage of each damper of a multiple-damper assembly.
 - F. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.
- 2.4 FIRE DAMPERS
- A. General: Labeled to UL 555.

- B. Fire Rating: One and one-half hours.
- C. Frame: SMACNA Type B with blades out of airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- D. Mounting Sleeve: Factory- or field-installed galvanized, sheet steel.
 - 1. Minimum Thickness: 0.138 inch thick and length to suit application.
 - 2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.
- E. Mounting Orientation: Vertical or horizontal as indicated.
- F. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized, sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized steel blade connectors.
- G. Horizontal Dampers: Include a blade lock and stainless-steel negator closure spring.
- H. Fusible Link: Replaceable, 165 deg F rating.

2.5 CEILING FIRE DAMPERS

- A. General: Labeled to UL 555C; comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."
- B. Frame: 0.040-inch-thick, galvanized, sheet steel; round or rectangular; style to suit ceiling construction.
- C. Blades: 0.034-inch-thick, galvanized, sheet steel with nonasbestos refractory insulation.
- D. Fusible Link: Replaceable, 165 deg F rated.

2.6 SMOKE DAMPERS

- A. General: Labeled to UL 555S. Combination fire and smoke dampers shall be labeled for one-and-one-half-hour rating to UL 555.
- B. Fusible Link: Replaceable, 165 deg F rating.
- C. Frame and Blades: 0.064-inch-thick, galvanized, sheet steel.
- D. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized, sheet steel; length to suit wall or floor application.
- E. Damper Motors: Provide for two-position action.
 - 1. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

2. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf .
3. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf
4. Two-Position Motor: 115 V, single phase, 60 Hz.

2.7 DUCT SILENCERS

- A. General: Factory-fabricated and -tested, round or rectangular silencer with performance characteristics and physical requirements as indicated.
- B. Fire Performance: Adhesives, sealers, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame spread and 50 for smoke developed when tested according to ASTM E 84.
- C. Rectangular Units: Fabricate casings with a minimum of 0.034-inch- thick, solid sheet metal for outer casing and 0.022-inch- thick, perforated sheet metal for inner casing.
- D. Sheet Metal Perforations: 1/8-inch diameter for inner casing and baffle sheet metal.
- E. Fibrous Acoustic-Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression.
- F. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.
 1. Do not use nuts, bolts, and sheet metal screws for unit assemblies.
 2. Lock form and seal or continuously weld joints.
 3. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 4. Reinforcement: Cross or trapeze angles for rigid suspension.
- G. Source Quality Control: Perform the following factory tests:
 1. Acoustic Performance: Test according to ASTM E 477, with airflow in both directions through silencer.
 2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels, for both forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) with an airflow of at least 2000-fpm face velocity.

2.8 TURNING VANES

- A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

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- B. Manufactured Turning Vanes: Fabricate of 1-1/2-inch- wide, curved blades set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into side strips suitable for mounting in ducts.
- C. Acoustic Turning Vanes: Fabricate of airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.9 DUCT MOUNTED ACCESS DOORS AND PANELS

- A. General: Fabricate doors and panels airtight and suitable for duct pressure class.
- B. Frame: Galvanized, sheet steel, with bend-over tabs and foam gaskets.
- C. Door: Double-wall, galvanized, sheet metal construction with insulation fill and thickness, and number of hinges and locks as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.
- D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
- E. Insulation: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.10 FLEXIBLE CONNECTORS

- A. General: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- B. Standard Metal-Edged Connectors: Factory fabricated with a strip of fabric 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized, sheet steel or 0.032-inch aluminum sheets. Select metal compatible with connected ducts.
- C. Extra-Wide Metal-Edged Connectors: Factory fabricated with a strip of fabric 5-3/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized, sheet steel or 0.032-inch aluminum sheets. Select metal compatible with connected ducts.
- D. Conventional, Outdoor System Flexible Connector Fabric: Glass fabric double coated with a synthetic-rubber, weatherproof coating resistant to the sun's ultraviolet rays and ozone environment.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 530 lbf/inch in the warp, and 440 lbf/inch in the filling.

2.11 FLEXIBLE DUCTS

- A. General: Comply with UL 181, Class 1.
- B. Flexible Ducts, Field insulated: Corrugated aluminum for primary air terminal equipment connection.

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- C. Flexible Ducts, Insulated: Factory-fabricated, insulated, round duct, with an outer jacket enclosing 1-1/2-inch- thick, glass-fiber insulation around a continuous inner liner.
 - 1. Reinforcement: Steel-wire helix encapsulated in inner liner.
 - 2. Outer Jacket: Reinforced metalized film outer vapor barrier wrap.
 - 3. Inner Liner: Polyethylene film.
- D. Pressure Rating: 2-inch wg positive, 1/2-inch wg negative.

2.12 ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments, and length to suit duct insulation thickness.
- B. Splitter Damper Accessories: Zinc-plated damper blade bracket; 1/4-inch, zinc-plated operating rod; and a duct-mounted, ball-joint bracket with flat rubber gasket and square-head set screw.
- C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 to 18 inches to suit duct size.
- D. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details shown in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and NAIMA's "Fibrous Glass Duct Construction Standards" for fibrous-glass ducts.
- B. Install volume dampers in lined duct; avoid damage to and erosion of duct liner.
- C. Provide test holes at fan inlet and outlet and elsewhere as indicated.
- D. Install fire and smoke dampers according to manufacturer's UL-approved written instructions.
 - 1. Install fusible links in fire dampers.
- E. Install duct access panels downstream from volume dampers, fire dampers, turning vanes, and equipment.
 - 1. Install duct access panels to allow access to interior of ducts for cleaning, inspecting, adjusting, and maintaining accessories and terminal units.
 - 2. Install access panels on side of duct where adequate clearance is available.
- F. Label access doors according to Division 15 Section "Mechanical Identification."

3.2 ADJUSTING

- A. Adjust duct accessories for proper settings.
- B. Adjust fire and smoke dampers for proper action.
- C. Final positioning of manual-volume dampers is specified in Division 15 Section "Testing, Adjusting, and Balancing."

END OF SECTION

SECTION 15830

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. Centrifugal roof ventilators.
 - 2. Upblast propeller roof exhaust fans.
 - 3. High-Plume Dilution Laboratory Exhaust System
 - 4. In-line centrifugal fans.

1.3 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.
 - 6. Variable Frequency Drives, Starters and Disconnects.
- 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.
 - 2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
 - 3. Roof framing and support members relative to duct penetrations.
 - 4. Size and location of initial access modules for acoustical tile.

5. Provide dimensional drawings and product data on each high-plume dilution laboratory exhaust fan assembly.
 6. Provide fan curves for each fan at the specified operation point with the flow, static pressure and horsepower clearly plotted.
 7. Provide nozzle velocity of exhaust fan, total exhaust flow, and discharge plume rise at specified wind velocity.
 8. Strictly adhere to QUALITY ASSURANCE requirements as stated in section 1.4 of this specification.
- C. Maintenance Data: For power ventilators to include in maintenance manuals specified in Division 1.

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. AMCA compliance below is optional requirement and not necessarily available from all manufacturers.
- B. Performance ratings: Conform to AMCA standard 211 and 311. Fans must be tested in accordance with AMCA 211 and 311 in an AMCA accredited laboratory. Fan shall be licensed to bear the AMCA ratings seal for air performance.
- C. Classification for Spark Resistant Construction Conform to AMCA 99.
- D. Each fan shall be vibration tested before shipping. Each assembled fan shall be test run at the factory at the specified fan RPM, and vibration signatures shall be taken on each bearing in three planes - horizontal, vertical, and axial. The maximum allowable fan vibration shall be less than 0.08 in./sec peak velocity, filter-in reading as measured at the fan RPM. This report shall be provided at no charge to the customer upon request.
- E. The manufacturer shall also provide, at the owner & engineer's option and expense, witness testing of fan discharge and entrainment airflow, performed in an AMCA accredited laboratory, in accordance with AMCA 210. This test shall verify the critical and safety related dilution performance of the high plume dilution blower, as stated by the manufacturer. This test shall be performed in the submittal stage of the project.
- F. Vektor laboratory exhaust system shall have a 36-month warranty.

1.5 REFERENCES

- A. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- B. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- C. UL Standard: Power ventilators shall comply with UL 705.
- D. AMCA -99 Standards Handbook

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- E. ANSI/AMCA Standard 210-99, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating"
 - F. AMCA Publication 211-05, "Certified Ratings Program - Product Rating Manual for Fan Air Performance"
 - G. AMCA Standard 300-96, "Reverberant Room Method for Sound Testing of Fans"
 - H. AMCA Publication 311-05, "Certified Ratings Program"
 - I. AMBA Method of Evaluating Load Ratings of Bearings ANSI-11 (r1999).
 - J. ANSI/AMCA Standard 204-05, "Balance Quality and Vibration Levels for Fans"
 - K. AMCA Standard 500-D-98, "Laboratory Methods of Testing Dampers For Rating"
 - L. AMCA Standard 500-L-99, "Laboratory Methods of Testing Louvers For Rating"
 - M. SMACNA - Medium Pressure Plenum Construction Standard.
 - N. ANSI Z9.5 - Laboratory Design
 - O. ASHRAE - Laboratory Design Guide
- 1.6 DELIVERY, STORAGE, AND HANDLING
- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
 - B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
 - C. Lift and support units with manufacturer's designated lifting or supporting points.
- 1.6 COORDINATION
- A. Coordinate size and location of structural-steel support members.
 - C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."
 - D. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."
- 1.7 EXTRA MATERIALS
- A. Belts: One for each belt-driven unit.

PART 2 PRODUCTS

2.1 GENERAL

A. Testing and Ratings

1. Fans shall be tested and rated in accordance with AMCA 210.

B. Drives

1. V-Belt drives shall be designed for not less than 150% of connected driving capacity and motor sheaves shall be adjustable to provide not less than 20% speed variation. Sheaves shall be selected to drive the fan at a speed to produce the scheduled capacity indicated on the drawings when set at the approximate midpoint of the sheave adjustment. Motors with V-belt drives shall be provided with adjustable bases.

C. Balancing

1. Fan wheels shall be statically and dynamically balanced.

D. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

E. Starter and Disconnects

1. Starters, Speed controllers and disconnects shall be furnished by equipment supplier.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or stainless steel wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

2.2 DUCTED ROOF EXHAUST FANS

A. Direct and Belt Drive Centrifugal

1. Roof exhaust fans shall be centrifugal type. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced. The fan housing and shroud shall be constructed of heavy gauge aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.

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2. The fan housing and shroud shall be constructed of heavy gauge aluminum with a rigid internal support structure. The fan shroud shall have a rolled bead for added strength.
3. Motors shall be mounted out of the airstream on vibration isolators. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants.
4. Motors shall be readily accessible for maintenance.
 - a. Direct Drive Fans:
 - 1) A disconnect switch shall be factory installed and wired from the motor compartment for ease of electrical wiring.
 - b. Belt Drive Fans:
 - 1) Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure.
 - 2) Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.
 - 3) Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings.
 - 4) Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed.
 - 5) Drives shall be sized for a minimum of 150% of driven horsepower.
 - 6) Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor pulleys shall be adjustable for final system balancing.
 - 7) A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment.
 - 8) A fan conduit chase shall be provided through the curb cap to the motor compartment for ease of installation.
5. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance.
6. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.
7. Fans shall be by the following manufactures or equal:

Acme Engineering & Mfg. Corp.
Cook, Loren Company.
Greenheck Fan Corp.; Models G and GB (Basis of Design)
Penn Ventilation Companies, Inc.

2.3 ROOF MOUNTED- ROOF EXHAUST FANS

A. Centrifugal Upblast Roof Mounted Fans

1. Roof exhaust fans shall be upblast centrifugal direct or belt drive type. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
2. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. Windbands shall have a rolled bead for added strength and shall be joined to curbcaps with a leakproof, continuously welded seam.
3. Motors shall be mounted out of the airstream on vibration isolators. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance.
 - 1) A disconnect switch shall be factory installed and wired from the fan motor to a junction box within the motor compartment. A conduit chase shall be provided through the curb cap to the motor compartment for ease of electrical wiring
 - 2) Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure.
 - 3) Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.
 - 4) Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed.
 - 5) Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
 - 6) Motor pulleys shall be adjustable for final system balancing. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A conduit chase shall be provided through the curb cap to the motor compartment for ease of electrical wiring.
4. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance.
5. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.
6. Fans shall be by the following manufactures or equal:
 - Acme Engineering & Mfg. Corp.
 - Cook, Loren Company.
 - Greenheck Fan Corp.
 - Penn Ventilation Companies, Inc

2.4 High-Plume Dilution Laboratory Exhaust System

A. General:

1. Base fan performance at standard conditions (density 0.075 Lb/ft³).

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2. Each fan shall be direct driven in AMCA arrangement 2 according to drawings.
3. Fans to be equipped with 316 stainless steel lifting lugs for corrosion resistance.
4. Fan, plenum and dampers shall be coated with a minimum of 4 mils of corrosion resistant Hi-Pro Polyester resin, electrostatically applied and baked. Coating shall be impervious to degradation when exposed to sunlight (UV). Finish color shall be gray.
5. Fasteners exposed to corrosive exhaust shall be stainless steel.
6. Curb cap shall be 316 stainless steel for corrosion resistance.
7. Fan assemblies that use flexible connectors that can fail and cause loss of laboratory containment shall not be acceptable.
8. Fan assembly shall be designed for a minimum of 125-mph wind loading, without the use of guy wires.

B. FAN HOUSING AND OUTLET

1. Base fan performance at standard conditions (density 0.075 Lb/ft3).
2. Each fan shall be direct driven in AMCA arrangement 2 according to drawings.
3. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
4. Fan housing shall be bifurcated, allowing all drive components, including the motor, to be serviced without contact of the contaminated air stream. Must be manufactured of welded steel, coated with minimum 4 mils of Hi-Pro Polyester resin, electrostatically applied and baked. Finish color shall be gray. No uncoated metal fan parts will be acceptable.
5. Fan housings that are fabricated of polypropylene or fiberglass that have lower mechanical properties than steel, have rough interior surfaces in which corrosive, hazardous compounds can collect, and / or which chalk and structurally degrade due to the UV component of the sunlight shall not be acceptable.
6. A multi-stage air induction discharge nozzle shall be supplied by the fan manufacturer, be integral to the fan body, and be designed to efficiently handle an outlet velocity of up to 7000 FPM. The multi-stage nozzle shall induce ambient air up to 270% of fan capacity. Nozzle / Windband assemblies that are manufactured by third party vendors, or that are fabricated of plastic or resins, having mechanical properties less than steel shall not be acceptable.
7. If stated in the schedule notes, an optional induction discharge windband, including an integral packed acoustic attenuator fabricated of corrosion-resistant coated steel and a perforated 304 stainless steel inner liner, shall be provided by the fan manufacturer. The acoustic attenuation windband shall not increase the overall height of the fan / nozzle assembly. Acoustic insertion loss shall be as follows:

63	125	250	500	1K	2K	4K	8K
0	5	6	15	20	13	13	10

8. An integral fan housing drain shall be used to drain rainwater when the fan is de-energized.
9. A bolted & gasketed access door shall be supplied for impeller inspection and service.
10. Fan assembly shall be AMCA type C spark resistant construction minimum or as noted on the schedule.

C. FAN IMPELLER

1. Fan impeller shall be mixed flow design with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically exceeding AMCA Standards.
2. Fan impeller shall be manufactured of welded and coated steel with minimum 4 mils of Hi-Pro Polyester resin electrostatically applied and baked. Finish color shall be gray.
3. Fan impellers that are fabricated of polypropylene or fiberglass that have lower mechanical properties than steel and lower maximum tip speeds are not acceptable.
4. Vacuum Seal : Fan impeller shall include a secondary fan blade located on the impeller back plate. This secondary impeller shall create a negative pressure at the shaft opening; preventing hazardous or toxic exhaust fumes from escaping through the housing shaft opening. Mechanical shaft seals that wear out and need to be replaced or seal systems that use hoses or tubes that can leak, are not acceptable.

D. BYPASS-AIR PLENUM

1. A bypass-air plenum shall be provided as shown on drawings. The plenum shall be provided with bypass-air damper(s) for introducing outside air at roof level upstream of the fan, complete with bypass-air rain hood and bird screen.
2. The plenum shall be constructed of welded cold rolled steel, and coated with minimum 4 mils of Hi-Pro Polyester resin, electrostatically applied and baked. Plenums that are fabricated of plastics or resin that are combustible and have mechanical properties less than steel shall not be acceptable.
3. The bypass-air plenum shall be mounted on factory fabricated roof curb provided by the fan manufacturer, as shown on the project drawings (see section 2.5).
4. Fan designs that use inlet flexible connectors that can leak causing loss of lab exhaust shall not be permitted.
5. Bypass air damper(s) shall be opposed-blade design for airflow control, airfoil design, fabricated of steel for structural rigidity, and coated with a minimum of 4 mils of chemically resistant Hi-Pro Polyester resin, electrostatically applied and baked. Bypass dampers shall have stainless steel damper rods, bearings and jamb seals and the blades shall have polymer edge seals. Dampers shall be suitable for application up to 15 inches w.g. Damper blade drive linkage shall be set by manufacture and welded to eliminate linkage slippage. All damper access and service (drive actuators) shall be performed outside of the contaminated plenum interior.
6. Damper shall include a factory mounted and wired actuator, complete with a mounted and wired step down transformer wired to the fan disconnect. Transformer shall be mounted in a NEMA 3R panel, minimum, or that shown on the schedule notes.
7. Blower / Plenum vibration isolation shall be limited to neoprene / cork vibration pads.

E. BYPASS-AIR PLENUM

1. BYPASS-AIR PLENUM CURB
2. Exhaust system manufacturer shall supply a structural support curb for the plenum of specified height as shown on the drawings.
3. Curb shall be fabricated of a minimum of 12 gauge corrosion-resistant coated steel and structurally reinforced.
4. Vertical exhaust inlet plenums shall have curbs that are insulated. Horizontal exhaust inlet plenums shall have un-insulated plenums.

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5. When properly anchored to the roof structure, the standard curb / plenum / blower assembly shall withstand wind loads of up to 125 mph without additional structural support.

F. FAN MOTOR AND DRIVE

1. Motors shall be premium efficiency, standard NEMA frame, 900, 1200, or 1800 RPM, TEFC with a 1.15 service factor, as scheduled. A factory-mounted NEMA 3R disconnect switch, mounted and wired, shall be provided for each fan. Motor maintenance shall be accomplished without fan or fan impeller removal, or requiring maintenance personnel to access the contaminated exhaust components.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Ceiling Units: Suspend units from structure; Install power ventilators level and plumb. Ceiling exhaust fans shall be supported by 1" x 16 gauge galvanized steel straps secured to each corner of the fan housing and to overhead building structural members. Straps shall be attached to fan housing with not less than 2 sheet metal screws per strap. In steel bar joist construction, straps shall be looped around the bottom chord of joists and fastened with not less than 2 sheet metal screws through the strap to secure the loop.
- B. Support suspended units from structure using threaded steel rods and spring hangers. Ceiling mounted fan use steel wire or metal straps
- C. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs. Roof exhaust fans shall be provided with factory supplied roof curbs or field fabricated railings to match roof structure and pitch.
- D. Wall mounted fans shall be secured to structure with bolts and nuts. Provide vibration isolation between fan housing and building structure.
- E. Install units with clearances for service and maintenance.
- F. Label units according to requirements specified in Division 15 Section "Mechanical Identification."
- G. All fans shall be installed per manufacturer's installation instructions.
- H. All fans shall be balanced field adjust and isolate to avoid all mechanical vibrations.
- I. Hood mounted exhaust utility fans shall be furnished with

3.2 CONNECTIONS

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SECTION – 15830 - FANS

- A. Coordinate duct installation and specialty arrangements with schematics on Drawings and with requirements specified in duct systems. If Drawings are explicit enough, these requirements may be reduced or omitted.
- B. 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."
- C. Install stainless steel exhaust stack on roof mounted hood exhaust fans with guy wires.
- D. Install ducts adjacent to power ventilators to allow service and maintenance.
- E. Ground equipment.
- F. 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.
 - 7. Disable automatic temperature-control operators.
- 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.

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- 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 bypass damper(s) for proper cfm bypass and exhaust.
- C. Adjust belt tension.
- D. 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.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain power ventilators.
- B. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
- C. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
- D. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
- E. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION

SECTION 15840
AIR TERMINAL UNITS

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.
- B. Related Sections include the following:
 - 1. Division 15 Section "Hangers and Supports" for vibration isolation hangers and supports.
 - 2. Division 15 Section "Mechanical Insulation" for field-applied equipment insulation.
 - 3. Division 15 Section "Building Management System (BAS) for mechanical equipment.
 - 4. Division 16 Section "Disconnect Switches and Circuit Breakers" for field-installed disconnect switches.
 - 5. Division 16 Section "Motor Controllers" for field-mounted alternating-current.

1.2 SUMMARY

- A. Section Includes:
 - 1. Single-duct air terminal units with hot water coil

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated. Include a schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished.
- B. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.
- C. Delegated-Design Submittal:
 - 1. Materials, fabrication, assembly, and spacing of hangers and supports.
- D. Field quality-control reports.

- E. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 SINGLE-DUCT AIR TERMINAL UNITS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering air terminals that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide air terminals by one of the following:
 - 1. Carrier Corp.; Carrier Air Conditioning Div.
 - 2. Environmental Technologies.
 - 3. Trane Company (The); Commercial Systems Group
 - 4. York, A Johnson Control Company
- C. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- D. Factory-assembled, externally powered, variable air volume control terminal. Unit shall be complete with damper assembly, flow sensor, externally mounted volume controller, collars for duct connections, and all required features.
 - 1. UNIT CABINET:
 - a. Constructed of 22-gage galvanized steel with round, rectangular or flat oval inlet collar and rectangular discharge with slip and drive connection. Terminals shall be able to withstand a 125 hour salt spray test per ASTM B-117. The terminal casing shall be mechanically assembled (spot-welded casings are not acceptable). Casing shall be internally lined with 1" thick Foil Faced Insulation Insulation shall be covered with scrim backed foil facing. All insulation edges shall be covered with foil or metal nosing. Insulation shall meet ASTM C1136 for mold, mildew, and humidity resistance.
 - b. Insulation shall be rated for a maximum air velocity of 5000 f.p.m. Maximum thermal conductivity shall be .24 (BTU • in) / (hr • ft² • °F). Insulation must meet all requirements of ASTM C1071 (including C665), UL 181 for erosion, and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and NFPA 90A. Raw insulation edges on the discharge of the unit must be covered with metal liner to eliminate flaking of insulation during field duct connections. All

appurtenances including control assemblies, control enclosures, hot water heating coils, and electric heating coils shall not extend beyond the top and bottom of the unit casing. At an inlet velocity of 2000 f.p.m., the static pressure drop across the basic terminal or basic terminal with a sound attenuator shall not exceed .08" W.G. for all unit sizes.

2. PRIMARY AIR VALVE

- a. The primary air valve shall consist of a minimum 22 gauge cylindrical body that includes embossment rings for rigidity. The damper blade shall be connected to a solid shaft by means of an integral molded sleeve which does not require screw or bolt fasteners. The shaft shall be manufactured of a low thermal conducting composite material, and include a molded damper position indicator visible from the exterior of the unit. The damper shall pivot in self lubricating bearings. The damper actuator shall be mounted on the exterior of the terminal for ease of service. The valve assembly shall include internal mechanical stops for both full open and closed positions. The damper blade seal shall be secured without use of adhesives. The air valve leakage shall not exceed 1% of maximum inlet rated airflow at 3" W.G. inlet pressure.
- b. Air volume control damper shall be factory calibrated assembly consisting of air modulation damper and extension for connection to control actuator. All actuator linkage shall be protected by a sheet metal enclosure.

3. PRIMARY AIRFLOW SENSOR

- a. For inlet diameters 6" or greater, the differential pressure airflow sensor shall traverse the duct along two perpendicular diameters. Cylindrically shaped inlets shall utilize the equal cross sectional area or log-linear traverse method. Single axis sensor shall not be acceptable for duct diameters 6" or larger. A minimum of 12 total pressure sensing points shall be utilized. The total pressure inputs shall be averaged using a pressure chamber located at the center of the sensor. A sensor that delivers the differential pressure signal from one end of the sensor is not acceptable. The sensor shall output an amplified differential pressure signal that is at least 2.5 times the equivalent velocity pressure signal obtained from a conventional pitot tube. The sensor shall develop a differential pressure of 0.03" w.g. at an air velocity of < 450 FPM. Documentation shall be submitted which substantiates this requirement. Balancing taps and airflow calibration charts shall be provided for field airflow measurements.
- E. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
- F. Direct Digital Controls: Single-package unitary controller and actuator specified in Division 15 Section "Building Management System."

2.2 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- C. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.3 SOURCE QUALITY CONTROL

- A. Factory Tests: Test assembled air terminal units according to ARI 880.
 - 1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- C. Install wall-mounted thermostats.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 CONNECTIONS

- A. Install piping adjacent to air terminal unit to allow service and maintenance.
- B. Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- C. Connect ducts to air terminal units according to Division 15 Section "Metal Ducts."
- D. Make connections to air terminal units with flexible connectors complying with requirements in Division 15 Section "Duct Accessories."

3.4 IDENTIFICATION

- A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 15 Section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Air terminal unit will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.

3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

- A. Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION

SECTION 15850
HIGH-WALL HEAT PUMP UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

Indoor, wall-mounted, direct-expansion fan coil units to be matched with roof mounted heat pump units.

1.3 QUALITY ASSURANCE

Unit shall be rated per ARI Standards 210/240 and listed in the ARI directory as a matched system.

1.4 DELIVERY, STORAGE, AND HANDLING

Units shall be stored and handled per unit manufacturer's recommendations.

1.5 WARRANTY

One-year parts, 3-year compressor limited warranty

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

Carrier (Basis of Design: Refer to Drawings)
Sanyo
Mitsubishi
York
Trane

2.2 EQUIPMENT

A. GENERAL:

Indoor direct-expansion, wall-mounted fan coil. Unit shall be complete with cooling/heating (heat pump system) coil, fan, fan motor, piping connectors, electrical controls, microprocessor control system, and integral temperature sensing. Unit shall be furnished

with integral wall-mounting bracket and mounting hardware, and thermistor interconnection cable.

B. INDOOR UNIT

a. Unit Cabinet:

Indoor unit cabinet shall be equipped with an integral discharge and inlet grilles. Cabinet shall be fully insulated for improved thermal and acoustic performance.

b. Fans:

Fan shall be tangential direct-drive blower type with air intake at the upper front face of the unit and discharge at the bottom front. Automatic, motor-driven vertical air sweep shall be provided standard

Air sweep operation shall be user selectable. Horizontal direction may be manually adjusted (using remote controller) and vertical air sweep may be manually set.

c. Coil:

Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins shall be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a drain connection for hose attachment to remove condensate. Condensate pan shall have internal trap and auxiliary drip pan under coil header.

Note: The unit shall have an AccuRater® piston refrigerant metering device in the indoor unit (for cooling) and at the outdoor unit liquid line service valve for heating.

d. Motors:

Motors shall be open drip-proof, permanently lubricated ball bearing with inherent overload protection. Fan motors shall be 3-speed.

e. Controls:

Controls shall consist of a microprocessor-based control system which shall control space temperature, determine optimum fan speed, and run self diagnostics. The temperature control range shall be from 64 F to 84 F. The unit shall have the following functions as a minimum.

1. An automatic restart after power failure at the same operating conditions as at failure.
2. A timer function to provide a minimum 24-hour timer cycle for system Auto. Start/Stop.
3. Temperature-sensing controls shall sense return-air temperature. Indoor-air high discharge temperature shutdown shall be provided.
4. Indoor coil freeze protection.
5. Wireless infrared remote control to enter set points and operating conditions.
6. Auto Stop features shall have integral setback control.
7. Automatic airsweep control to provide on or off activation of airsweep louvers.
8. Dehumidification mode shall provide increased latent removal capability by modulating system operation and set point temperature.
9. Fan only operation shall provide room air circulation when no cooling is required.

10. Diagnostics shall provide continuous checks of unit operation and warn of possible malfunctions. Error messages shall be displayed at the unit and at the remote controller.
11. An indoor to outdoor thermistor connection cable shall be provided with the fan coil unit.
12. Fan speed control shall be user-selectable: high, medium, low, or microprocessor automatic operation during all operating modes.
13. A time delay shall prevent compressor restart in less than 3 minutes.
14. Automatic heating-to cooling changeover to provide automatic heating and cooling operation. Control shall include deadband to prevent rapid mode cycling.
15. Demand defrost shall be provided and shall minimize defrost cycles by internally adjusting defrost timing based on frost accumulation.
16. Indoor coil high temperature protection shall be provided to detect excessive indoor discharge temperature when unit is in heat pump mode.

f. Filters:

Unit shall have filter track with factory-supplied cleanable filters.

g. Electrical Requirements:

Unit shall operate on 115 V, 60 Hz power supply as specified on the equipment schedule. Power and control connections shall have terminal block connections.

h. Operating Characteristics:

The unit is to be supplied per schedule as called for on the drawings.

i. Refrigerant Lines:

The unit shall have rotatable refrigerant lines for penetration through the wall using flare connections and a 90-degree suction elbow shall be provided for rear connection.

C. CONDENSER:

- a. The unit is to be supplied per schedule as called for on the drawings. The design is based on Carrier. Alternatives of the same capacity can be considered. Height and foot print plus clearances required for air flow shall be such that the proposed equipment will operate satisfactory.
- b. Provide with motor starters, disconnect, and single point power connection.
- c. The unit shall be started and stopped by the Air Handler thermostat.
- d. The unit shall be complete with all controls and shall have a minimum 12. SEER.
- e. Refrigeration circuit components will include liquid and hot gas line, liquid line shut-off valve with sweat connections, suction shut-off valves with sweat connections, system charge of refrigerant R-22, compressor oil and accumulator. Refrigerant line shall be sized and be insulated per manufactures recommendation.
- f. Compressor shall be hermetically sealed against contamination. Compressor shall be externally mounted on the roof on rubber isolators for quiet operation.
- g. The split system unit includes a suction-tube accumulator that reduces the amount of liquid refrigerant that reaches the compressor, a low-pressure switch to stop the compressor if refrigerant charge is lost, and a crank case heater.
- h. Unit shall incorporate a defrost relay, defrost timer and low voltage terminations.
- i. Unit shall be equipped with totally enclosed fan motors for greater reliability under rain and snow conditions. The large wraparound copper tube coil and aluminum fins shall be

designed for optimum heat transfer during cooling. The vertical air discharge shall carry the sound and air up. Fan blades shall be statistically and dynamically balanced.

- j. Units shall be guaranteed for 1 (one) year for parts and 3 (three) years for the compressor beginning on the start-up date.
- k. Units shall be supplied with factory installed accessories like thermostatic expansion valve.
- l. Units shall be installed on the roof with Unirail roof curb.

PART 3 - EXECUTION

- 3.1 ALL EQUIPMENT shall be installed as recommended by the Manufacturer. The equipment shall be cleaned, adjusted, balanced, and placed into operation.
- A. Support the units per manufacturer's recommendations with supplier furnished concealed mounting brackets.
 - B. Clean or replace all filters before start up.
 - C. Place into operation and test for proper operation.
 - D. Furnish units with condensate pumps if gravity drainage is not possible. Check for proper drainage every unit.
 - E. Furnish DDC temperature sensors in the two IT Rooms for remote monitoring only.

END OF SECTION

SECTION 15855

DIFFUSERS, REGISTERS, AND GRILLES

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 ceiling- and wall-mounted diffusers, registers, and grilles.
- B. Related Sections include the following:
 - 1. Division 10 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
 - 2. Division 15 Section "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.
 - 3. Division 15 Section "Testing, Adjusting, and Balancing" for balancing diffusers, registers, and grilles.

1.3 DEFINITIONS

- A. Diffuser: Square air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.
- B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.
- C. Register: A combination grille and damper assembly over an air opening.

1.4 SUBMITTALS

- A. Product Data: For each model indicated, include the following:
 - 1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
 - 2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
 - 3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished.

4. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.

1.5 QUALITY ASSURANCE

- A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."
- B. NFPA Compliance: Install diffusers, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Diffusers, registers, and grilles are scheduled on Drawings.
- B. Products: Subject to compliance with requirements, provide one of the following:
 - a. Titus. (Basis of Design)
 - b. Air Systems Components; Krueger Div.
 - c. Price Industries.
 - d. Ruskin Company

2.2 AIR DISTRIBUTION DEVICES

- A. Air distribution devices shall be constructed of aluminum. See the Air Distribution Device schedule for the size and description of the air distribution devices.
- B. Wall mounted return grille shall be louvered face type with flanges. Grille shall be constructed of aluminum with clear anodized finish.
- C. Eggcrate grille shall provide 90% free area and 1/2"x1/2"x1/2" aluminum grid. Border width shall be 1 1/4" on all sides.
- D. Return mounted grilles shall be 3/16" diameter holes on 1/4" staggered. Frame shall be aluminum with baked off-white finish.
- E. Square ceiling diffuser shall be grid mounted, constructed of extruded aluminum with baked-off white enamel finish. Diffuser shall be multi-blade, fixed louver type furnished in four-way air diffusion. Diffuser shall be complete with an opposed blade damper.
- F. Linear louver diffusers shall be clear anodized aluminum, two-way diffusers. Diffuser core shall have fixed extruded deflection louvers. Frame shall be heavy duty extruded aluminum construction. Diffuser shall be complete with an opposed blade damper.

- G. Drum Louvers shall be constructed of heavy gauge extruded aluminum with 1 ¼” wide outer border. Corners shall be assembled with full penetration resistance welds with a reinforcing steel patch for extra strength. Drum shall rotate a minimum of 25⁰ up and down from center line of the diffuser. Extruded aluminum blades shall be individually adjustable. Louver shall be furnished with opposed blade dampers operable from the face of the register.
- H. Louvers shall be constructed of extruded aluminum with 4” deep stationary, drainable blades, and concealed blade supports. Blade thickness shall be minimum 0.081”. Frame thickness shall be minimum 0.081”. Minimum free are shall be 50%. Bird screen shall be 0.5” mesh attached to inside face of louver.
 - 1. Finish shall be prime coat for painted as indicated under Division 1, per Architect’s choice of finish.
 - 2. Main return air louver shall be circular.
 - 3. Control dampers shall be parallel multi-blade type design to withstand air velocities of 3,000 fpm. Motor operated dampers shall be parallel blade type provided with 120 volt, single phase electric operators for interlocking.
- I. Diffusers, registers, and grilles manual volume dampers shall be opposed blade type furnished complete with locking lever and quadrant with, stand-off mounting brackets.
- J. Roof Hoods for intake and relief shall be aluminum construction with 0.5” mesh bird screen, reinforcing angles, curb cap and roof curb. Roof Hoods shall be as manufactured by
 - a. Greenheck
 - b. PENN,
 - c. Loren Cook.

2.3 SOURCE QUALITY CONTROL

- A. Testing: Test performance according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, grilles and louver plumb, according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of the panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connection to flexible ducts and to allow service and maintenance of dampers, air extractors, and fire dampers. Ceiling mounted diffusers and grilles shall be connected with flex duct not to exceed 5 foot length.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.4 CLEANING

- A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION

SECTION 15900

BUILDING MANAGEMENT SYSTEM (BMS)

PART 1: GENERAL

The Building Management System shall be fully installed as a complete package by the Building Management System contractor. The system shall include all wiring, installation of services, calibrations, adjustments that are necessary for a complete and fully operational system in accordance to Fulton County Guidelines.

The Building Management System (BMS) shall provide a complete graphic floor plan showing all areas of the facility including room numbers, and space temperatures.

The BMS shall be connected and operable via the Fulton County LAN. The system shall also provide a modem backup via a dedicated telephone line.

All BMS components shall be of the same manufacturer with the BMS Contractor being responsible for any devices connected to the BMS system.

1.1 SECTION INCLUDES

- A. Description
- B. Related Work
- C. Approved Control System Contractor
- D. Quality Assurance
- E. System Performance
- F. Submittals
- G. Warranty

1.2. DEFINITIONS

- A. Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.
- B. Binary: A two-state system where an “ON” condition is represented by one discrete signal level and an “OFF” condition is represented by a second discrete signal level.
- C. Building Management System (BMS): The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division BMS Contractor and to be interfaced to the associated work of other related trades.
- D. BMS Contractor: The single Contractor to provide the work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the BMS work.
- E. Control Sequence: A BMS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.
- F. Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BMS software to provide direct closed-loop control for the designated equipment and

controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.

- G. BMS Network: The total digital on-line real-time interconnected configuration of BMS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.
- H. Node: A digitally programmable entity existing on the BMS network.
- I. BMS Integration: The complete functional and operational interconnection and interfacing of all BMS work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BMS as required by this Division.
- J. Provide: The term “Provide” and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.
- K. PC: IBM-compatible Personal Computer from a recognized major manufacturer.
- L. Furnish: The term “Furnish” and its derivatives when used in this Division shall mean supply at the BMS Contractor’s cost to the designated third party trade contractor for installation. BMS Contractor shall connect furnished items to the BMS, calibrate, test, commission, warrant and document.
- M. Wiring: The term “Wiring” and its derivatives when used in this Division shall mean provide the BMS wiring and terminations.
- N. Install: The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.
- O. Protocol: The term “protocol” and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between BMS network nodes.
- P. Software: The term “software” and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BMS industry for real-time, on-line, integrated BMS configurations.
- Q. The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.
- R. Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.
- S. The following abbreviations and acronyms may be used in describing the work of this Division:
 - ADC - Analog to Digital Converter
 - AI - Analog Input
 - AN - Application Node
 - ANSI - American National Standards Institute
 - AO - Analog Output
 - ASCII - American Standard Code for Information Interchange
 - ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers
 - AWG - American Wire Gauge
 - CPU - Central Processing Unit
 - CRT - Cathode Ray Tube
 - DAC - Digital to Analog Converter
 - DDC - Direct Digital Control

DI	-	Digital Input
DO	-	Digital Output
EEPROM	-	Electrically Erasable Programmable Read Only Memory
EMI	-	Electromagnetic Interference
FAS	-	Fire Alarm Detection and Annunciation System
GUI	-	Graphical User Interface
HOA	-	Hand-Off-Auto
ID	-	Identification
IEEE	-	Institute of Electrical and Electronics Engineers
I/O	-	Input/Output
LAN	-	Local Area Network
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
MCC	-	Motor Control Center
NC	-	Normally Closed
NIC	-	Not In Contract
NO	-	Normally Open
OWS	-	Operator Workstation
OAT	-	Outdoor Air Temperature
PC	-	Personal Computer
RAM	-	Random Access Memory
RF	-	Radio Frequency
RFI	-	Radio Frequency Interference
RH	-	Relative Humidity
ROM	-	Read Only Memory
RTD	-	Resistance Temperature Device
SPDT	-	Single Pole Double Throw
SPST	-	Single Pole Single Throw
XVGA	-	Extended Video Graphics Adapter
TBA	-	To Be Advised
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TTD	-	Thermistor Temperature Device
UPS	-	Uninterruptible Power Supply
VAC	-	Volts, Alternating Current
VAV	-	Variable Air Volume
VDC	-	Volts, Direct Current
WAN	-	Wide Area Network

1.3 DESCRIPTION

- A. General: The control system shall be as indicated on the drawings and described in the specifications.

The building central plant includes an existing chiller with constant volume primary pump and a cooling tower with a constant volume pump for chiller condenser and an addition pump for the WSHP. The plant has been upgraded with two boiler with primary and two secondary variable volume pumps with VFDs.

The building HVAC system includes three existing AHUs and one WSHP. Two central station AHUs and the WSHP are variable air volume units with cooling only coils. Each building zones has been provided with reheat VAV dampers through out with incremental control valves for reheat control. The second floor Library/meeting room is conditioned by a dedicated four pipe constant air, single zone AHU to be furnished with temperature and humidity control.

- B. The Building Management System (BMS) technology shall be used to provide the functions necessary for control of mechanical systems on this project.
- C. Devices residing on the automation network located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.
- D. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser.
- E. The work of the single BMS Contractor shall be as defined individually and collectively in all Sections of this Division specifications together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.
- F. The BMS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.
- G. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.
- H. Manage and coordinate the BMS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.
- I. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:
 - a. Operator information, alarm management and control functions.
 - b. Enterprise-level information and control access.
 - c. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
 - d. Diagnostic monitoring and reporting of BMS functions.
 - e. Offsite monitoring and management access.
 - f. Energy management

- g. Standard applications for terminal HVAC systems.
- h. Indoor Air Quality monitoring and control where indicated.
- J. The control system shall accommodate simultaneous multiple user operation. Access to the control system data should be limited only by operator password. Multiple users shall have access to all valid system data. An operator shall be able to log onto any workstation on the control system and have access to all appropriate data.
- K. The control system shall be designed such that each mechanical system will be able to operate under stand-alone control. As such, in the event of a network communication failure, or the loss of any other controller, the control system shall continue to independently operate under control.
- L. Communication between the control panels and all workstations shall be over a high-speed network. All nodes on this network shall be peers. The operator shall not have to know the panel identifier or location to view or control an object. Application Specific Controllers shall be constantly scanned by the network controllers to update point information and alarm information.
- M. The documentation is schematic in nature. The contractor shall provide hardware and software necessary to implement the functions and sequences shown.

1.4 INSTRUCTIONS TO BIDDERS

- A. All Bidders shall submit a Technical Compliance Statement stating full and complete compliance with the Technical Specification or any and all deviations or exceptions to the Technical Specification.
- B. Bidder is cautioned that the Owner reserves the right to reject any Bidder's Bid that, in the Owners sole judgment, takes meaningful deviation or exception to the Technical Specification in the Technical Compliance Statement and compatibility with existing Owners Energy Management System.

1.5 RELATED WORK

- A. All work of this Division shall be coordinated and provided by the single Building Management System (BMS) Contractor.
- B. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 15 Sections for details.
- C. The work of this Division shall be as required by the Specifications, Point Schedules, Drawings and true design intent.
- D. If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

- E. Smoke Detectors shall be furnished and specified and interlocked to the fire alarm system by Division 16, and Smoke detectors in supply and/or return ductwork shall be interlocked by the controls contractor to fan(s) for emergency shut down. Smoke detectors in supply and/or return ductwork shall be installed by Division 15 mechanical contractor.
- F. Master Emergency shut off switches shall be furnished and installed in hallway outside the central plant mechanical room.

1.6 QUALITY ASSURANCE

A. General

- 1. The Building Management System Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Management Systems.
- 2. The BMS Contractor shall be a recognized national manufacturer, installer and service provider of BMS.
- 3. The BMS Contractor shall have a branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.
- 4. As evidence and assurance of the contractor's ability to support the Owner's system with service and parts, the contractor must have been in the BMS business for at least the last ten (10) years and have successfully completed total projects of at least 10 times the value of this contract in each of the preceding five years.
- 5. The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.

B. Quality Management Program

- 1. The BMS Contractor shall be a recognized national manufacturer, installer and service provider of BMS.
- 2. Designate a competent and experienced employee to provide BMS Project Management. The designated Project Manger shall be empowered to make technical, scheduling and related decisions on behalf of the BMS Contractor. At minimum, the Project Manager shall:
 - a. Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.
 - b. Manage the financial aspects of the BMS Contract.
 - c. Coordinate as necessary with other trades.
 - d. Be responsible for the work and actions of the BMS workforce on site.

C. Codes and Standards: Meet requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.

- 1. Underwriters Laboratories: Products shall be UL-916-PAZX listed.

2. All work shall conform to the following Codes and Standards, as applicable:
3. National Fire Protection Association (NFPA) Standards.
4. National Electric Code (NEC) and applicable local Electric Code.
5. Underwriters Laboratories (UL) listing and labels.
6. UL 864 UUKL Smoke Control
7. UL 268 Smoke Detectors.
8. UL 916 Energy Management
9. NFPA 70 - National Electrical Code.
10. NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.
11. NFPA 92A and 92B Smoke Purge/Control Equipment.
12. Factory Mutual (FM).
13. American National Standards Institute (ANSI).
14. National Electric Manufacturer's Association (NEMA).
15. American Society of Mechanical Engineers (ASME).
16. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
17. Air Movement and Control Association (AMCA).
18. Institute of Electrical and Electronic Engineers (IEEE).
19. American Standard Code for Information Interchange (ASCII).
20. Electronics Industries Association (EIA).
21. Occupational Safety and Health Administration (OSHA).
22. American Society for Testing and Materials (ASTM).
23. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices.
24. Americans Disability Act (ADA)
25. ANSI/EIA 909.1-A-1999 (LonWorks)
- 24 ANSI/ASHRAE Standard 195-2004 (BACnet)
26. In the case of conflicts or discrepancies, the more stringent regulation shall apply.
27. All work shall meet the approval of the Authorities Having Jurisdiction at the project site.

- D. All products used in this installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of 2 years. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's representative in writing prior to bid date. Spare parts shall be available for at least 5 years after completion of this contract.
- 1.7 The demarcation of work and responsibilities between the BMS Contractor and other related trades shall be as outlined in the BMS RESPONSIBILITY MATRIX

BMS RESPONSIBILITY MATRIX				
WORK	FURNISH	INSTAL L	Low Volt. WIRING/TUB E	LINE POWER
BMS low voltage and communication wiring	BMS	BMS	BMS	N/A
VAV box nodes	BMS	15	BMS	16
BMS conduits and raceway	BMS	BMS	BMS	BMS
Automatic dampers	BMS	15	N/A	N/A
Manual valves	15	15	N/A	N/A
Automatic valves	BMS	15	BMS	N/A
VAV boxes	15	15	N/A	N/A
Pipe insertion devices and taps including thermowells, flow and pressure stations.	BMS	15	BMS	BMS
BMS Current Switches.	BMS	BMS	BMS	N/A
BMS Control Relays	BMS	BMS	BMS	N/A
Power distribution system monitoring interfaces	16	16	BMS	16
Concrete and/or inertia equipment pads and seismic bracing	15	15	N/A	N/A
BMS interface with Chiller controls	BMS	BMS	BMS	BMS
Chiller controls interface with BMS	15	15	BMS	16
BMS interface with Zone unit controls	BMS	BMS	BMS	16
Zone unit controls interface with BMS	15	15	BMS	16
All BMS Nodes, equipment, housings, enclosures and panels.	BMS	BMS	BMS	BMS
Smoke Detectors	16	15	16	16
Fire/Smoke Dampers	15	15	BMS	16
Fire Dampers	15	15	N/A	N/A
Chiller Flow Switches	15	15	BMS	N/A
Boiler wiring	15	15	15	15
Water treatment system	15	15	15	16
VFDs	15	16	BMS	16
Refrigerant monitors	15	BMS	BMS	16
Computer Room A/C Unit field-mounted controls	15	15	BMS	16
Fire Alarm shutdown relay interlock wiring	16	16	16	16
Fire Alarm smoke control relay interlock wiring	16	16	BMS	16
Fireman's Smoke Control Override Panel	16	16	16	16
AHU Unit controls	BMS	BMS	BMS	16
Unit Heater controls	BMS	BMS	BMS	16
WSHP field-mounted controls	BMS	BMS	BMS	16
Cooling Tower Vibration Switches	15	15	16	16
Cooling Tower Level Control Devices	15	15	16	16

Cooling Tower makeup water control devices	15	15	16	16
Plant Sequence Controls	BMS	BMS	BMS	16
Starters, HOA switches	16	16	N/A	16
Control damper actuators	BMS	BMS	BMS	16

1.8 SYSTEM PERFORMANCE

A. The BMS contractor shall provide a BMS system with the minimum standards as outlined:

1. BAC Net compliant per ANSI/ASHRAE Standard 195-2004 (BACnet)
2. The Energy Management System (EMS) shall be capable of controlling multiple building functions such as lighting alarm systems, HVAC equipment.
3. The EMS shall be modular, and shall permit modular expansion of both capacity and functionality through the addition of sensors, actuators, stand-alone DDC panels.
4. The system architecture shall eliminate dependence on any single device for alarm reporting and control execution.
5. The DDC shall be used at all individual HVAC equipment components and/or systems and networked into the BMS and capable of operation after programming from the central site located at owner's remote monitoring center.
6. The EMS contractor shall comply with all other requirements as determined by the design officials.
7. The system shall provide global set point and schedule modifications and popup operation sequence for any mechanical device shown by graphic.

1.9 SUBMITTALS

A. Shop Drawings, Product Data, and Samples

1. The BMS contractor shall submit a list of all shop drawings with submittals dates within 30 days of contract award.
2. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance.
3. Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BMS work.
4. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.
5. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.
6. The BMS Contractor shall correct any errors or omissions noted in the first review.
7. Provide manufacturers cut sheets for major system components. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is being submitted to cover. At a minimum, submit the following:

- a. BMS network architecture diagrams including all nodes and interconnections.
- b. Systems schematics, sequences and flow diagrams.
- c. Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
- d. Samples of Graphic Display screen types and associated menus.
- e. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
- f. Building Controllers
- g. Custom Application Controllers
- h. Application Specific Controllers
- i. Operator Interface Computer
- j. Auxiliary Control Devices
- k. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.
- l. Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, close-off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
- m. Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address.
- n. Details of all BMS interfaces and connections to the work of other trades.
- o. Product data sheets or marked catalog pages including part number, photo and description for all products including software.

1.10 RECORD DOCUMENTATION

A. Shop Drawings, Product Data, and Samples

1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:
 - a. Table of contents.
 - b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
 - c. Manufacturers product data sheets or catalog pages for all products including software.
 - d. System Operator's manuals.
 - e. Archive copy of all site-specific databases and sequences.
 - f. BMS network diagrams.
 - g. Interfaces to all third-party products and work by other trades.
2. Drawings: Submit a total Energy Management System Diagram for the individual on site building(s) and the Central remote Station Interface. Wiring diagrams shall show location of all wiring runs, ladder diagrams of control logic, schematics showing terminal strips, controller setpoints and reset ranges, controller gains, transmitter spans. Riser diagram

shall show schematically the entire system with all major components identified. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work

3. Submit a total Energy Management System Diagram for the individual on site building(s) and the Central remote Station Interface.
4. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

1.11 WARRANTY

A. Standard Material and Labor Warranty:

1. Provide a one-year labor and material warranty on the BMS.
2. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the cost of the BMS Contractor.
3. Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Control System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner. The Contractor shall respond to the Owner's request for warranty service within 24 hours during customary business hours.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 CONTROL SYSTEM

A. Available Manufacturers

1. Automated Logic Corporation.
2. Johnson Controls, Inc.; Controls Group.
3. Staefa Control System Inc.; Siemens Building Technologies, Inc.
4. Trane; Worldwide Applied Systems Group.

- B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to

control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

- C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
- D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
 - 1. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
 - 2. The System shall maintain all settings and overrides through a system reboot.
- E. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

2.3 REMOTE OPERATOR INTERFACE

- A. Contractor shall install all required interface components necessary to allow access to the BMS system via the Owner Wide Area Network (WAN). The contractor shall furnish the latest software version.
- B. The BMS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Network Automation Engines to facilitate greater fault tolerance and reliability.
- C. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically it must be implemented to conform to the following interface standards.
 - 1. Microsoft Internet Explorer for user interface functions
 - 2. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions
 - 3. Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports
 - 4. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries

2.3 OPERATOR WORKSTATION HARDWARE

- A. The Contractor shall provide a desktop workstation and all required interface components necessary to allow access to the BMS system including all graphics, alarm and report printing capability as a part of the building's operator workstation. PC Hardware – The personal computer(s) shall be configured as follows:
 - 1. Memory – 1 GB (512 MB Minimum)

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2. CPU– Pentium 4 processor. 2.8 Hz Clock Speed (2.0 GHz minimum)
 3. Hard Drive – 80 GB free hard drive space (40GB minimum)
 4. Hard drive backup system – CD/RW, DVD/RW or network backup software provided by IT department
 5. CD ROM Drive – 32X performance
 6. Ports – (2) Serial and (1) parallel, (2) USB ports
 7. Keyboard – 101 Keyboard and 2 Button Mouse
 8. CRT configuration – 1-2 CRTs as follows:
 - a. Each Display – 17” Flat Panel Monitor 1280 x 1024 resolution minimum
 - b. 16 bit or higher color resolution
 - c. Display card with multiple monitor support
 9. LAN communications – Ethernet communications board; 3Comm or equal
- B. Operator Operating System Software
1. Windows XP Professional
 2. Where user interface is not provided via browser, provide complete operator workstation software package, including any hardware or software keys. Include the original installation disks and licenses for all included software, device drivers, and peripherals.
 3. Provide software registration cards to the Owner for all included software.
- C. Distributed Web Based User Interface
1. All features and functions of the dedicated user interface previously defined in this document shall be available on any computer connected directly or via a wide area or virtual private network (WAN/VPN) to the automation network and conforming to the following specifications.
 2. The software shall run on the Microsoft Internet Explorer (6.0 or higher) browser supporting the following functions:
 - a. Configuration
 - b. Commissioning
 - c. Data Archiving
 - d. Monitoring
 - e. Commanding
 - f. System Diagnostics
 3. Minimum hardware requirements:
 - a. 512 MB RAM
 - b. 2.0 GHz Clock Speed Pentium 4 Microprocessor
 - c. 100.0 GB Hard Drive.
 - d. 1 Keyboard with 83 keys (minimum).
 - e. SVGA 1024x768 resolution display with 64K colors and 16 bit color depth
 - f. Mouse or other pointing device

2.4 SYSTEM SOFTWARE

A. Operator Operating System Software

1. Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each workstation.
2. System Graphics. The Operator Workstation software local and at Fulton County headquarters shall be graphically oriented. All points shown on the points list and

necessary to carry out the sequence of operations shall be displayed in the graphics screens. The system graphics shall be able to be modified while on line. An operator with the proper password level shall be able to add, delete, or change dynamic points on a graphic. Dynamic points shall include analog and binary values, dynamic text, static text, and animation files.

- a. Custom Graphics. Custom graphic files shall be created with the use of commonly available graphics packages. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as PCX, BMP, GIF and JPEG. The graphics generation package shall also provide the capability of capturing or converting graphics from other programs such as Designer, or AutoCAD.
 - b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.
 - c. The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.
 - d. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
 - All graphics shall be fully scalable
 - The graphics shall support a maintained aspect ratio.
 - Multiple fonts shall be supported.
 - Unique background shall be assignable on a per graphic basis.
 - The color of all animations and values on displays shall indicate if the status of the object attribute.
 - e. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.
 - The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.
 - In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.
 - f. Graphics Library. Furnish a complete library of standard HVAC equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library shall also include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
3. Automatic System Database Save and Restore. Each workstation shall store on the hard disk a copy of the current database of each building controller. This database shall be updated whenever a change is made in any panel in the system. The storage of this data shall be automatic and not require operator intervention. In the event of a database loss in a building management panel, the first workstation to detect the loss shall automatically restore the database for that panel.

4. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to archive the database from any system panel and store on magnetic media. The operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
5. System Configuration. The workstation software shall provide a graphical method of configuring the system. The user with proper security shall be able to add new devices, and assign modems to devices. This shall allow for future system changes or additions.
6. On-Line Help and Training. Provide a context sensitive, on line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. Provide an interactive tutorial CD, which will act as on-line training/help for the systems operator.
7. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time shall be set per operator password. All system security data shall be stored in an encrypted format.
 - a. Minimum of five levels of access shall be supported individually or in any combination as follows:
 - 1) Level 1 = View Data
 - 2) Level 2 = Command
 - 3) Level 3 = Operator Overrides
 - 4) Level 4 = Database Modification
 - 5) Level 5 = Database Configuration
 - 6) Level 6 = All privileges, including Password Add/Modify
 - b. Minimum of eight (8) passwords shall be supported.
 - 1) Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
8. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
9. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The BMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.
 - a. Alarm Reactions. The operator shall be able to determine what actions, if any, are to be taken, by object (or point), during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations,

- paging, forwarding to an e-mail address, providing audible annunciation or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day. An object in alarm that has not been acknowledged within an operator specified time period shall be re-routed to an alternate operator specified alarm receipt device.
- b. Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to disable alarming when the associated equipment is turned off or is being serviced.
 - c. Analog Alarms. Each analog object shall have both high and low alarm limits and warning limits. Alarming must be able to be automatically and manually disabled.
10. Trend Logs. The operator shall be able to define a custom trend log for any data in the system. This definition shall include interval, start-time, and stop-time. Trend intervals of 1, 5, 15, 30, and 60 minutes as well as once a shift (8 hours), once a day, once a week, and once a month shall be selectable. All trends shall start based on the hour. Each trend shall accommodate up to 64 system objects. The system operator with proper password shall be able to determine how many samples are stored in each trend. Trend data shall be sampled and stored on the Building Controller panel and be archived on the hard disk. Trend data shall be able to be viewed and printed from the operator interface software. Trends must be viewable in a text-based format or graphically. They shall also be storable in a tab delimited ASCII format for use by other industry standard word processing and spreadsheet packages.
 11. Dynamic Graphical Charting. The operator shall be able to select system values to be charted in real time. Up to three values at one time can be selected for each chart. The type of chart (bar, line, 3-D, etc.) shall be selectable.
 12. Alarm and Event Log. The operator shall be able to view all logged system alarms and events from any location in the system. The operator shall be able to sort and filter alarms. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the workstation.
 13. Object and Property Status and Control. Provide a method for the operator with proper password protection to view, and edit if applicable, the status of any object and property in the system. These statuses shall be available by menu, on graphics, or through custom programs.
 14. Reports and Logs. Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archived on the hard disk for historical reporting. Provide the ability for the operator to obtain real time logs of designated lists of objects. Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer. The operator shall be able to designate reports that shall be printed or stored to disk at selectable intervals.

2.5 BUILDING CONTROLLERS

- A. General. Provide Building Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.
1. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor based Building Controllers to manage the global strategies described in System software section.
 2. The Building Controller shall have sufficient memory to support its operating system, database, and programming requirements.
 3. The controller shall provide a communications port for connection of the Portable Operators Terminal or Laptop using Point to Point BACnet physical/data link layer protocol or a connection to the inter-network.
 4. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
 5. Controllers that perform scheduling shall have a real time clock.
 6. Data shall be shared between networked Building Controllers.
 7. The Building Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
 - a) Assume a predetermined failure mode.
 - b) Generate an alarm notification.
- B. Serviceability: Provide diagnostic LEDs for power, communications, and processor. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connected by a ribbon cable.
- C. Memory: The Building Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

2.6 BUILDING CONTROLLER PORTABLE OPERATOR DISPLAY

- A. The building controller that do not provide full access to systems configuration and definition via the Browser Based user interface the BMS Contractor shall provide a portable operator terminal for programming purposes. The terminal shall be configured as follows:
1. Personal Laptop Computer Manufacturer – Dell, Compaq or HP
 2. 1 GB RAM (256 MB minimum) – XP Professional
 3. 1.8 GHz Clock Speed Pentium 4 Microprocessor (800 MHz minimum)
 4. 40 GB Hard Drive (40 GB minimum)
 5. (1) CD-ROM Drive, 32x speed
 6. (1) Serial (1) Parallel (2) USB ports
 7. 1 Keyboard with 83 keys (minimum).

8. Integral 2 button Track Point or Track Ball.
9. 10" SVGA 1024x768 resolution color display
10. Two PCMCIA Type II or one Type III card slot
11. Complete operator workstation software package, including any hardware or software.
12. Original printed manuals for all software and peripherals.
13. Original installation disks or CD for all software, device drivers, and peripherals
14. Software registration cards for all included software shall be provided to the Owner.
15. Carrying case, Spare battery and External power supply/battery charger

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B. Proprietary Portable Terminal

1. Manufacturers providing proprietary portable terminals shall submit technical data sheets for the terminal and all associated software and hardware. The proprietary terminal shall meet the same operator interface software requirements as specified above.

2.7 CUSTOM APPLICATION CONTROLLERS

A. General. Provide Custom Application Controllers to provide the performance specified in section 1 of this division. Each custom application controller shall be unit mounted, or wall mounted in locked mechanical or electrical rooms to prevent damage. Controllers with microprocessor controls that are to be located on a wall shall not be acceptable. Each of these controllers shall meet the following requirements.

1. The Building Management System shall be composed of one or more independent, stand-alone, microprocessor based Building Controllers to manage the local strategies described in System software section.
2. The Controller shall have sufficient memory to support its operating system, database, and programming requirements.
3. Controllers that perform scheduling shall have a real time clock.
4. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
5. The Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
 - a) Assume a predetermined failure mode.
 - b) Generate an alarm notification.

B. Serviceability. Provide diagnostic LEDs indicators to identify the following conditions:

1. Power - On/Off
2. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic
3. Ethernet Connection Speed – 10 Mbps/100 Mbps
4. FC Bus – Normal Communications/No Field Communications
5. Peer Communication – Data Traffic between Control Devices
6. Run –Running/in Startup/Shutting Down/Software Not Running
7. Battery Fault – Battery Defective, Data Protection Battery Not Installed

8. Fault – General Fault
9. Modem RX – Modem Receiving Data
10. Modem TX – Modem Transmitting Data

- C. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
- D. Communications Ports – The Controller shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator’s terminals.
 1. USB port
 2. URS-232 serial data communication port
 3. RS-485 port
 4. Ethernet port
- E. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
- F. Diagnostics – The Controller shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The BMS software shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
- G. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
- H. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.
- I. Certification – The Controller shall be listed by Underwriters Laboratories (UL).
- J. Controller network – The Controller shall support the manufacturer’s Field BUS and following communication protocols on the controller network:
 1. The Controller shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
 - a. The Controller shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 - b. The Controller shall be tested and certified as a BACnet Building Controller (B-BC).
 - c. A BACnet Protocol Implementation Conformance Statement shall be provided for the Controller.
 - d. The Conformance Statements shall be submitted 10 days prior to bidding.
 - e. The Controller shall support a minimum of 50 control devices.
 2. The Controller shall support LonWorks enabled devices using the Free Topology Transceiver FTT10.
 - a. The Controller shall support LonWorks enabled devices using the Free Topology Transceiver FTT10.
 - b. All LonWorks controls devices shall be LonMark certified.
 - c. The NAE shall support a minimum of 64 LonWorks enabled control devices.

2.8 APPLICATION SPECIFIC CONTROLLERS

- A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
 - 1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation.
 - 2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 - d. Software applications, scheduling, and alarm processing.
 - e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

- B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
 - 1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
 - 2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 - 3. Local operator interface provides for download from or upload to operator workstation.

- C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
 - 1. Binary Inputs: Allow monitoring of on-off signals without external power.
 - 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 - 3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
 - 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation.
 - 5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA)
 - 6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
 - 7. Universal I/Os: Provide software selectable binary or analog outputs.

- D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
 - 1. Binary Inputs: Allow monitoring of on-off signals without external power.
 - 2. Output ripple of 5.0 mV maximum peak to peak.

3. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
4. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Minimum dielectric strength of 1000 V.
3. Maximum response time of 10 nanoseconds.
4. Minimum transverse-mode noise attenuation of 65 dB.
5. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

F. ANALOG CONTROLLERS

1. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
2. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.
3. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

G. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

H. TIME CLOCK

1. Solid-state, programmable time control with 4 separate programs each with up to 100 on-off operations; 1-second resolution; lithium battery backup; keyboard interface and manual override; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; system fault alarm; and communications package allowing networking of time controls and programming from PC.

2.9 COMMUNICATIONS

- A. The owner will provide all communication media, connectors, repeaters, hubs, and routers necessary for the inter-network. A 10BaseT jack will be provided adjacent to each Building Control Panel and PC Workstation for connection to this network.
- D. All Building Controllers shall have a communications port for connections with the operator interfaces. This may be either an RS-232 port for Point to Point connection or a network interface node for connection to the Ethernet network.

- E. Communications services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:
 - 1. Connection of an operator interface device to any one controller on the internetwork will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the internetwork.
 - 2. All database values (i.e., points, software variable, custom program variables) of any one controller shall be readable by any other controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to a point name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communications services to perform internetwork value passing.
- D. The time clocks in all controllers shall be automatically synchronized daily.

2.10 INPUT/OUTPUT INTERFACE

- A. Hard-wired inputs and outputs may tie into the system through Building, Custom, or Application Specific Controllers.
- B. All input points and output points shall be protected such that shorting of the point to itself, another point, or ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.
- C. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 ma to be compatible with commonly available control devices.
- D. Pulse accumulation input points. This type of point shall conform to all the requirements of Binary Input points, and also accept up to 2 pulses per second for pulse accumulation, and shall be protected against effects of contact bounce and noise.
- E. Analog inputs shall allow the monitoring of low voltage (0-10 Vdc), current (4-20 ma), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.
- F. Binary outputs shall provide for on/off operation, or a pulsed low voltage signal for pulse width modulation control. Outputs shall be selectable for either normally open or normally closed operation.
- G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0-10 Vdc or a 4-20 ma signal as required to provide proper control of the output device.

2.11 CONTROL DEVICES AND ACCESSORIES

- A. Positive positioning devices will be provided for all control motors used for proportioning or sequencing controls, to make available full power of the motor in both directions; this includes air dampers.
- B. Room sensors shall be 1000 ohm RTD or linear precision thermistor element. Mount room sensors adjacent to room light switches if possible and/or as shown on the drawings, at a height to be determined by the Owner. Coordinate sensor locations with the work of other trades and with room fixtures [i.e., chalkboard, bulletin board, casework, etc.]. Provide Mason TG-1 covers for all thermostats and sensors subject to occupant access. (If room sensors do not require set point adjustment nor override switches)
- C. Motor operated dampers will be as specified under the Air Distribution Section hereof.
- D. Miscellaneous controls and accessories, such as relays, switches, sail switches, etc., required for a complete control system will be of heavy-duty type, suitable for the service required.
- E. Firestats will be electric, rigid element or remote bulb type, as required, but will be manually reset. Firestats will have a fixed setpoint and will be set at 125 degrees F, unless otherwise noted.
- F. Fire and smoke detectors will be ionization type, Pry-A-Larm or equal (refer to fire alarm division 16 for system requirements), which sense the presence of the products of combustion. Detector system will be complete and will accomplish the sequence specified. Furnish all detectors, indicating panels, control power units, transformers, wiring, relays and all other items under this section. All components will be UL listed.
- H. Instrumentation and Control
 - 1. Output Devices.
 - a. Temperature Sensors; Sensors shall be of the type and have accuracy ratings as indicated and/or required for the application and shall permit accuracy rating of within 1% of the temperature range of their intended use.
 - 1. Sensors used for mixed air application shall be the averaging type and have an accuracy of +1 degree F.
 - 2. Duct sensors shall protrude into the air stream a minimum of 6" or to the far quarter of the duct width, whichever is greater.
 - 3. OSA temperature sensors shall have a minimum range of -52 degrees F to 152 degrees F and an accuracy of within 1 degree F in this temperature range.
 - 4. Room temperature sensors shall have an accuracy of within 0.25 degrees F in the range of 45 degrees F to 96 degrees F.
 - 5. Chilled water sensors shall have an accuracy of within 0.25 degrees F in their range of application.

6. Heating temperature sensors shall have an accuracy of within 0.75 degrees F over the range of their application.
 7. Low Limit Thermostats shall be of manual reset type, with setpoint adjustment. The sensing element shall be 20 foot minimum and shall be installed completely across the coil. When any one foot of the element senses a temperature as low as the setpoint, the thermostat contacts shall open. These shall contain double pole switches for simultaneous remote alarms or as desired. Thermostat shall be Johnson Controls A70 or equal.
- b. Pressure Instruments:
1. Differential Pressure and Pressure Sensors. Sensors shall have a 4-20 mA output proportional signal, with provisions for field checking. Sensors shall withstand up to 150% of rated pressure, without damaging the device. Accuracy shall be within 2% of full scale. Sensors shall be manufactured by Leeds & Northrup, Setra, Robertshaw, Dwyer Instruments, Rosemont, or be approved equal.
 2. Pressure Switches. Pressure switches shall have a repetitive accuracy of 2% of range and withstand up to 150% of rated pressure. Sensors shall be diaphragm or bourdon tube design. Switch operation shall be adjustable over the operating pressure range. The switch shall have an application rated Form C, snap-acting, self-wiping contact of platinum alloy, silver alloy, or gold plating. Switches shall be manufactured by Honeywell, Johnson Controls, MCC Powers, Dwyer Instruments, or be approved equal.
- c. Humidity Sensors:
1. Humidity Transmitter (Duct) shall be capable of providing continuous measurement of percent relative humidity with an accuracy of + 4% over the range of 10 to 80% RH. The output shall be proportional VDC over a cable pair.
 2. Humidity Transmitter (Outside Air) shall be capable of providing continuous measurement of percent relative humidity with an accuracy of $\pm 2\%$ over the range 20 to 90% RH. The output shall be a 4 to 20 Ma signal over a shielded cable pair. Transmitter shall have outside weather enclosure. Transmitter shall be General Eastern RH-1 or equal.
 3. Humidity Transmitter (Space) shall be capable of providing continuous measurement of percent relative humidity with an accuracy of $\pm 3\%$ over the range of 20 to 60% RH. The output shall be proportional VDC over a cable pair.
- d. Relay Instruments:
1. Voltage-to-Digital Alarm Relays shall monitor status of boiler or chiller safeties and overloads and shall be sized and connected so as not to impede the function of the monitored contacts. Switch shall have self-wiping, snap-acting Form C contacts rated for the application.
 2. Current Sensing Relays shall monitor status of motor loads. Switch contacts shall be rated for the application. The setpoint of the contact operation shall be field adjustable.

3. Control Relay Contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting Form C contacts, enclosed in dustproof enclosure. Relays shall have silver cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices.
4. Solid State Relays (SSR). Input/output isolation shall be greater than 10 billion ohms with a breakdown voltage of 15 V root mean square, or greater, at 60 Hz. The contact operating life shall be 10 million operations or greater. The ambient temperature range of SSRs shall be 20°F-140°F. Input impedance shall be greater than 500 ohms. Relays shall be rated for the application. Operating and release time shall be 10 milliseconds or less. Transient suppression shall be provided as an integral part of the relays.
- e. Flow Switches shall have a repetitive accuracy of 1% of its operating range. Switch actuation shall be adjustable over the operating flow range. The switch shall have snap action form C contacts, rated for the specific electrical application.
- f. Watt-hour Transducers shall have an accuracy of $\pm 0.25\%$ for kW and kWh outputs from full lag to full lead power factor. Input ranges for kW and kWh transducers shall be selectable without requiring the changing of current or potential transformers, and shall have dry contact pulse accumulation.

2.12 CONTROL VALVES:

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

2.13 OPERATORS:

Damper or valve operator shall be electric and be provided for each automatic damper or valve and shall be of sufficient capacity to operate the damper or valve under all conditions and to guarantee tight close-off of valves, as specified, against system pressure encountered. Each shall be provided with spring-return for normally closed or normally open position for fail safe operation to account for fire, low temperatures, or power interruption as indicated. Damper and valve operators are to be made out of diecast metal; no plastic or sheet metal bodies will be allowed.

PART 3: EXECUTION

3.1 SECTION INCLUDES:

A. Examination

- B. General Workmanship
- C. Wiring
- D. Installation of Sensors
- E. Flow Switch Installation
- F. Actuators
- G. Identification of Hardware and Wiring
- H. Controllers
- I. Programming
- J. Cleaning
- K. Protection
- L. Field Quality Control
- M. Training
- N. Acceptance

3.2 EXAMINATION

- A. The project plans shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- B. The contractor shall inspect the site to verify that equipment is installable as shown, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

3.3 GENERAL WORKMANSHIP

- A. Install equipment, piping, wiring/conduit parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install all equipment in readily accessible location as defined by chapter 1 article 100 part A of the NEC. Control panels shall be attached to structural walls unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. *All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.*

3.4 COORDINATION WITH EQUIPMENT SUPPLIER:

- A. HVAC equipment DDC controllers shall be factory installed or furnished and installed by the BMS contractor. Coordinate with equipment supplier on factory installed controllers.

3.5 ELECTRICAL WORK FOR CONTROLS:

- A. Electrical Contractor shall furnish, install and connect all power feeds through all disconnect starters and variable speed controllers to electrical motors and all wiring of 120 VAC normal/emergency power feeds for controllers and motor actuators.
- B. Complying with the principle of "unit responsibility", all low voltage (24V) electrical work for automatic controls, except as otherwise specified, or shown on the electrical drawings, shall be provided by the controls contractor.
- C. Electrical work shall, in general, comply with the following:
 - 1. All low voltage wiring in finished rooms shall be concealed below/above working heights and exposed below floor or above ceiling.
 - 2. Class 2 wire may be concealed in surface mounted wiremold for wall mounted controllers and room sensor drop on existing and new concrete block walls. Wireless room sensors shall be considered pending owner approval instead of surface mounted wiremold on existing and new concrete block walls.
 - 3. Electrical work may include both line voltage (coordinate with Division 16 Contractor) and low voltage wiring, as required.
 - 4. Conduit network for power systems shall be used for running control high voltage wiring.
 - 5. All electrical work shall comply with the N.E.C. and local electrical codes.
 - 6. All safety devices shall be wired through both hand and auto positions of motor starting device to insure 100% safety shut-off.
 - 7. All magnetic starters furnished by Electrical subcontractor for mechanical equipment shall be furnished with integral 120 volt control transformers, sized to handle the additional VA needed for the controls – damper and valves, actuators, etc.
 - 8. The motor starter supplier shall provide auxiliary contacts as required for interlock by BMS Contractor the supplier shall estimate an allowance of at least one auxiliary contact per starter. All interlock and control wiring shown on the electrical drawings and mechanical drawings are by the Division 16 electrical subcontractor.
 - 9. Low voltage plenum rated wiring can be run exposed above/below working heights in equipment rooms and above accessible ceiling. Wiring shall be neatly tied to pipes, EMT or other devices and not laid on ceiling tile.

3.6 THE MECHANICAL CONTRACTOR SHALL:

- A. Install automatic valves, temperature sensor wells, flow meters, etc., which are specified to be supplied by this section.
- B. Furnish and install any necessary reducing fittings required to install smaller than line-size control valves.
- D. Provide all necessary pressure taps, water, drain, and overflow connections and piping.
- E. Provide and install all necessary penetrations and spool pieces required for flow devices.
- F. Install all automatic dampers and provide necessary blank off plates or transitions required to install dampers that are smaller than duct size.
- G. Assemble multiple section dampers with required interconnecting and jackshaft linkage and extend required number of shafts through duct for external mounting of damper motors.

- H. Provide necessary sheet metal baffle plates to eliminate stratification and provide the air volumes specified. Locate baffles by experimentation. Fix and seal permanently in place only after stratification problems have been eliminated.
 - I. Provide access doors or other approved means of access through ducts for service to control equipment.
- 3.7 THE GENERAL CONTRACTOR SHALL:
- A. Provide all necessary cutting, patching and painting.
 - B. Provide necessary housekeeping pads and where required, concrete inertia BMSes.
- 3.8 WIRING
- A. All control and interlock wiring shall comply with the national and local electrical codes and Division 16 of these specifications. Where the requirements of this section differ with those in Division 16, the requirements of this section shall take precedence.
 - B. Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that:
 - 1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
 - 2. *All cables shall be UL listed for application, i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.*
 - C. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).
 - D. Where class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 10 ft intervals. Such bundled cable shall be fastened to the structure, using specified fasteners, at 5 ft intervals or more often to achieve a neat and workmanlike result.
 - E. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
 - F. Maximum allowable voltage for control wiring shall be 120V. If only higher voltages are available, the Control System Contractor shall provide step down transformers.
 - G. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.

- H. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with other sections of this specification and local codes.
- I. Size of conduit and size and type of wire shall be the design responsibility of the Control System Contractor, in keeping with the manufacturer's recommendation and NEC.
- J. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures.
- K. *Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring.*
- L. Adhere to Division 16 requirements for installation of raceway.
- M. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- N. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.9 INSTALLATION OF SENSORS

Install sensors in accordance with the manufacturer's recommendations.

Mount sensors rigidly and adequate for the environment within which the sensor operates.

Zone temperature sensors shall be installed with software controllable band of 1-3 degrees.

All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor readings.

Install duct static pressure tap with tube end facing directly down-stream of air flow.

Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.

All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.

Wiring for space sensors shall be concealed in building walls. EMT conduit is acceptable within mechanical and service rooms.

Install outdoor air temperature sensors on north wall complete with sun shield at designated location.

Sensors in common areas, such as hallways, lobbies, classrooms, break rooms and media centers will be flat plate sensors without setpoint adjustment and with wire protective grill type thermostat guard.

3.8 FLOW SWITCH INSTALLATION

- A. Install using a thread-o-let in steel pipe. In copper pipe use C x C x F Tee, no pipe extensions or substitutions allowed.
- B. Mount a minimum of 5 pipe diameters upstream and 5 pipe diameters downstream or 2 feet whichever ever is greater, from fittings and other obstructions.
- C. Install in accordance with manufacturers' instructions.
- D. Assure correct flow direction and alignment.
- E. Mount in horizontal piping - flow switch on top of the pipe.

3.9 ACTUATORS

- A. Mount and link control damper actuators per manufacturer's instructions. All existing AHUs' and WSHP mixing boxes shall be provided with new linkage and control damper actuators.
- B. To compress seals when spring return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
- C. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- D. Valves - Actuators shall be mounted on valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following manufacturer's recommendations.

3.10 IDENTIFICATION OF HARDWARE AND WIRING

- A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information.
- B. Permanently label or code each point of field terminal strips to show the instrument or item served.
- C. Identify control panels with minimum 1-cm letters on laminated plastic nameplates.

- D. Identify all other control components with permanent labels. Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

3.11 CONTROLLERS

- A. Provide a separate Controller for each major piece of HVAC equipment. Points used for control loop reset such as outside air or space temperature are exempt from this requirement.
- B. Each application specific controller shall be unit mounted or wall mounted.

3.12 PROGRAMMING

- A. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25% of available memory free for future use.
- B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.
- C. Software Programming
 - 1. Provide programming for the system as per specifications and adhere to the strategy algorithms provided. All other system programming necessary for the operation of the system but not specified in this document shall also be provided by the Control System Contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.
- D. Operators' Interface
 - 1. Standard Graphics. Provide graphics for each major piece of equipment and a floor plan for each floor in the building. This includes each Chiller, Air Handler, VAV Terminal, Fan Coil, Boiler, and Cooling Tower. These standard graphics shall show all points dynamically as specified in the points list or this specification.
 - 2. The controls contractor shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface data BMS, and any third party software installation and integration required for successful operation of the operator interface.

3.13 CLEANING

- A. This contractor shall clean up all debris resulting from his or her activities daily. The contractor shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Construction Manager or General Contractor.

- B. At the completion of work in any area, the Contractor shall clean all of his/her work, equipment, etc., making it free from dust, dirt and debris, etc.
- C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.14 PROTECTION

- A. The Contractor shall protect all work and material from damage by his/her work or workers, and shall be liable for all damage thus caused.
- B. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.15 FIELD QUALITY CONTROL

- A. All work, materials and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this Section.
- B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to building lines and properly supported.
- C. Contractor shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.

3.14 TRAINING, OPERATORS MANUALS

- A. Controls training session shall be scheduled in conjunction with equipment items. All OEM training sessions shall be recorded on videotape and two copies of taped training shall be furnished to for use in training additional Fulton County personnel and new hires.
- B. At least two similar sessions of 8 hours each, shall be conducted for Mechanical Equipment and systems.
- C. The BMS system training shall be by manufacturer-trained personnel and consist of a minimum of two 16-hour sessions, for three (3) operators per session. The first session shall be a hand-on type training to be conducted at the time of start-up and checkout. The second session shall occur no later than the beginning of the next season changeover.
- D. A Training Program description shall be submitted in advance to Fulton County to allow the scheduling and designation of personnel in a timely manner. The information contained in the

program shall include how the training will be conducted; when and where the sessions will be held; names and company affiliation of trainer(s); recommended reference materials; outside reading, etc. The County will furnish the lists of Fulton County personnel for each training session.

Provide a comprehensive operators manual, including programming documentation, setpoints and override instructions & a diagram & listing of all points.

3.15 ACCEPTANCE

- A. The BMS shall be connected to operate at the Fulton County Central Site for a period of 48 hours, and have a demo conducted by the BMS contractor with the following representatives present; BMS Contractor, Mechanical Contractor, Project Engineer, Fulton County Project Manager and Fulton County Maintenance.
- B. The controls contractor must perform an in house commissioning with the subcontractors, design engineer and other parties involved to demonstrate how well all the plant equipment controls function and respond. Furthermore, the BMS contractor in the presence of the design engineer and other parties shall demonstrate that every function and control sequence or cycle for each equipment are functional and that the system controls perform in accordance to the sequence of operations and design intent

3.16 WARRANTIES and GUARANTEES

- A. The materials of the controls system shall have a manufacturer's and/or supplier's Guarantee or Warranty put into effect by execution and filing of any and all related papers. For one (1) year from date of acceptance, obtain services or repair under the terms of any said Guaranty or Warranty in behalf of Fulton County.
- B. The controls system installed shall be left to Fulton County in proper working order. The contractor shall for a period of one (1) year replace any work or material which develops defects, excluding normal wear and tear, from the date of beneficial acceptance by Fulton County.

END OF SECTION

System	CHILL and HOT WATER SYSTEM POINT LIST	
Type	Point	Description
AI	OA-T	Outside Air Temperature
AI	CHWS-T	Chill Water Supply Temperature
AI	CHWR-T	Chill Water Return Temperature
AI	CH1S-T	Chiller Supply Temperature
AI	BH1S-T	Boilers Supply Temperature
AI	CWS-T	Condenser Water Supply Temperature
AI	CWR-T	Condenser Water Return Temperature
AI	SCHW-P	Secondary Chill Water Pressure
AO	CTBYP-O	Cooling Tower Bypass Valve Output
AO	SCHP1-D	Secondary Chill Water Pump
AO	SBHP1-D	Secondary Boiler Water Pump 1 Speed Control
AO	SBHP2-D	Secondary Boiler Water Pump 2 Speed Control
BI	PCHP1-S	Primary Chill Water Pump 1 Status
BI	PBHP1-S	Primary Boiler Water Pump 1 Status
BI	PBHP2-S	Primary Boiler Water Pump 2 Status
BI	SCHP1-S	Secondary Chill Water Pump 1 Status
BI	SBHP1-S	Secondary Boiler Water Pump 1 Status
BI	SBHP2-S	Secondary Boiler Water Pump 2 Status
BI	CH1-ALM	Chiller 1 Alarm
BI	BH1-ALM	Boiler 1 Alarm
BI	BH2-ALM	Boiler 2 Alarm
BI	CWP1-S	Condenser Water Pump 1 Status (Chiller)
BI	CWP2-S	Condenser Water Pump 2 Status (WSHP)
BI	CT1-S	Cooling Tower 1 Status
BO	CH1-EN	Chiller 1 Enable
BO	BH1-EN	Boiler 1 Enable
BO	BH2-EN	Boiler 2 Enable
BO	PCHP1-C	Primary Chill Water Pump 1 Command
BO	PBHP1-C	Primary Hot Water Pump 1 Command
BO	PBHP2-C	Primary Hot Water Pump 2 Command
BO	SCHP1-C	Secondary Chill Water Pump 1 Command
BO	SCHP2-C	Secondary Hot Water Pump 1 Command
BO	SCHP2-C	Secondary Hot Water Pump 2 Command
BO	CWP1-C	Condenser Water Pump 1 Command Chiller
BO	CWP2-C	Condenser Water Pump 2 Command WSHP
BO	CT1-C	Cooling Tower 1 Fan Command

HVAC POINT LIST

SECTION 15940

SEQUENCE OF OPERATIONS

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 sequences for HVAC systems, subsystems, and equipment.
- B. Related Sections include the following:
 - 1. Division 15 Section "BUILDING MANAGEMENT SYSTEM" for control equipment and devices and submittal requirements.

1.3 DEFINITIONS

- A. DDC: Direct-digital controls.
- B. BAS: Building Automation System
- C. VAV: Variable air volume.

1.4 CHILLERS

- A. General - The standalone microprocessor based chiller control panel shall monitor and control the chiller in a standalone mode or as directed by the BAS chiller sequencing software.

The chiller sequencing software shall perform the following control strategies, provide the points listed on the chiller point list and support the specified monitoring and diagnostics.

- B. System Scheduling – The BAS chiller sequencing software will start the chiller system based upon an 8 day (7 + Holiday) time of day schedule.

An override Input will allow an external device to lock out chiller system operation.

SECTION - 15940- SEQUENCE OF OPERATIONS

- C. Chiller Sequencing - The chiller sequencing software will start and stop system water pump and chiller based upon the loading of the operating chiller. The chilled water system shall be enabled on a call for cooling from any single air handler.
1. When the chilled water system is enabled the chiller system control will:
 - a. Start the system primary chilled water pump
 - b. Allow the chiller to prove flow through the evaporator.
 - c. Start the condenser water pump
 - d. Start the chiller after both chilled water and condenser water pump flow is proven.
 2. The BAS shall control chiller's setpoint to equalize the chiller unloading and meet system demands as the system load varies.
 3. The chiller sequencing software will not shutdown the chiller pump until it has confirmed that the chiller compressor has shutdown.
 4. The chiller sequencing software shall control individual chiller setpoints to the system supply water temperature setpoint. The system setpoint shall be 44 degrees F and editable by the operator. Chilled water reset shall be used depending on the outdoor temperature and building load demand.
 5. Upon sensing a chiller failure the chiller sequencing software shall lockout. Upon sensing a chilled water pump failure the system shall lockout that chilled water pump. Upon sensing a condenser water pump failure the system shall lockout that condenser water pump. In all cases the BAS shall alarm at the central PC and indicate which equipment has failed.
- D. Chiller Soft Start - The chiller sequencing software shall provide a user adjustable loading time at system start-up. This prevents the unnecessary operation of chiller and limits system electrical demand during chilled water loop pulldown.
- E. Chiller Demand Limiting - As part of the demand limiting scheme on the building, the chiller sequencing software shall be able to monitor and reduce peak power demand through the limiting of chiller system capacity.
- F. Chiller System Status Graphic - The chiller plant control software shall provide operating status for the system by providing graphic displays at the PC front end. The display shall include:
1. System mode of the chiller plant
 2. Chiller enable/disable status
 3. System supply water setpoint
 4. System supply and return water temperature
 5. System Chilled water and Condenser water pump status
 6. Current chiller plant control operation
 7. Add information

8. Subtract information
 9. System failure information
 10. Chiller failure information see points list
 11. Override capabilities to force an add control or subtract control.
- G. Event Processing - All chiller plant control and status events shall be recorded, at the operator's selection, in the building management system event log to facilitate troubleshooting.
- H. ASHRAE Standard 15 control functions
1. The existing refrigeration monitor shall provide an analog output (0-10 VDC or 4-20 ma) that corresponds to the level of refrigerant detected by the monitor. Any increase in detected refrigerant levels shall trigger a diagnostic alarm indicating a refrigerant leak and the system should be checked.
 2. The building automation system shall monitor the following alarms:
 - a. Alarm status of Refrigerant Monitor
 3. The building automation system shall be tied to the mechanical equipment room ventilation system to provide control of both normal and purge ventilation of the mechanical equipment room. This control shall be in parallel to the primary control of the ventilation fans by the refrigerant monitor. During normal operation the mechanical room exhaust fan shall operate to maintain a setpoint of 80 degrees. The set point shall be adjustable thru the BAS.
 4. The building automation system shall monitor as a minimum the following points on each chiller.
 - a. Chilled water inlet temperature.
 - b. Chilled water outlet temperature
 - c. Chilled water flow status
 - d. Condenser water inlet temperature
 - e. Condenser water outlet temperature
 - f. Condenser water flow status
 - g. Compressor amps per phase (3)
 - h. Evaporator refrigerant temperature.
 - i. Condenser refrigerant pressure (water cooled chillers only).
 - j. Condenser refrigerant temperature (water cooled chillers only).
 - k. Condenser approach temperature (water cooled chillers only).
 - l. Compressor refrigerant discharge temperature.
 - m. Compressor refrigerant suction temperature.
 - n. Compressor volts per phase (3).
 5. The following points in ASHRAE Guideline 3-1990 shall remain manual tasks:
 - a. Refrigerant level
 - b. Oil level
 - c. Addition of refrigerant
 - d. Addition of oil

1.2 SECONDARY CHILLED WATER PUMP CONTROL

- A. Secondary chilled water pump shall be enabled by the BAS.
- B. Upon failure of the secondary pump the pump shall be locked out. An alarm shall be sent to the central PC.

1.3 COOLING TOWER CONTROL

- A. The building automation system (BAS) shall constantly monitor the chiller operating and ambient conditions and calculate the condenser water supply setpoint to minimize the total system energy consumption. These calculations shall be based on chiller performance data, cooling tower performance data, chiller load and outdoor air ambient temperature and relative humidity. The condenser water set point shall be reset between 85 F and 60 F. The condenser water setpoint shall be at least 9 degrees above the ambient wet bulb temperature.

- B. Cooling Tower Bypass Valve Control

- 1. Tower fan shall be started, through their on-off-auto selector switches, by the BAS.
- 2. Tower Fan 2 speed motor control.

When the tower fan's on-off-auto switch is indexed to the auto position and condenser water flow is proven by the CWS sensor, the BAS shall start a single tower fan in low speed maintain the adjustable condenser water supply (CWS) setpoint. If after five minutes the CWS temperature is more than 2 degrees above setpoint the fan will turn the motor on high speed. When the CWS temperature is 2 degrees below setpoint the above sequence shall be reversed on a loss of communications with the BAS, the fan shall fail to 100% load operation.

- 3. Fan shall be directly commandable from any BAS workstation by an operator having sufficient authority. For graphics based systems, the status of fan, shall be displayed on the top level graphic for the cooling tower system. Condenser water supply and return temperatures, CW pump status, chilled water pump status and chiller status shall also be shown on this graphic.
- 4. The condenser water 2 way by-pass valve shall be modulated to maintain a minimum condenser water setpoint of 60 F during low ambient conditions.

1.4 BOILER CONTROL

- A. Control Strategies - The central plant control software shall perform the following control strategies:

1. System Scheduling - The boiler plant shall start based on a time of day schedule and outside air temperature initially set at 60 degrees (adjustable) or a call for heating from any of the building zones. An override Input will allow the operator to manually override boiler system operation.
2. Upon a call for heating, hot water both pumps and boilers shall be enabled. Each boilers internal control shall modulate to maintain leaving water temperature setpoint.
3. The primary hot water pumps will have a hardwired interlock to each boiler such that if the pump fails the boilers will be shut down and taken out of rotation. An alarm shall be provide by the BMS system.
4. The boiler sequencing software shall start another boiler whenever there is deficit flow in the primary - secondary decoupler (bypass) pipe. The boiler sequencing software shall determine when there is deficit flow by measuring the system supply and return water and decoupler water temperatures. Mixing equations shall then be used to calculate the deficit flow volume. If mixing equations are not included in the control system standard software then a bi-directional flow meter shall be provided in the decoupler pipe.

When deficit flow exists continuously for an operator - specified length of time (initially set at 20 minutes), the boiler sequencing software shall initiate the start of the next boiler in the sequence.

a. Lag boiler(s) shall start in a similar manner to the lead boiler start sequence.

5. The boiler sequencing software shall stop a boiler whenever the excess flow in the decoupler (bypass) pipe exceeds 120 percent of a single boiler's flow.

The boiler sequencing software shall determine the quantity of excess flow by measuring the system supply and return water and decoupler water temperatures. Mixing equations shall then be used to calculate the deficit flow volume or as stated previously a bi-directional flow meter shall be provided.

When the calculated excess flow exceeds [120] percent of the next off boiler's flow continuously for [20] minutes, the boiler sequencing software shall initiate the shutdown of the next boiler in the sequence. The excess flow setpoint and duration shall be easily modifiable by the boiler systems operator.

a. The boiler sequencing software will not shutdown the boiler pump until it has shutdown the boiler.

6. Upon sensing a boiler or pump failure the boiler sequencing software shall lockout that boiler/pump combination and immediately initiate the start of the next boiler in the rotation sequence. In all cases the BAS shall alarm at the central PC and indicate which pump and /or boiler has failed.

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7. Automatic rotation of boiler operation will equalize boiler run time.
 - a. Rotation shall be initiated based on an operator entered day interval or by the cycling of a binary point.

B. Boiler System Status Graphic- The boiler plant control software shall provide operating status for the system by providing graphic displays at the PC front end. The display shall include:

1. System mode of the boiler plant
2. Boiler enable/disable status
3. System supply water setpoint
4. System supply and return water temperature
5. System primary and secondary hot water pump status
6. Boiler general alarm status.

C. Event Processing - All chiller plant control and status events shall be recorded, at the operator's selection, in the building management system event log to facilitate troubleshooting.

1.5 SECONDARY HOT WATER PUMP CONTROL

- A. Secondary hot water pumps shall be controlled by associated variable frequency drives. When the hot water system is enabled by the BAS the lead secondary pump shall start. The pump speed shall be modulated to maintain a minimum differential pressure between the plant supply and return chilled water. The differential pressure shall be operator adjustable and initially set at 35 psi.
- B. Upon failure of the lead secondary pump the lag secondary pump shall be started and the lead secondary pump shall be locked out. An alarm shall be sent to the central PC.
- C. A lead lag rotation sequence shall be set up for the secondary pumps.

1.6 SEQUENCE OF OPERATION FOR CONSTANT VOLUME (CV) AIR-HANDLING UNITS

- A. Occupied Mode -Each air-handling unit (AHU) shall have a dedicated microprocessor-based controller that shall monitor and control the AHU in a stand-alone mode or as a part of the building automation system. When the AHU is in the occupied mode, the supply fan shall operate continuously. The cooling valve, economizer dampers and heating valve shall modulate in sequence to maintain the discharge air temperature setpoint. The discharge air temperature setpoint shall be determined through a comparison of the space temperature and space temperature setpoint and shall be reset according to heating or cooling demand.
- B. Unoccupied Mode - When the air-handling unit (AHU) is in the unoccupied mode, the supply fan shall be off, and the outdoor air damper, cooling valve and heating valve shall be closed. The hydronic-heating and cooling valves shall open fully if the outdoor

temperature falls below a low-limit temperature setpoint of 35 degrees F (adjustable). If the space temperature moves beyond the unoccupied heating or cooling setpoints, the fan shall be started and the controller shall bring on 100 percent of unit capacity while keeping the outside air damper closed. If the space temperature rises above the unoccupied cooling setpoint and the outside air temperature is less than the economizer changeover setpoint, the fan shall be cycled on and the outside air damper shall economize.

- C. Morning Warm-Up Mode and Cool-Down Modes - When the air handling unit (AHU) transitions from the unoccupied mode to occupied mode, morning warm-up and cool down routines shall be activated.

When there is a call for heating and the zone temperature is three degrees or more below setpoint, a morning warm-up sequence shall be initiated. During morning warm-up the fan shall be turned on, the outside air damper shall remain closed and the heating valve shall open 100 percent. When the zone temperature comes within two degrees of the heating setpoint, the outside air damper shall go to the occupied minimum ventilation position and the AHU shall operate in the occupied mode.

When there is a call for cooling and the space temperature is more than three degrees above the occupied cooling setpoint, a morning cool-down sequence shall be initiated. The AHU shall operate in the economizing mode if possible and the fan shall be indexed on. If economizing mode is not available, the cooling valve shall open and the outside air damper shall remain closed. When the zone temperature reaches the cooling setpoint, the AHU shall transition to the occupied mode.

- D. Supply Fan Control - The supply fan shall operate continuously whenever the air-handling unit (AHU) is in either the occupied mode or the warm-up/cool-down modes. The supply fan shall be off whenever the AHU run-stop interlock is open, the mixed air low limit is tripped or the supply fan status indicates a failure (after a 30-second delay).
- E. Economizer Damper Control - When the outdoor air temperature is less than the economizer changeover setpoint, the outdoor air damper shall modulate between the adjustable minimum position (i.e., occupied standby minimum position) and full open to maintain the discharge air temperature at the supply air setpoint. The outdoor air damper shall modulate closed as required (overriding the minimum position) to maintain the mixed air temperature at or above the mixed air low-limit setpoint. A separate manual reset mixed air low limit shall turn the supply fan off if any 12 inches of its sensing element is below its setpoint (38 degrees F, adjustable at the device).

The outdoor air damper shall close if the outdoor air temperature falls below a low ambient damper lockout setpoint. If the air-handling unit is in the morning warm-up mode, the supply fan is off or the mixed air temperature sensor has failed, the outdoor air damper shall be closed.

- F. Return Fan Control - The return fan operation shall be coordinated with the unit supply fan operation. The return fan shall be energized whenever the supply fan is on.

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- G. Hydronic Heating Valve Control - The heating valve shall modulate to maintain the discharge air temperature at the supply temperature setpoint that is determined by the space temperature control setpoint. The heating valve shall be closed if the outdoor air damper is open past its minimum position or if the cooling valve is open. The heating valve shall be fully open if the supply fan is off and the outdoor temperature drops below the low-limit temperature setpoint of 35 degrees F (adjustable).
- H. Cooling Valve Control - The cooling valve shall modulate to maintain the discharge air temperature at the supply air setpoint that is determined by the space temperature control setpoint. If the economizer function is enabled and the outdoor air damper is not fully opened, the cooling valve shall be closed. The cooling valve shall be closed if the heating valve is open or if the supply fan is off.
- I. Stand-Alone Operation - Stand-alone operation shall require an outside air sensor. A Timed Override mode as indicated by the air-handling unit space sensor should return the system to occupied mode. The Timed Override shall be adjustable.
- J. Building Automation System (BAS) Interface - The BAS shall send the air-handling unit (AHU) controller the occupied space heating and cooling temperature setpoints. The BAS shall also send the following mode commands:
1. Occupied
 2. Unoccupied
 3. Morning warm-up/cool-down
 4. Heating/cooling
 5. Economizer enable
 6. Timed override
 7. Night economizing
 8. Priority shutdown commands

If communication with the BAS is lost, the AHU shall use predetermined default setpoints and shall operate in the occupied mode.

K. Diagnostics

The building automation system shall provide alarm messages for the air-handling unit (AHU) diagnostics that are sensed by the AHU controller (listed below). The AHU controller shall initiate a failsafe operational sequence based on the diagnostic condition.

1. Low temperature detection (low-limit)
2. Low ambient outdoor air damper lockout
3. Supply fan failure
4. Return fan failure
5. Space temperature sensor failure
6. Local space setpoint
7. Outdoor air temperature sensor failure
8. Mixed air temperature sensor failure
9. Discharge air temperature sensor failure

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10. Unit shutdown
 - L. Troubleshooting
 - a) Manual Output Test – The air-handling unit controller shall be able to manually exercise all outputs for troubleshooting. This shall be done through a test switch located at the controller or using a software service tool.
 - b) Unit Identification – The air-handling unit (AHU) controller shall have the capability of flashing an LED upon receiving a communications test message from a software service tool or building automation system (BAS). The AHU controller shall also include a switch that will send the unit address to a software service tool or BAS for unit identification.
 - c) Hydronic Valve Override – This command from a software service tool or building automation system shall cause all valves to stroke fully open for water balancing.
- 1.7 SEQUENCE OF OPERATION FOR VARIABLE AIR VOLUME (VAV) AIR-HANDLING UNITS (Cooling Only)
- A. Occupied Mode - Each air-handling unit (AHU) shall have a dedicated microprocessor based controller that shall monitor and control the unit in a stand-alone mode or as a part of the building automation system. When the AHU is in the occupied mode, the supply fan shall operate continuously and the variable frequency drive shall modulate to maintain the duct static pressure at 3.0 inches wc (adjustable). The cooling valve, economizer dampers and heating valve (and face-and-bypass dampers) shall modulate in sequence to maintain the discharge air temperature setpoint.
 - B. Unoccupied Mode - When the air-handling unit (AHU) is in the unoccupied mode, the supply fan shall be off, and the outdoor air damper, control valves shall be closed. The control valves shall open fully if the outdoor temperature falls below a low-limit temperature setpoint of 35 degrees F (adjustable).
 - C. Supply Fan Control - The supply fan shall operate continuously whenever the air-handling unit (AHU) is in either the occupied mode or the warm-up/cool-down modes. The supply fan shall be off whenever the AHU run-stop interlock is open, the mixed air low limit is tripped or the supply fan status indicates a failure. If the duct static pressure exceeds a high limit of four inches wc (adjustable), the AHU shall be shut down and a diagnostic message generated.
 - D. Cooling Valve Control - The cooling valve shall modulate to maintain the discharge air temperature at the supply air setpoint. If the economizer function is enabled and the outdoor air damper is not fully opened, the cooling valve shall be closed. The cooling valve shall be closed if the supply fan is off.

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- E. Stand-Alone Operation - Stand-alone operation shall require an outside air sensor. A Timed Override mode as indicated by the air-handling unit space sensor should return the system to occupied mode. The Timed Override shall be adjustable.
- F. Building Automation System (BAS) Interface - The BAS shall send the air-handling unit (AHU) controller the discharge air temperature setpoint and duct static pressure setpoint. The BAS shall also send the following mode commands:
1. Occupied
 2. Unoccupied
 3. Morning warm-up/cool-down
 4. Heating/cooling
 5. Timed override
 6. Night economizing
 7. Priority shutdown commands

If communication with the BAS is lost, the AHU shall use predetermined default setpoints and shall operate in the occupied mode.

- I. VAV Box Reheat Interlock Control - Each VAV box reheat shall be disabled from, or enabled for local control by the VAV box standalone controller. At a minimum, all boxes being served by an AHU shall be controlled as a group. Provide more groups as designated in the points list, drawings or elsewhere in this specification.

The interlock shall be controlled by comparing the outside air ambient temperature to the interlock setpoint (adjustable) set at 70 degrees F. If AHU controller is individually sensing the outside air ambient temperature serving the unit, then the temperature sensor for that AHU shall be used for the interlock for its group of boxes.

The interlock shall also be controlled by a system operator command and other processes.

- J. Diagnostics - The building automation system shall provide alarm messages for the air-handling unit (AHU) diagnostics that are sensed by the AHU controller (listed below). The AHU controller shall initiate a failsafe operational sequence based on the diagnostic condition
1. Low temperature detection (low-limit)
 2. Unit shutdown
 3. Supply fan failure
 4. Return fan failure
 5. Duct static pressure high limit
 6. Duct static pressure sensor failure
 7. Space temperature sensor failure
 8. Outdoor air temperature sensor failure
 9. Mixed air temperature sensor failure
 10. Return air

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K. Troubleshooting

Manual Output Test – The air-handling unit controller shall be able to manually exercise all outputs for troubleshooting. This shall be done through a test switch located at the controller or using a software service tool.

Unit Identification – The air-handling unit (AHU) controller shall have the capability of flashing an LED upon receiving a communications test message from a software service tool or building automation system (BAS). The AHU controller shall also include a switch that will send the unit address to a software service tool or BAS for unit identification.

Hydronic Valve Override – This command from a software service tool or building automation system shall cause all valves to stroke fully open or fully closed for water balancing.

1.9 SEQUENCE OF OPERATION, WATER SOURCE HEAT PUMP

A. WATER SOURCE HEAT PUMP SYSTEM (Cooling Only WSHP)

When the building is occupied, the BAS system energizes the cooling tower pump to run continuously upon a request from WSHP. Upon failure of the pump, an alarm will be activated.

The BAS system controls the cooling tower to maintain the heat pump supply water temperature between 60 and 88 deg f. when the heat pump temperature water supply rises above 88 deg f., the BAS system shall energize the cooling tower pump and when the supply temperature rises above 90 deg. f. energizes the tower fan.

When the supply condenser water temperature rises above 95 deg. F., the BAS system shall stop WSHP unit, stop loop pump and activate an alarm condition.

When the supply condenser water temperature falls below 50 deg. F., the BAS system shall stop WSHP compressor and stop the loop pump but maintain the supply fan energized. The WSHP shall go into economizer mode to maintain primary supply air temperature at setpoint.

When the building is unoccupied, the heat pump system is de-energized until the heat pump unit requires cooling. The system then operates until the respective area temperature is satisfied.

The BAS system shall monitor points and will initiate an alarm condition if any point is not within the operating limits:

WSHP system supply & return temperature
Cooling tower supply & return temperatures
Pump operation

B. WATER SOURCE HEAT PUMP VAV UNIT:

Occupied Mode - The unit fan runs continuously according to an operator adjustable unit schedule. The WSHP BAS module controls the compressor to maintain the zone spaces' temperature of 74°F (adjustable). The WSHP units shall maintain 55°F (supply air adjustable) for VAV units. When the primary air is above Setpoint, the BAS module energizes the compressor for cooling and de-energizes the compressor for heating. BAS module requests Cooling water from the building loop water system.

When the WSHP is in the occupied mode, the supply fan shall operate continuously and the variable frequency drive shall modulate to maintain the duct static pressure at 3.0 inches wc (adjustable). The compressor, refrigerant valve and economizer dampers shall modulate in sequence to maintain the discharge air temperature setpoint.

Unoccupied Mode - When the unit is on the unoccupied cycle the BAS module continues to monitor the space temperature requirements. If the space temperature goes above 90°F (adjustable) the BAS module shall request the building supply system to provide supply water to the WSHP and shall start the unit after the loop water system is operating. The BAS module will start the WSHP pump as required to be at the occupied temperature setpoint at the start of the scheduled occupied cycle.

Supply Fan Control - The supply fan shall operate continuously whenever the WSHP is in either the occupied mode or the warm-up/cool-down modes. The supply fan shall be off whenever the AHU run-stop interlock is open, the mixed air low limit is tripped or the supply fan status indicates a failure. If the duct static pressure exceeds a high limit of four inches wc (adjustable), the WSHP shall be shut down and a diagnostic message generated.

VAV Box Reheat Interlock Control - Each VAV box reheat shall be disabled from, or enabled for local control by the VAV box standalone controller. At a minimum, all boxes being served by an AHU shall be controlled as a group. Provide more groups as designated in the points list, drawings or elsewhere in this specification.

C. Building Automation System (BAS) Interface - The BAS shall send the air-handling unit (AHU) controller the discharge air temperature setpoint and duct static pressure setpoint. The BAS shall also send the following mode commands:

1. Occupied
2. Unoccupied
3. Morning warm-up/cool-down
4. Heating/cooling
5. Timed override
6. Night economizing
7. Priority shutdown commands

If communication with the BAS is lost, the AHU shall use predetermined default setpoints and shall operate in the occupied mode.

2.0 SEQUENCE OF OPERATION, VARIABLE AIR VOLUME TERMINAL UNITS

A. Direct Digital Controls

1. General. DDC Controls, actuator and factory costs to mount, calibrate and test the system shall be the responsibility of BAS Contractor.
2. Terminal unit manufacturer shall provide price for factory mounting and continuity check of direct digital controls to the BAS contractor. Field mounted DDC controls are not acceptable.
3. Multi-point, multi-axis flow ring or cross sensor to be furnished and mounted by terminal unit manufacturer. Single point or flow bar sensors are not acceptable. Shall be capable of maintaining airflow to within +/- 5 percent of rated unit airflow setpoint with 1.5 duct diameters straight duct upstream from the unit.

B. VARIABLE AIR VOLUME (VAV) TERMINAL UNIT CONTROL

1. The VAV terminal units shall be individually controlled by a DDC VAV controller per VAV terminal unit. The transducer and transformer shall be supplied by the BAS contractor and furnished to the terminal unit supplier. The cost to factory mount, calibrate and test the controller, transducer, transformer and actuator shall be coordinated prior to bid day and included in the BAS price.
 - a. To assure proper operation and control, the BAS contractor as part of this bid shall recalibrate the transducers six (6) months after acceptance of the BAS system to correct any deviations as a result of transducer drift.
2. Submit a copy of the recalibration report to the Engineer, Mechanical Contractor, Test, Adjust and Balance Contractor and Owner.
3. The BAS shall perform the following VAV Terminal unit control strategies and provide the points as listed on the DDC/VAV point list and the specified monitoring and diagnostics.
 - a. Grouping - The BAS shall be able to group VAV boxes via keyboard commands. These groups shall make it possible for the operator to send a common command to all boxes in a group to operate in the same mode. A sample of this group report must be provided in the submittal package for approval by engineer and owner. BAS shall also compile on a group basis, the following:
 1. Minimum group temperature
 2. Maximum group temperature
 3. Average group temperature

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4. Current airflow through boxes in group (total)
 - b. Setpoint Control - The BAS shall edit the zone space temperature setpoint of each VAV box. The zone temperature setpoint shall be operator adjustable. Individual zone setpoint and control logic shall reside at the zone level, and not be dependent upon the BAS for control. In the event of communication loss, the box will continue to control to current setpoints.
 - c. Cooling Air Valve Control - The BAS shall control the cooling air valve to a fully open, fully closed, maximum CFM, or minimum CFM position based on operator commands. The operator shall also have the capability to adjust the maximum & minimum airflow limits of the air valve through the BAS.
 - d. Operating Mode - The BAS shall place the box in either the occupied or unoccupied mode based on an operator adjustable time schedule. Separate heating & cooling setpoints shall be enterable for each mode through the BAS. Other modes available for special applications shall include full open, full closed, maximum flow, and minimum flow.
 - e. Control Offset - The BAS shall be capable of offsetting the cooling or heating setpoints of one or more groups of boxes by an operator adjustable amount. This capability will allow for automatic zone setpoint changes based on system requirements, such as demand limiting.
 - f. Automatic Recalibration - The system shall automatically recalibrate its air flow sensing & air valve position measurement system at system startup and on a scheduled basis.
 - g. Remote Setpoint Adjustment - The BAS zone temperature setpoint programmed in software shall be capable of being manually overridden by a remote adjustment at the temperature sensor. This manual readjustment feature may be disabled through the BAS, if desired.
 - h. Override Button - The VAV box shall be capable of being placed in the "occupied" mode by pressing an override button mounted on the zone temperature sensor.
 - i. Terminal unit status reports - For each terminal unit, the BAS shall provide an operating status summary of all unit sensed values (zone temperature, CFM, etc.), setpoints, and modes.
 - j. Terminal unit group report - For each group of VAV terminal units, the BAS shall report the group mode, heating and cooling airflow, average zone temperature, minimum zone temperature, and maximum zone temperature. The report shall also display for each terminal unit in the

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group the present temperature control setpoints and the current zone temperature.

4. Zone Sensors
 - a. The zone sensor shall be accurate to within 0.5 F. The sensor shall be a product of the VAV box controls manufacturer and designed specifically for the installed controller.
5. Terminal box diagnostics.
 - a. If zone temperature sensor input fails above its high range, unit shall control at its maximum CFM setpoint. If sensor input fails below its low range, unit shall control to its minimum CFM setpoint.
 - b. In both cases, all heat outputs shall be disabled. a diagnostic message shall be displayed upon operator inquiry.
 - c. If flow measuring system fails, unit shall automatically convert to a pressure dependent, damper position based algorithm. Diagnostic message shall be displayed upon operator inquiry.
 - d. If zone temperature setpoint potentiometer on zone sensor fails, unit shall automatically control to programmed occupied setpoints. Diagnostic message shall be displayed upon operator inquiry.
 - e. If communications are lost, controller shall continue to operate in the current mode of operation. All setpoints shall be retained in nonvolatile memory. If communications are not restored within 15 minutes, unit shall automatically initiate a reset-recalibrate.

2.1 SEQUENCE OF OPERATION, AIR TERMINAL UNITS

A. DDC Controls

1. Shutoff VAV Terminals
 - a. On a rise in space temperature, the unit will modulate to provide maximum CFM. As space temperature decreases, the box will modulate down to its minimum CFM.
2. Shutoff VAV terminals with reheat
 - a. On a rise in temperature above the cooling setpoint, the VAV terminal unit shall modulate to its maximum CFM. As the space temperature drops below the cooling setpoint, the terminal unit shall modulate to its

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minimum CFM. As the space temperature continues to fall to the heating setpoint, the terminal shall modulate to its heating minimum CFM. At this point, the heat will be staged on as follows:

- 1) Incremental Hot Water - Below heating setpoint open hot water valve.

2.2 SEQUENCE OF OPERATION VENTILATION UNITS

- A. Gravity Roof Ventilator: interlock with AHU/RTU to open dampers.
- B. Exhaust Fan: Time clock during "Occupancy" energizes all restroom exhaust fans. Room thermostat shall cycle thermostatic controlled fans.
- C. Kitchen Exhaust Fan: Hood switch and/or AHU-F-2 starts fan and energizes makeup air unit.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 15990

TESTING, ADJUSTING, AND BALANCING

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 testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:

1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
2. Adjusting total HVAC systems to provide indicated quantities.
3. Building pressurization.
4. Measuring electrical performance of HVAC equipment.
5. Setting quantitative performance of HVAC equipment.
6. Verifying that automatic control devices are functioning properly.
7. Measuring sound and vibration.
8. Reporting results of the activities and procedures specified in this Section.

- B. Related Sections include the following:

1. Testing and adjusting requirements unique to particular systems and equipment are included in the Sections that specify those systems and equipment.
2. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment Sections.
3. Division 15 “Sequence of Operations”
4. Division 15 “Building Management System” for controls.

1.3 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.
- C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

- D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
 - E. Report Forms: Test data sheets for recording test data in logical order.
 - F. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
 - G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
 - H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - I. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
 - J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
 - K. Test: A procedure to determine quantitative performance of a system or equipment.
 - L. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.
 - M. AABC: Associated Air Balance Council.
 - N. AMCA: Air Movement and Control Association.
 - O. NEBB: National Environmental Balancing Bureau.
 - P. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.
- 1.4 SUBMITTALS
- A. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit 2 copies of evidence that the testing, adjusting, and balancing Agent and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Article below.
 - B. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3 of this Section.
 - C. Strategies and Procedures Plan: Within 60 days from the Contractor's Notice to Proceed, submit 2 copies of the testing, adjusting, and balancing strategies and step-by-step procedures as specified in Part 3 "Preparation" Article below. Include a complete set of report forms intended for use on this Project.

- D. Certified Testing, Adjusting, and Balancing Reports: Submit 2 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.
- E. Warranty: Submit 2 copies of special warranty specified in the "Warranty" Article below.

1.5 QUALITY ASSURANCE

- A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by either AABC or NEBB.
- B. Testing, Adjusting, and Balancing Conference: Meet with the Owner's and the Architect's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, HVAC controls Installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.
 - 1. Agenda Items: Include at least the following:
 - a. Contract Documents examination report.
 - b. Testing, adjusting, and balancing plan.
 - c. Coordination and cooperation of trades and subcontractors.
- C. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
 - 2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.
- D. Testing, Adjusting, and Balancing Reports: Use standard forms from AABC's "National Standards for Testing, Adjusting, and Balancing." Or use testing, adjusting, and balancing Agent's standard forms approved by the Architect.
- E. Instrumentation Type, Quantity, and Accuracy: As described in AABC national standards.
- F. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.6 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 testing, adjusting, and balancing activities.
- B. Notice: Provide 7 days' advance notice for each test. Include scheduled test dates and times.

- C. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 WARRANTY

- A. General Warranty: The national project performance guarantee specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
- B. National Project Performance Guarantee: Provide a guarantee on AABC'S "National Standards" forms stating that AABC will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:
 - 1. The certified Agent 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 Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.
 - 1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
 - 2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, 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 "Project Record Documents."
- D. Examine Architect's and Engineer's 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 the 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 Specification 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, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and 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 air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.
- L. Examine plenums, utilized for supply air, to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- M. Examine strainers for clean screens and proper perforations.
- N. Examine control valves for proper installation for their intended function of diverting or mixing fluid flows.
- O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- P. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping.
- Q. Examine equipment for installation and for properly operating safety interlocks and controls.
- R. Examine automatic temperature system components to verify the following:
 - 1. Dampers, valves, and other controlled devices operate by the intended controller.
 - 2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in phase and bypass, mixing boxes, and variable-air-volume terminals.
 4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 6. Sensors are located to sense only the intended conditions.
 7. Sequence of operation for control modes is according to the Contract Documents.
 8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
 9. Interlocked systems are operating.
 10. Changeover from heating to cooling mode occurs according to design values.
- S. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 PREPARATION

- A. Prepare a testing, adjusting, and balancing 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. Equipment and duct access doors are securely closed.
 5. Balance, smoke, and fire dampers are open.
 6. Isolating and balancing valves are open and control valves are operational.
 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 8. Windows and doors can be closed so design conditions for system operations can be met.

3.3 GENERAL TESTING AND BALANCING PROCEDURES

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC national standards and this Section.
- B. Cut insulation, ducts, 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 the insulation Specifications for this Project.
- C. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Determine the best locations in main duct for accurate duct airflow measurements.
- C. Check the airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- D. Check the airflow from the return plenum at open end return ducts and fire dampered wall openings.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check dampers for proper position to achieve desired airflow path.
- H. Check for airflow blockages.
- I. Check condensate drains for proper connections and functioning.
- J. Check for proper sealing of air-handling unit components.

3.5 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES

- A. The procedures in this Article apply to constant-volume supply-, return-, and exhaust-air systems. Additional procedures are required for variable-air-volume and induction-unit supply-air systems and process exhaust-air systems. These additional procedures are specified in other articles in this Section.
- B. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer.
 - 1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 - 2. Measure static pressure across each air-handling unit component.
 - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers under final balanced conditions.
 4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
 5. Adjust fan speed higher or lower than design with the approval of the Architect. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
 6. 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 no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.
- C. Adjust volume dampers for main duct, submain ducts, and major branch ducts to design airflows within specified tolerances.
1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
 - a. Where sufficient space in submains and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submains and branch ducts to design airflows within specified tolerances.
- D. Measure terminal outlets and inlets without making adjustments.
1. Measure terminal outlets using a direct-reading hood or the outlet manufacturer's written instructions and calculating factors.
- E. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers rather than extractors and the dampers at the air terminals.
1. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 2. Adjust patterns of adjustable outlets for proper distribution without drafts.
- 3.6 VARIABLE-AIR-VOLUME SYSTEMS' ADDITIONAL PROCEDURES
- A. Compensating for Diversity: When the total airflow of all terminal units is more than the fan design airflow volume, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the design airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure-Dependent, Variable-Air-Volume System without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance systems similar to constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to design airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets.

3.7 FUNDAMENTAL 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 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 flow-control valves for specified sequence of operation and set at design flow.
 5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type, unless several terminal valves are kept open.
 6. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
 7. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 HYDRONIC SYSTEMS' BALANCING PROCEDURES

- A. Determine 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. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the

- point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.
 2. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.
 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the 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 design flow.
- E. Adjust balancing stations to within specified tolerances of design flow rate as follows:
1. Determine the balancing station with the highest percentage over design flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design 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.
- G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer, model, and serial numbers.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Efficiency rating if high-efficiency motor.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.10 CHILLERS

- A. Balance water flow through evaporator and condenser to within specified tolerances of design flow with pump operating. Measure and record the following data with chiller operating at design conditions:
 - 1. Evaporator water entering and leaving temperatures, pressure drop, and water flow.
 - 2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by the chiller manufacturer.
 - 3. Power factor if factory-installed instrumentation is furnished for measuring kW.
 - 4. The kW input if factory-installed instrumentation is furnished for measuring kW.
 - 5. Capacity: Calculate in tons of cooling.

3.11 HEAT-TRANSFER COILS

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

3.12 TEMPERATURE TESTING

- A. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of 2 successive 8-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside-air, wet- and dry-bulb temperatures.

3.13 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. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Verify free travel and proper operation of control devices such as damper and valve operators.

- F. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.
- G. Confirm interaction of electrically operated switch transducers.
- H. Confirm interaction of interlock and lockout systems.
- I. Verify main control supply-air pressure and observe compressor and dryer operations.
- J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.14 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans: Plus 5 to plus 10 percent.
 - 2. Air Outlets and Inlets: 0 to minus 10 percent.
 - 3. Heating-Water Flow Rate: 0 to minus 10 percent.
 - 4. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.15 REPORTING

- A. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard paper, in 3-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 the instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to the 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 approved Shop Drawings and Product Data.
- D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:

1. Title page.
 2. Name and address of testing, adjusting, and balancing Agent.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of testing, adjusting, and balancing Agent who certifies the report.
 10. Summary of contents, including the following:
 - a. Design versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 11. Nomenclature sheets for each item of equipment.
 12. Data for terminal units, including manufacturer, type size, and fittings.
 13. Notes to explain why certain final data in the body of reports vary from design values.
 14. Test conditions for fans and pump performance forms, including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings, including settings and percentage of maximum pitch diameter.
 - f. Frequency Drive settings for variable-air-volume system.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- E. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Number of belts, make, and size.
 - i. Number of filters, type, and size.
 2. Motor Data: Include the following:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.

3. Test Data: Include design and actual values for the following:
 - a. Total airflow rate in cfm
 - b. Total system static pressure in inches wg .
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg .
 - e. Filter static-pressure differential in inches wg.
 - f. Cooling coil static-pressure differential in inches wg .
 - g. Outside airflow in cfm.
 - h. Return airflow in cfm.
 - i. Outside-air damper position.
 - j. Return-air damper position.

- F. Apparatus-Coil Test Reports: For apparatus coils, include the following:
 1. Coil Data: Include the following:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Make and model number.
 - f. Circuiting arrangement.

 2. Test Data: Include design and actual values for the following:
 - a. Airflow rate in cfm .
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outside-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water flow rate in gpm .
 - i. Water pressure differential in feet of head or psig.
 - j. Entering-water temperature in deg F.
 - k. Leaving-water temperature in deg F.

- G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 1. Fan Data: Include the following:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches (mm), and bore.
 - h. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).

2. Motor Data: Include the following:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
 - g. Number of belts, make, and size.
 3. Test Data: Include design and actual values for the following:
 - a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Suction static pressure in inches wg (Pa).
- H. Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data: Include the following:
 - a. System and air-handling unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg .
 - e. Duct size in inches.
 - f. Design airflow rate in cfm.
 - g. Actual airflow rate in cfm.
 - h. Actual average velocity in fpm.
 - i. Barometric pressure in psig.
- I. Air-Terminal-Device Reports: For terminal units, include the following:
1. Unit Data: Include the following:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Test apparatus used.
 - d. Area served.
 - e. Air-terminal-device make.
 - f. Air-terminal-device number from system diagram.
 - g. Air-terminal-device type and model number.
 - h. Air-terminal-device size.
 2. Test Data: Include design and actual values for the following:
 - a. Airflow rate in cfm (L/s).
 - b. Air velocity in fpm (m/s).
 - c. Preliminary airflow rate as needed in cfm (L/s).

- d. Preliminary velocity as needed in fpm (m/s).
 - e. Final airflow rate in cfm (L/s).
 - f. Final velocity in fpm (m/s).
 - g. Space temperature in deg F (deg C).
- J. System-Coil Reports: For reheat coils of terminal units, include the following:
- 1. Unit Data: Include the following:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Heating Element KW.
 - 2. Test Data: Include design and actual values for the following:
 - a. Airflow rate in cfm (L/s).
 - b. Entering-water temperature in deg F (deg C).
 - c. Leaving-water temperature in deg F (deg C).
 - d. Entering-air temperature in deg F (deg C).
 - e. Leaving-air temperature in deg F (deg C).
- K. Chiller Reports:
- 1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Make and model number.
 - c. Manufacturer's serial number.
 - d. Refrigerant type and capacity in gal..
 - e. Starter type and size.
 - f. Starter thermal protection size.
 - 2. Condenser Test Data: Include design and actual values for the following:
 - a. Refrigerant pressure in psig (kPa).
 - b. Refrigerant temperature in deg F (deg C).
 - c. Entering-water temperature in deg F (deg C).
 - d. Leaving-water temperature in deg F (deg C).
 - e. Entering-water pressure in feet of head or psig (kPa).
 - f. Water pressure differential in feet of head or psig (kPa).
 - 3. Evaporator Test Reports: Include design and actual values for the following:
 - a. Refrigerant pressure in psig (kPa).
 - b. Refrigerant temperature in deg F (deg C).
 - c. Entering-water temperature in deg F (deg C).
 - d. Leaving-water temperature in deg F (deg C).
 - e. Entering-water pressure in feet of head or psig (kPa).
 - f. Water pressure differential in feet of head or psig (kPa).

4. Compressor Test Data: Include design and actual values for the following:
 - a. Make and model number.
 - b. Manufacturer's serial number.
 - c. Suction pressure in psig (kPa).
 - d. Suction temperature in deg F (deg C).
 - e. Discharge pressure in psig (kPa).
 - f. Discharge temperature in deg F (deg C).
 - g. Oil pressure in psig (kPa).
 - h. Oil temperature in deg F (deg C).
 - i. Voltage at each connection.
 - j. Amperage for each phase.
 - k. The kW input.
 - l. Crankcase heater kW.
 - m. Chilled water control set point in deg F (deg C).
 - n. Refrigerant low-pressure-cutoff set point in psig (kPa).
 - o. Refrigerant high-pressure-cutoff set point in psig (kPa).

5. Refrigerant Test Data: Include design and actual values for the following:
 - a. Oil level.
 - b. Refrigerant level.
 - c. Relief valve setting in psig (kPa).
 - d. Low-temperature-cutoff set point in deg F (deg C).

- L. Pump Test Reports: For pumps, include the following data.
 1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model and serial numbers.
 - f. Water flow rate in gpm (L/s).
 - g. Water pressure differential in feet of head or psig (kPa).
 - h. Required net positive suction head in feet of head or psig (kPa).
 - i. Pump rpm.
 - j. Impeller diameter in inches (mm).
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.

 2. Test Data: Include design and actual values for the following:
 - a. Static head in feet of head or psig (kPa).
 - b. Pump shutoff pressure in feet of head or psig (kPa).
 - c. Actual impeller size in inches (mm).
 - d. Full-open flow rate in gpm (L/s).

- e. Full-open pressure in feet of head or psig (kPa).
- f. Final discharge pressure in feet of head or psig (kPa).
- g. Final suction pressure in feet of head or psig (kPa).
- h. Final total pressure in feet of head or psig (kPa).
- i. Final water flow rate in gpm (L/s).
- j. Voltage at each connection.
- k. Amperage for each phase.

M. Instrument Calibration Reports: For instrument calibration, include the following:

1. Report Data: Include the following:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.17 ADDITIONAL TESTS

A. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

END OF SECTION

SECTION 16060
GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Grounding systems and equipment.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.2 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad; 3/4 inch by 10 feet (19 mm by 3 m in diameter).

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No.8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- C. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.

6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
 10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch (6.3-by-100-by-300-mm) grounding bus.
 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

- C. Test Wells: Ground rod driven through drilled hole in bottom of hand hole. Handholes are specified in Division 2 Section "Underground Ducts and Utility Structures," and shall be at least 12 inches (300 mm) deep, with cover.
 - 1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- E. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

3.4 LABELING

- A. Comply with requirements in Division 16 Section "Electrical Identification" Article for instruction signs. The label or its text shall be green.
- B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - 1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. 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. Make tests at ground rods before any conductors are connected.

- B. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

- C. 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 16073

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

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

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

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

SECTION -16073- HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 5 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - 6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 To Light Steel: Sheet metal screws.

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7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
 - E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
- 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS
- A. Comply with installation requirements in Division 5 Section "Metal Fabrications" for site-fabricated metal supports.
 - B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
 - C. Field Welding: Comply with AWS D1.1/D1.1M.
- 3.4 PAINTING
- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
 - B. Touchup: Comply with requirements in Division 9 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
 - C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 16073

SECTION 16075
ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. White letters on a black field.
 2. Legend: Indicate voltage, phase and wire.
- C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Colors for Raceways Carrying Circuits at 600 V and Less:
1. White letters on a Black field
 2. Legend: Indicate voltage, phase and wire.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

- C. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- D. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE

- A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.7 INSTRUCTION SIGNS

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

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

2.8 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

- C. Stenciled Legend: In non-fading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 9 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Apply identification devices to surfaces that require finish after completing finish work.
- C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- E. Painted Identification: Comply with requirements in Division 9 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A, and 120 V to ground: Install labels at 30-foot (10-m) maximum intervals.
- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. Emergency Power.
 - 2. Power.
- C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - 1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.

- a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- E. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
- G. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
1. Comply with 29 CFR 1910.145.
 2. Identify system voltage with black letters on an orange background.
 3. Apply to exterior of door, cover, or other access.
 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.

- I. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.
- K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 1. Labeling Instructions:
 - a. Indoor Equipment: Adhesive film label with clear protective overlay. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

END OF SECTION 16075

SECTION – 16091– SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

SECTION 16091

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Division 7 Section "Through-Penetration Firestop Systems" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

B. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).

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- b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings; product name or designation or comparable product by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
 3. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 4. Pressure Plates: Carbon steel.
 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Presealed Systems.

2.4 GROUT

- A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

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- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 7 Section "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.
- D. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work. All roof penetration and sealing work shall be performed by owners approved contractor.
- E. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- F. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

SECTION – 16091– SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 16091

SECTION 16092

SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Division 7 Section "Through-Penetration Firestop Systems" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized-steel sheet.
2. Minimum Metal Thickness:

SECTION – 16092– SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

- a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
- b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
 3. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 4. Pressure Plates: Carbon steel.
 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Presealed Systems.

SECTION - 16092- SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 7 Section "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

SECTION – 16092– SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 16092

SECTION 16120
CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Copper Conductors: Comply with NEMA WC 70.
- B. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.
- C. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with ground wire.
- D. Hospital Grade Cabling and conductors shall be installed in all areas labeled for medical occupancy

2.2 CONNECTORS AND SPLICES

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

2.3 SLEEVES FOR CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water stop, unless otherwise indicated.
- C. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."

2.4 SLEEVE SEALS

- 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:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Pipeline Seal and Insulator, Inc.
- D. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

2. Pressure Plates: Carbon steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

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

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway or Metal-clad cable, Type MC.
- C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- D. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway
- G. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- H. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- I. Class 2 Control Circuits: Power-limited cable, concealed in building finishes.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- 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 cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 16 Section "Electrical Supports and Seismic Restraints."
- F. Identify and color-code conductors and cables according to Division 16 Section "Electrical Identification."
- G. 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.
- H. 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.
- I. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- D. Cut sleeves to length for mounting flush with both wall surfaces.
- E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 7 Section "Joint Sealants."

- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 7 Section "Through-Penetration Firestop Systems."
- J. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
- K. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- L. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.5 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground exterior-wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.6 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 7 Section "Through-Penetration Firestop Systems."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test feeder conductors and conductors feeding relocated panelboards.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. (All Service Distribution Equipment (Existing and New) shall be scanned)

- a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
 - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- C. 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.
- D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 16120

SECTION 16130
RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. See Division 2 Section "Underground Ducts and Utility Structures" for exterior ductbanks and manholes, and underground handholes, boxes, and utility construction.

1.2 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, details, and attachments to other work.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Rigid Steel Conduit: ANSI C80.1.
- B. IMC: ANSI C80.6.
- C. EMT: ANSI C80.3.
- D. FMC: Zinc-coated steel.
- E. LFMC: Flexible steel conduit with PVC jacket.

- F. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 2. Fittings for EMT: Steel, compression type.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. ENT: NEMA TC 13.
- B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- C. LFNC: UL 1660.
- D. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- E. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

- 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:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman.
 - 3. Square D; Schneider Electric.
- C. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.
- D. 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.
- E. Wireway Covers: Screw-cover type.
- F. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS

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

1. Hoffman.
 2. Lamson & Sessions; Carlon Electrical Products.
- C. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- D. 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.

2.5 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.
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 following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Thomas & Betts Corporation.
 - b. Walker Systems, Inc.; Wiremold Company (The).
 - c. Wiremold Company (The); Electrical Sales Division.
- B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors.
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 following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Butler Manufacturing Company; Walker Division.
 - b. Enduro Systems, Inc.; Composite Products Division.
 - c. Hubbell Incorporated; Wiring Device-Kellems Division.
 - d. Lamson & Sessions; Carlon Electrical Products.
 - e. Panduit Corp.
 - f. Walker Systems, Inc.; Wiremold Company (The).
 - g. Wiremold Company (The); Electrical Sales Division.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

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

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 - 1. Exposed Conduit: Rigid steel conduit.
 - 2. Concealed Conduit, Aboveground: Rigid steel conduit.
 - 3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Comply with the following indoor applications, unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 - 3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 6. Damp or Wet Locations: Rigid steel conduit.
 7. Raceways for Optical Fiber or Communications Cable: EMT>.
 8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations.
- C. Minimum Raceway Size: 1/2-inch (16-mm) trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
- 3.2 INSTALLATION
- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Support raceways as specified in Division 16 Section "Electrical Supports and Seismic Restraints."
- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Raceways Embedded in Slabs:
1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 3. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
- I. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

- J. 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.
- K. Raceways for Optical Fiber and Communications Cable: Install as follows:
1. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
 2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- L. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where otherwise required by NFPA 70.
- M. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).
1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - d. Attics: 135 deg F (75 deg C) > temperature change.
 2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.
 3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.
- N. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.

2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- O. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
- P. Set metal floor boxes level and flush with finished floor surface.
- Q. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 2 Section "Earthwork" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Division 2 Section "Earthwork."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 2 Section "Earthwork."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of conduit.

3.4 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Through-Penetration Firestop Systems."

END OF SECTION 16130

SECTION 16140
WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Wall-box motion sensors.
 - 3. Snap switches and wall-box dimmers.
 - 4. Solid-state fan speed controls.
 - 5. Wall-switch and exterior occupancy sensors.
 - 6. Communications outlets.
- B. See Division 16 Section "Voice and Data Communication Cabling" for workstation outlets.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5351 (single), 5352 (duplex).
 - b. Hubbell; HBL5351 (single), CR5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5381 (single), 5352 (duplex).

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; GF20.
 - b. Pass & Seymour; 2084.

2.4 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
 - b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).

- c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
 - d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).
- C. Pilot Light Switches, 20 A:
- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221PL for 120 V and 277 V.
 - b. Hubbell; HPL1221PL for 120 V and 277 V.
 - c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
 - d. Pass & Seymour; PS20AC1-PLR for 120 V.
 - 3. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
- D. Key-Operated Switches, 120/277 V, 20 A:
- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221L.
 - b. Hubbell; HBL1221L.
 - c. Leviton; 1221-2L.
 - d. Pass & Seymour; PS20AC1-L.
 - 3. Description: Single pole, with factory-supplied key in lieu of switch handle.
- E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995.
 - b. Hubbell; HBL1557.
 - c. Leviton; 1257.
 - d. Pass & Seymour; 1251.
- F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:

- a. Cooper; 1995L.
- b. Hubbell; HBL1557L.
- c. Leviton; 1257L.
- d. Pass & Seymour; 1251L.

2.5 WALL-BOX DIMMERS

- A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- B. Control: Continuously adjustable toggle switch; with single-pole or three-way switching. Comply with UL 1472.
- C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
 1. 1000 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF."
- D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.6 FAN SPEED CONTROLS

- A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
 1. Continuously adjustable toggle switch, 5 A.
 2. Three-speed adjustable slider, 1.5 A.

2.7 OCCUPANCY SENSORS

- A. Wall-Switch Sensors:
 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 6111 for 120 V, 6117 for 277 V.
 - b. Hubbell; WS1277.
 - c. Leviton; ODS 10-ID.
 - d. Pass & Seymour; WS3000.
 - e. Watt Stopper (The); WS-200.
 3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m):

B. Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; AT120 for 120 V, AT277 for 277 V.
 - b. Leviton; ODS 15-ID.
3. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

2.8 COMMUNICATIONS OUTLETS

A. Telephone Outlet:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3560-6.
 - b. Leviton; 40649.
3. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1 complying with Category 5e. Comply with UL 1863.

B. Combination TV and Telephone Outlet:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3562.
 - b. Leviton; 40595.
3. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

2.9 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch- (1-mm-) thick, satin-finished stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant , die-cast aluminum with lockable cover.

2.10 FLOOR SERVICE FITTINGS

- A. Type: Modular, flap-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: Rectangular solid brass with satin finish.
- D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
- E. Voice and Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 Category 5e jacks for UTP cable.

2.11 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
 - 1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Wiring Devices Connected to Emergency Power System: Red.
 - 3. TVSS Devices: Blue.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 - 1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:
1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 8. Tighten unused terminal screws on the device.
 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- G. Dimmers:
1. Install dimmers within terms of their listing.
 2. Verify that dimmers used for fan speed control are listed for that application.
 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

SECTION – 16140– WIRING DEVICES

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Electrical Identification."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with white-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.

END OF SECTION 16140

SECTION 16145
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following lighting control devices:
 - 1. Time switches.
 - 2. Outdoor photoelectric switches.
 - 3. Indoor occupancy sensors.
 - 4. Outdoor motion sensors.
 - 5. Lighting contactors.
 - 6. Emergency shunt relay.
- B. See Division 13 Section "Lighting Controls" for low-voltage, manual and programmable lighting control systems.
- C. See Division 16 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.
- D. See Division 16 Section "Stage Lighting" for theatrical lighting controls.
- E. See Division 16 Section "Dimming Controls" for architectural dimming system equipment.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.
- C. Operation and maintenance data.

1.3 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.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

- 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:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Area Lighting Research, Inc.; Tyco Electronics.
 - 2. Grasslin Controls Corporation; a GE Industrial Systems Company.
 - 3. Intermatic, Inc.
 - 4. Leviton Mfg. Company Inc.
 - 5. Lightolier Controls; a Genlyte Company.
 - 6. Lithonia Lighting; Acuity Lighting Group, Inc.
 - 7. Paragon Electric Co.; Invensys Climate Controls.
 - 8. Square D; Schneider Electric.
 - 9. TORK.
 - 10. Touch-Plate, Inc.
 - 11. Watt Stopper (The).
- D. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
 - 1. Contact Configuration: DPST.
 - 2. Contact Rating: 30-A inductive or resistive, 240-V ac.
 - 3. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
 - 4. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
 - 5. Programs: 2 channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
 - 6. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
 - 7. Astronomic Time: All channels.
 - 8. Battery Backup: For schedules and time clock.

2.2 INDOOR OCCUPANCY SENSORS

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

- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Hubbell Lighting.
 2. Leviton Mfg. Company Inc.
 3. Lithonia Lighting; Acuity Lighting Group, Inc.
 4. Novitas, Inc.
 5. RAB Lighting, Inc.
 6. Sensor Switch, Inc.
 7. TORK
 8. Watt Stopper (The).
- D. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the on function in case of sensor failure.
 7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
- E. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.

2.3 LIGHTING CONTACTORS

- 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:

- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Allen-Bradley/Rockwell Automation.
 - 2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
 - 3. Eaton Electrical Inc.; Cutler-Hammer Products.
 - 4. GE Industrial Systems; Total Lighting Control.
 - 5. Grasslin Controls Corporation; a GE Industrial Systems Company.
 - 6. Hubbell Lighting.
 - 7. Lithonia Lighting; Acuity Lighting Group, Inc.
 - 8. MicroLite Lighting Control Systems.
 - 9. Square D; Schneider Electric.
 - 10. TORK.
 - 11. Touch-Plate, Inc.
 - 12. Watt Stopper (The).
- D. Description: Electrically operated and electrically held, combination type with nonfused disconnect, complying with NEMA ICS 2 and UL 508.
 - 1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
 - 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
 - 3. Enclosure: Comply with NEMA 250.
 - 4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.4 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 16 Section "Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 16 Section "Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 16 Section "Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.
- B. When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.2 CONTACTOR INSTALLATION

- A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 16 Section "Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non power-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 16 Section "Electrical Identification."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work.

END OF SECTION 16145

SECTION 16289

TRANSIENT VOLTAGE SUPPRESSION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes field-mounted TVSS for low-voltage (120 to 600 V) power distribution and control equipment.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.
- B. Field quality-control reports.
- C. Operation and maintenance data.
- D. Warranties: Sample of special warranties.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.
- B. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.
- C. Comply with NEMA LS 1.
- D. Comply with UL 1449.
- E. Comply with NFPA 70.

1.4 WARRANTY

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

- 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SERVICE ENTRANCE SUPPRESSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. ABB USA.
 - 2. AC Data Solutions.
 - 3. Advanced Protection Technologies Inc. (APT).
 - 4. Atlantic Scientific.
 - 5. Current Technology Inc.; Danaher Power Solutions.
 - 6. Danaher Power Solutions; United Power Products.
 - 7. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 8. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 9. Intermatic, Inc.
 - 10. LEA International.
 - 11. Leviton Mfg. Company Inc.
 - 12. Liebert Corporation; a division of Emerson Network Power.
 - 13. Northern Technologies, Inc.; a division of Emerson Network Power.
 - 14. Siemens Energy & Automation, Inc.
 - 15. Square D; a brand of Schneider Electric.
 - 16. Surge Suppression Incorporated.
- C. Surge Protection Devices:
 - 1. Non-modular.
 - 2. LED indicator lights for power and protection status.
 - 3. Comply with UL 1449.
 - 4. Fuses, rated at 200-kA interrupting capacity.
 - 5. Fabrication using bolted compression lugs for internal wiring.
 - 6. Integral disconnect switch.
 - 7. Redundant suppression circuits.
 - 8. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
 - 9. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 10. LED indicator lights for power and protection status.
- D. Peak Single-Impulse Surge Current Rating: 320 kA per mode/640 kA per phase.
- E. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2
 - 1. Line to Neutral: 70,000 A.
 - 2. Line to Ground: 70,000 A.
 - 3. Neutral to Ground: 50,000 A.

- F. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V, 3-phase, 4-wire circuits shall be as follows:
 - 1. Line to Neutral: 800 V for 480Y/277 V.
 - 2. Line to Ground: 800 V for 480Y/277 V.
 - 3. Neutral to Ground: 800 V for 480Y/277 V.

- G. Protection modes and UL 1449 SVR for 240/120 V, single-phase, 3-wire circuits shall be as follows:
 - 1. Line to Neutral: 400 V.
 - 2. Line to Ground: 400 V.
 - 3. Neutral to Ground: 400 V.

- H. Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
 - 1. Line to Neutral: 400 V, 800 V from high leg.
 - 2. Line to Ground: 400 V.
 - 3. Neutral to Ground: 400 V.

- I. Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:
 - 1. Line to Line: 2000 V for 480 V.
 - 2. Line to Ground: 2000 V for 480 V.

2.2 ENCLOSURES

- A. Indoor Enclosures: NEMA 250 Type 1.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install TVSS devices at service entrance on load side, with ground lead bonded to service entrance ground.

- B. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 - 1. Provide multiple, 100-A circuit breaker as a dedicated disconnecting means for TVSS unless otherwise indicated.

3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 - B. Tests and Inspections:
 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
 2. After installing TVSS devices but before electrical circuitry has been energized, test for compliance with requirements.
 3. Complete startup checks according to manufacturer's written instructions.
 - C. TVSS device will be considered defective if it does not pass tests and inspections.
 - D. Prepare test and inspection reports.
- 3.3 STARTUP SERVICE
- A. Do not energize or connect service entrance equipment to their sources until TVSS devices are installed and connected.
 - B. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.
- 3.4 DEMONSTRATION
- A. Engage a factory-authorized service representative to train owner's maintenance personnel to maintain TVSS devices.

END OF SECTION 16289

SECTION 16410

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Enclosures.

1.2 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. 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."

1.4 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
- D. Field quality-control reports.

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- E. Operation and maintenance data.

1.5 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge fuse interiors to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- D. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- E. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- F. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- G. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

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2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Suitable for number, size, and conductor material.
5. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- D. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- E. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Lugs: Suitable for number, size, and conductor material.

2.3 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.

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- C. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- D. 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.
- E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
 - 1. Instantaneous trip.
 - 2. Long- and short-time pickup levels.
 - 3. Long- and short-time time adjustments.
 - 4. Ground-fault pickup level, time delay, and I^2t response.
- F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- G. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Suitable for number, size, trip ratings, and conductor material.
 - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - 7. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.

2.4 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 250, Type 3R.
 - 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 3R.
 - 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Comply with mounting and anchoring requirements specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NECA 1.

3.2 IDENTIFICATION

- A. Comply with requirements in Division 16 Section "Electrical Identification."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 16410

SECTION 16442

PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

1.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - 1. 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."

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Include evidence of NRTL listing for series rating of installed devices.
 - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 7. Include wiring diagrams for power, signal, and control wiring.
 - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.
- C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."
- D. Field quality-control reports.
- E. Panelboard schedules for installation in panelboards.
- F. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA PB 1.
- C. Comply with NFPA 70.

1.5 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Flush-mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 4. Directory Card: Inside panelboard door, mounted in transparent card holder.
- C. Incoming Mains Location: Top and bottom.
- D. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Main and Neutral Lugs: Mechanical] type.
 - 3. Ground Lugs and Bus Configured Terminators: Compression type.
 - 4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 5. Sub feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

- F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, and listed and labeled for series-connected short-circuit rating by an NRTL.
- I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. Panelboards: NEMA PB 1, power and feeder distribution type.
- D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- E. Mains: Main Circuit Breaker.
- F. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- G. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes Larger than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- H. Branch Overcurrent Protective Devices: Fused switches.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and 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 Class A ground-fault protection (6-mA trip).
 6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
- D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
1. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Division 16 Section "Fuses."

2.4 ACCESSORY COMPONENTS AND FEATURES

- A. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Receive, inspect, handle, store and install panelboards and accessories according to NEMA PB 1.1.
- B. Comply with mounting and anchoring requirements specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.
- D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- E. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- F. Install filler plates in unused spaces.
- G. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- H. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
- I. Comply with NECA 1.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 16 Section "Electrical Identification."
- B. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 16 Section "Electrical Identification."
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 16 Section "Electrical Identification."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 16442

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
- C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
- E. Metal Parts: Free of burrs and sharp corners and edges.
- F. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- H. Diffusers and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
 - b. UV stabilized.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
- I. Air-Handling Fluorescent Fixtures: For use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in Division 15 Section "Diffusers, Registers, and Grilles."
 - 1. Air-Supply Units: Slots in one or both side trims join with air-diffuser-boot assemblies.
 - 2. Heat-Removal Units: Air path leads through lamp cavity.
 - 3. Combination Heat-Removal and Air-Supply Unit: Heat is removed through lamp cavity at both ends of the fixture door with air supply same as for air-supply units.

4. Dampers: Operable from outside fixture for control of return-air volume.
5. Static Fixture: Air-supply slots are blanked off, and fixture appearance matches active units.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. General Requirements for Electronic Ballasts:

1. Comply with UL 935 and with ANSI C82.11.
2. Designed for type and quantity of lamps served.
3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
4. Sound Rating: Class A.
5. Total Harmonic Distortion Rating: Less than 10 percent.
6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
7. Operating Frequency: 42 kHz or higher.
8. Lamp Current Crest Factor: 1.7 or less.
9. BF: 0.88 or higher.
10. Power Factor: 0.95 or higher.

B. Luminaires controlled by occupancy sensors shall have programmed-start ballasts.

C. Electromagnetic Ballasts: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.

1. Ballast Manufacturer Certification: Indicated by label.

D. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.

E. Ballasts for Low-Temperature Environments: Electronic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.

F. Ballasts for Residential Applications: Fixtures designated as "Residential" may use low-power-factor electronic ballasts having a Class B sound rating and total harmonic distortion of approximately 30 percent.

G. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.

1. Dimming Range: 100 to 5 percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
4. Control: Coordinate wiring from ballast to control device to ensure that the ballast, controller, and connecting wiring are compatible.

H. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
 - a. High-Level Operation: 100 percent of rated lamp lumens.
 - b. Low-Level Operation: 30 percent of rated lamp lumens.
2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

- A. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:
 1. Lamp end-of-life detection and shutdown circuit.
 2. Automatic lamp starting after lamp replacement.
 3. Sound Rating: Class A.
 4. Total Harmonic Distortion Rating: Less than 20 percent.
 5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 6. Operating Frequency: 20 kHz or higher.
 7. Lamp Current Crest Factor: 1.7 or less.
 8. BF: 0.95 or higher unless otherwise indicated.
 9. Power Factor: 0.95 or higher.
 10. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

2.5 EMERGENCY FLUORESCENT POWER UNIT

- A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.
 1. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
 2. Nightlight Connection: Operate one fluorescent lamp continuously.
 3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
 - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 4. Battery: Sealed, maintenance-free, nickel-cadmium type.
 5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.

6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.6 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 1. Lamps for AC Operation: Fluorescent, two for each fixture, 20,000 hours of rated lamp life.
 2. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
 3. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - a. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - b. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2.7 EMERGENCY LIGHTING UNITS

- A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
 1. Battery: Sealed, maintenance-free, lead-acid type.
 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
 7. Integral Time-Delay Relay: Holds unit on for fixed interval of 5 minutes when power is restored after an outage.

2.8 FLUORESCENT LAMPS

- A. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches (1220 mm), 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 4100 K, and average rated life 20,000 hours unless otherwise indicated.
- B. T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 4100 K, and average rated life of 20,000 hours unless otherwise indicated.
- C. Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 4100 K, average rated life of 10,000 hours at three hours operation per start unless otherwise indicated.
 - 1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
 - 2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
 - 3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
 - 4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
 - 5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
 - 6. 57 W: T4, triple tube, rated 4300 initial lumens (minimum).
 - 7. 70 W: T4, triple tube, rated 5200 initial lumens (minimum).

2.9 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 16 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).
- F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.10 RETROFIT KITS FOR FLUORESCENT LIGHTING FIXTURES

- A. Reflector Kit: UL 1598, Type I. Suitable for two- to four-lamp, surface-mounted or recessed lighting fixtures by improving reflectivity of fixture surfaces.
- B. Ballast and Lamp Change Kit: UL 1598, Type II. Suitable for changing existing ballast, lamps, and sockets.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Comply with NFPA 70 for minimum fixture supports.
- C. Suspended Lighting Fixture Support:
 - 1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 - 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
- D. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.
- E. Adjust aimable lighting fixtures to provide required light intensities.
- F. Connect wiring according to Division 16 Section "Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 16511

SECTION 16511
INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.
5. Retrofit kits for fluorescent lighting fixtures.

B. Related Sections:

1. Division 16 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.
2. Division 16 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multi-pole lighting relays and contactors.

1.2 SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, and finishes.
- B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- C. Field quality-control reports.

1.3 QUALITY ASSURANCE

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

SECTION 16720

FIRE DETECTION AND ALARM SYSTEM

ENGINEERING SPECIFICATION
INTELLIGENT FIRE ALARM DETECTION SYSTEM

PART 1 GENERAL

1.1 DESCRIPTION:

- A. This section of the specification includes the furnishing, installation, and connection of an intelligent reporting, microprocessor controlled, addressable, fire detection. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, control panels, auxiliary control devices, annunciators, power supplies, and wiring as shown on the drawings and specified herein.
- B. The fire alarm system shall comply with requirements of NFPA Standard 72 for Protected Premises Signaling Systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.
- C. The system shall be an active/interrogative type system where each addressable device is repetitively scanned, causing a signal to be transmitted to the main fire alarm control panel (FACP) indicating that the device and its associated circuit wiring is functional. Loss of this signal at the main FACP shall result in a trouble indication as specified hereinafter for the particular input.
- D. Each designated zone shall transmit separate and different alarm, supervisory and trouble signals to the Fire Command Center (FCC) and designated personnel in other buildings at the site via a multiplex communication network.
- E. The fire alarm system shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001-1994.
- F. The system and its components shall be Underwriters Laboratories, Inc. listed under the appropriate UL testing standard as listed herein for fire alarm applications and the installation shall be in compliance with the UL listing.
- G. The installing company shall employ NICET (minimum Level II Fire Alarm Technology) technicians on site to guide the final check-out and to ensure the systems integrity.
- H. System specifications are based on a Notifier system; equivalent vendors shall submit alternate systems.

1.3 SCOPE:

- A. The existing fire alarm system and associated components shall be removed from the building. A new intelligent reporting, microprocessor controlled fire detection system shall be installed in accordance with the specifications and drawings.

- B. The system shall be designed such that each signaling line circuit (SLC) is limited to only 80% of its total capacity at initial installation.
- C. Basic Performance:
 - 1. Alarm, trouble and supervisory signals from all intelligent reporting devices shall be encoded on NFPA Style 6 (Class A) Signaling Line Circuits (SLC).
 - 2. Initiation Device Circuits (IDC) shall be wired Class A (NFPA Style D) as part of an addressable device connected by the SLC Circuit.
 - 3. Notification Appliance Circuits (NAC) shall be wired Class A (NFPA Style Z) as part of an addressable device connected by the SLC Circuit.
 - 4. On Style 6 or 7 (Class A) configurations a single ground fault or open circuit on the system Signaling Line Circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
 - 5. Alarm signals arriving at the FACP shall not be lost following a primary power failure (or outage) until the alarm signal is processed and recorded.
- D. Basic System Functional Operation
 - 1. When a fire alarm condition is detected and reported by one of the system initiating devices, the following functions shall immediately occur:
 - a. The System Alarm LED shall flash.
 - b. A local piezo electric signal in the control panel shall sound.
 - c. The 640-character LCD display shall indicate all information associated with the fire alarm condition, including the type of alarm point and its location within the protected premises.
 - d. Printing and history storage equipment shall log the information associated each new fire alarm control panel condition, along with time and date of occurrence.
 - e. All system output programs assigned via control-by-event interlock programming to be activated by the particular point in alarm shall be executed, and the associated system outputs (notification appliances and/or relays) shall be activated.
 - f. System shall be provided with sufficient spare capacity to provide monitoring for the vacant areas within the building. Vacant areas shall be built-out under a separate contract.

1.4 SUBMITTALS

- A. General:
 - 1. Two copies of all submittals shall be submitted to the Architect/Engineer for review.
 - 2. All references to manufacturer's model numbers and other pertinent information herein is intended to establish minimum standards of performance, function and quality. Equivalent compatible UL-listed equipment from other manufacturers may be substituted for the specified equipment as long as the minimum standards are met.

3. All substitute equipment proposed as equal to the equipment specified herein, shall meet or exceed the following standards. For equipment other than that specified, the contractor shall supply proof that such substitute equipment equals or exceeds the features, functions, performance, and quality of the specified equipment.
- B. Shop Drawings:
1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 2. Include manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.
 3. Show annunciator layout, configurations, and terminations.
- C. Manuals:
1. Submit simultaneously with the shop drawings, complete operating and maintenance manuals listing the manufacturer's name(s), including technical data sheets.
 2. Wiring diagrams shall indicate internal wiring for each device and the interconnections between the items of equipment.
 3. Provide a clear and concise description of operation that gives, in detail, the information required to properly operate the equipment and system.
 4. Approvals will be based on complete submissions of manuals together with shop drawings.
- D. Software Modifications
1. Provide the services of a factory trained and authorized technician to perform all system software modifications, upgrades or changes. Response time of the technician to the site shall not exceed 4 hours.
 2. Provide all hardware, software, programming tools and documentation necessary to modify the fire alarm system on site. Modification includes addition and deletion of devices, circuits, zones and changes to system operation and custom label changes for devices or zones. The system structure and software shall place no limit on the type or extent of software modifications on-site. Modification of software shall not require power-down of the system or loss of system fire protection while modifications are being made.
- E. Certifications:
- Together with the shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of the installation and the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer. Include names and addresses in the certification.
- 1.5 GUARANTY:
- A. All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one (1) year from the date of acceptance. The full cost of maintenance, labor and materials required to correct any defect during this one year period shall be included in the submittal bid.

1.6 POST CONTRACT MAINTENANCE:

- A. Complete maintenance and repair service for the fire alarm system shall be available from a factory trained authorized representative of the manufacturer of the major equipment for a period of five (5) years after expiration of the guaranty.
- B. As part of the bid/proposal, include a quote for a maintenance contract to provide all maintenance, tests, and repairs described below. Include also a quote for unscheduled maintenance/repairs, including hourly rates for technicians trained on this equipment, and response travel costs for each year of the maintenance period. Submittals that do not identify all post contract maintenance costs will not be accepted. Rates and costs shall be valid for the period of five (5) years after expiration of the guaranty.
- C. Maintenance and testing shall be on a semiannual basis or as required by the AHJ. A preventive maintenance schedule shall be provided by the contractor describing the protocol for preventive maintenance. The schedule shall include:
 - 1. Systematic examination, adjustment and cleaning of all detectors, manual fire alarm stations, control panels, power supplies, relays, waterflow switches and all accessories of the fire alarm system.
 - 2. Each circuit in the fire alarm system shall be tested semiannually.
 - 3. Each smoke detector shall be tested in accordance with the requirements of NFPA 72 Chapter 7.

1.7 POST CONTRACT EXPANSIONS:

- A. The contractor shall have the ability to provide parts and labor to expand the system specified, if so requested, for a period of five (5) years from the date of acceptance.
- B. As part of the submittal, include a quotation for all parts and material, and all installation and test labor as needed to increase the number of intelligent or addressable devices by ten percent (10%). This quotation shall include intelligent smoke detectors, intelligent heat detectors, addressable manual stations, addressable monitor modules and addressable modules equal in number to one tenth of the number required to meet this specification (list actual quantity of each type).
- C. The quotation shall include installation, test labor, and labor to reprogram the system for this 10% expansion. If additional FACP hardware is required, include the material and labor necessary to install this hardware.
- D. Do not include cost of conduit or wire or the cost to install conduit or wire.
- E. Submittals that do not include this estimate of post contract expansion cost will not be accepted.

1.8 APPLICABLE PUBLICATIONS:

The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only.

- A. National Fire Protection Association (NFPA) - USA:
 - No. 70 National Electric Code (NEC)

SECTION – 16442 PANELBOARDS

No. 72	National Fire Alarm Code
No. 90A	Air Conditioning Systems
No. 92A	Smoke Control Systems
No. 92B	Smoke Management Systems in Malls, Atria, Large Areas
No. 101	Life Safety Code

B. Underwriters Laboratories Inc. (UL) - USA:

No. 50	Cabinets and Boxes
No. 268	Smoke Detectors for Fire Protective Signaling Systems
No. 864	Control Units for Fire Protective Signaling Systems
No. 268A	Smoke Detectors for Duct Applications.
No. 521	Heat Detectors for Fire Protective
No. 228	Door Closers-Holders for Fire Protective Signaling Systems.
No. 464	Audible Signaling Appliances.
No. 38	Manually Actuated Signaling Boxes.
No. 346	Waterflow Indicators for Fire Protective Signaling Systems.
No. 1481	Power supplies for Fire Protective Signaling Systems.
No. 1076	Control Units for Burglar Alarm Proprietary Protective Signaling Systems.
No. 1971	Visual Notification Appliances.

C. Local and State Building Codes.

D. All requirements of the Authority Having Jurisdiction (AHJ).

1.9 APPROVALS:

- A. The system shall have proper listing and/or approval from the following nationally recognized agencies:

UL Underwriters Laboratories Inc

- B. The Fire Alarm Control Panel and all transponders shall meet the modular listing requirements of Underwriters Laboratories, Inc. Each subassembly, including all printed circuits, shall include the appropriate UL modular label. This includes all printed circuit board assemblies, power supplies, and enclosure parts. Systems that do not include modular labels may require return to the factory for system upgrades, and are not acceptable.

PART 2.0 PRODUCTS

2.1 EQUIPMENT AND MATERIAL, GENERAL:

- A. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.
- B. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams,

schematics, physical equipment sizes, etc. before beginning system installation. Refer to the riser/connection diagram for all specific system installation/termination/wiring data.

- C. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

2.2 CONDUIT AND WIRE:

A. Conduit:

1. Conduit shall be in accordance with The National Electrical Code (NEC), local and state requirements.
2. Where possible, all wiring shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.
3. Cable must be separated from any open conductors of Power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, as per NEC Article 760-29.
4. Wiring for 24 volt control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.
5. Conduit shall not enter the fire alarm control panel, or any other remotely mounted control panel equipment or backboxes, except where conduit entry is specified by the FACP manufacturer.
6. Conduit shall be 3/4 inch (19.1 mm) minimum.

B. Wire

1. All fire alarm system wiring must be new; remove all existing wiring associated with the existing system.
2. Wiring shall be in accordance with local, state and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG (1.02 mm) for initiating device circuits and signaling line circuits, and 14 AWG (1.63 mm) for notification appliance circuits.
3. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
4. Wire and cable not installed in conduit shall have a fire resistance rating suitable for the installation as indicated in NFPA 70 (e.g., FPLR).
5. The system shall permit the use of IDC and NAC wiring in the same conduit with the multiplex communication loop.
6. All field wiring shall be completely supervised. In the event of a primary power failure, disconnected standby battery, removal of any internal modules, or any open circuits in the field wiring; a trouble signal will be activated until the system and its associated field wiring are restored to normal condition.
7. All analog voice speaker and analog telephone circuits shall use twisted/shielded pair to eliminate cross talk.

- C. Terminal Boxes, Junction Boxes and Cabinets:
 - 1. All boxes and cabinets shall be UL listed for their intended purpose.
 - D. Initiating circuits shall be arranged to serve like categories (manual, smoke, waterflow). Mixed category circuitry shall not be permitted except on signaling line circuits connected to intelligent reporting devices.
 - E. The fire alarm control panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The control panel cabinet shall be grounded securely to either a cold water pipe or grounding rod.
- 2.3 MAIN FIRE ALARM CONTROL PANEL OR NETWORK NODE:
- A. The main FACP Central Console shall be a NOTIFIER Model NFS2-3030 and shall contain a microprocessor based Central Processing Unit (CPU). The CPU shall communicate with and control the following types of equipment used to make up the system: intelligent addressable smoke and thermal (heat) detectors, addressable modules, control circuits, and notification appliance circuits, local and remote operator terminals, printers, annunciators, and other system controlled devices.
 - B. In conjunction with intelligent Loop Control Modules and Loop Expander Modules, the main FACP shall perform the following functions:
 - 1. Supervise and monitor all intelligent addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
 - 2. Supervise all initiating signaling and notification circuits throughout the facility by way of connection to addressable monitor and control modules.
 - 3. Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed. In the event of CPU failure, all SLC loop modules shall fallback to degrade mode. Such degrade mode shall treat the corresponding SLC loop control modules and associated detection devices as conventional two-wire operation. Any activation of a detector in this mode shall automatically activate associated Notification Appliance Circuits.
 - 4. Visually and audibly annunciate any trouble, supervisory, security or alarm condition on operator's terminals, panel display, and annunciators.
 - 5. When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
 - a. The system alarm LED shall flash.
 - b. A local piezo-electric audible device in the control panel shall sound a distinctive signal.

- c. The 640-character backlit LCD display shall indicate all information associated with the fire alarm condition, including the type of alarm point and its location within the protected premises.
 - d. Printing and history storage equipment shall log and print the event information along with a time and date stamp.
 - e. All system outputs assigned via preprogrammed equations for a particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.
 - f. When a trouble condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
 - g. The system trouble LED shall flash.
 - h. A local piezo-electric audible device in the control panel shall sound a distinctive signal.
 - i. The 640-character backlit LCD display shall indicate all information associated with the trouble condition, including the type of trouble point and its location within the protected premises.
 - j. Printing and history storage equipment shall log and print the event information along with a time and date stamp.
 - k. All system outputs assigned via preprogrammed equations for a particular point in trouble shall be executed, and the associated system outputs (trouble notification appliances and/or relays) shall be activated.
6. When a supervisory condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
- a. The system trouble LED shall flash.
 - b. A local piezo-electric audible device in the control panel shall sound a distinctive signal.
 - c. The 640-character backlit LCD display shall indicate all information associated with the supervisory condition, including the type of trouble point and its location within the protected premises.
 - d. Printing and history storage equipment shall log and print the event information along with a time and date stamp.
 - e. All system outputs assigned via preprogrammed equations for a particular point in trouble shall be executed, and the associated system outputs (notification appliances and/or relays) shall be activated.
7. When a security alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
- a. The system security LED shall flash.
 - b. A local piezo-electric audible device in the control panel shall sound a distinctive signal.
 - c. The 640-character backlit LCD display shall indicate all information associated with the fire alarm condition, including the type of alarm point and its location within the protected premises.
 - d. Printing and history storage equipment shall log and print the event information along with a time and date stamp.

- e. All system outputs assigned via preprogrammed equations for a particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.
8. When a pre-alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
- a. The system pre-alarm LED shall flash.
 - b. A local piezo-electric audible device in the control panel shall sound a distinctive signal.
 - c. The 640-character backlit LCD display shall indicate all information associated with the fire alarm condition, including the type of alarm point and its location within the protected premises.
 - d. Printing and history storage equipment shall log and print the event information along with a time and date stamp.
 - e. All system outputs assigned via preprogrammed equations for a particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.

C. Operator Control

- 1. Acknowledge Switch:
 - a. Activation of the control panel acknowledge switch in response to new alarms and/or troubles shall silence the local panel piezo electric signal and change the alarm and trouble LEDs from flashing mode to steady-ON mode. If multiple alarm or trouble conditions exist, depression of this switch shall advance the LCD display to the next alarm or trouble condition. In addition, the FACP shall support Block Acknowledge to allow multiple trouble conditions to be acknowledged with a single depression of this switch.
 - b. Depression of the Acknowledge switch shall also silence all remote annunciator piezo sounders.
- 2. Signal Silence Switch:
 - a. Depression of the Signal Silence switch shall cause all programmed alarm notification appliances and relays to return to the normal condition. The selection of notification circuits and relays that are silence able by this switch shall be fully field programmable within the confines of all applicable standards. The FACP software shall include silence inhibit and auto-silence timers.
- 3. Drill Switch:
 - a. Depression of the Drill switch shall activate all programmed notification appliance circuits. The drill function shall latch until the panel is silenced or reset.
- 4. System Reset Switch:
 - a. Depression of the System Reset switch shall cause all electronically latched initiating devices to return to their normal condition. Initiating devices shall re-report if active.

Active notification appliance circuits shall not silence upon Reset. Systems that deactivate and subsequently re-activate notification appliance circuits shall not be considered equal. All programmed Control-By-Event equations shall be re-evaluated after the reset sequence is complete if the initiating condition has cleared. Non-latching trouble conditions shall not clear and re-report upon reset.

5. Lamp Test:
 - a. The Lamp Test switch shall activate all local system LEDs, light each segment of the liquid crystal display and display the panel software revision for service personal.
6. Scroll Display Keys:
 - a. There shall be Scroll Display keys for FIRE ALARM, SECURITY, SUPERVISORY, TROUBLE, and OTHER EVENTS. Depression of the Scroll Display key shall display the next event in the selected queue allowing the operator to view events by type.
7. Print Screen:
 - a. Depression of the PRINT SCREEN switch shall send the information currently displayed on the 640-character display to the printer.

D. System Capacity and General Operation

1. The control panel shall be capable of expansion via up to 10 SLC modules. Each module shall support a maximum of 318 analog/addressable devices for a maximum system capacity of 3180 points. The system shall be capable of 3072 annunciation points per system regardless of the number of addressable devices.
2. The Fire Alarm Control Panel shall include a full featured operator interface control and annunciation panel that shall include a backlit 640-character liquid crystal display, individual, color coded system status LEDs, and a QWERTY style alphanumeric keypad for the field programming and control of the fire alarm system. Said LCD shall also support graphic bit maps capable of displaying the company name and logo of either the owner or installing company.
3. All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel.
4. The FACP shall be able to provide the following software and hardware features:
 - a. Pre-signal and Positive Alarm Sequence: The system shall provide means to cause alarm signals to only sound in specific areas with a delay of the alarm from 60 to up to 180 seconds after start of alarm processing. In addition, a Positive Alarm Sequence selection shall be available that allows a 15-second time period for acknowledging an alarm signal from a fire detection/initiating device. If the alarm is not acknowledged within 15 seconds, all local and remote outputs shall automatically activate immediately.

- b. Smoke Detector Pre-alarm Indication at Control Panel: To obtain early warning of incipient or potential fire conditions, the system shall support a programmable option to determine system response to real-time detector sensing values above the programmed setting. Two levels of Pre-alarm indication shall be available at the control panel: alert and action.
- c. Alert: It shall be possible to set individual smoke detectors for pre-programmed pre-alarm thresholds. If the individual threshold is reached, the pre-alarm condition shall be activated.
- d. Action: If programmed for Action and the detector reaches a level exceeding the pre-programmed level, the control panel shall indicate an action condition. Sounder bases installed with either heat or smoke detectors shall automatically activate on action Pre-Alarm level, with general evacuation on Alarm level.
- e. The system shall support a detector response time to meet world annunciation requirements of less than 3 seconds.
- f. Device Blink Control: Means shall be provided to turn off detector/module LED strobes for special areas.
- g. NFPA 72 Smoke Detector Sensitivity Test: The system shall provide an automatic smoke detector test function that meet the requirements of NFPA 72.
- h. Programmable Trouble Reminder: The system shall provide means to automatically initiate a reminder that troubles exist in the system. The reminder will appear on the system display and (if enabled) will sound a piezo alarm.
- i. On-line or Off-line programming: The system shall provide means to allow panel programming either through an off-line software utility program away from the panel or while connected and on-line. The system shall also support upload and download of programmed database and panel executive system program to a Personal Computer/laptop.
- j. History Events: The panel shall maintain a history file of the last 4000 events, each with a time and date stamp. History events shall include all alarms, troubles, operator actions, and programming entries. The control panels shall also maintain a 1000 event Alarm History buffer, which consists of the 1000 most recent alarm events from the 4000 event history file.
- k. Smoke Control Modes: The system shall provide means to perform FSCS mode Smoke Control to meet NFPA-92A and 90B and HVAC mode to meet NFPA 90A.
- l. The system shall provide means for all SLC devices on any SLC loop to be auto programmed into the system by specific address. The system shall recognize specific device type ID's and associate that ID with the corresponding address of the device.
- m. Drill: The system shall support means to activate all silenceable fire output circuits in the event of a practice evacuation or "drill". If enabled for local control, the front panel switch shall be held for a minimum of 2 seconds prior to activating the drill function.
- n. Passwords and Users: The system shall support two password levels, master and user. Up to 9 user passwords shall be available, each of which may be assigned access to the programming change menus, the alter status menus, or both. Only the master password shall allow access to password change screens.

- o. Two Wire Detection: The system shall support standard two wire detection devices specifically all models of System Sensor devices, Fenwal PDS-7125/7126 and CPD-7021, Hochiki model SLK-24F/24FH, Edwards 6250B/6270B and 6264B and Simplex models 2098-9201/9202 and 9576.
- p. Block Acknowledge: The system shall support a block Acknowledge for Trouble Conditions
- q. Sensitivity Adjust: The system shall provide Automatic Detector Sensitivity Adjust based on Occupancy schedules including a Holiday list of up to 15 days.
- r. Environmental Drift Control: The system shall provide means for setting Environmental Drift Compensation by device. When a detector accumulates dust in the chamber and reaches an unacceptable level but yet still below the allowed limit, the control panel shall indicate a maintenance alert warning. When the detector accumulates dust in the chamber above the allowed limit, the control panel shall indicate a maintenance urgent warning.
- s. Custom Action Messages: The system shall provide means to enter up to 100 custom action messages of up to 160 characters each. It shall be possible to assign any of the 100 messages to any point.
- t. Print Functions: The system shall provide means to obtain a variety of reports listing all event, alarm, trouble, supervisory, or security history. Additional reports shall be available for point activation for the last Walk Test performed, detector maintenance report containing the detector maintenance status of each installed addressable detector, all network parameters, all panel settings including broad cast time, event ordering, and block acknowledge, panel timer values for Auto Silence, Silence Inhibit, AC Fail Delay time and if enabled, Proprietary Reminder, and Remote Reminder timers, supervision settings for power supply and printers, all programmed logic equations, all custom action messages, all non-fire and output activations (if pre-programmed for logging) all active points filtered by alarms only, troubles only, supervisory alarms, prealarms, disabled points and activated points, all installed points filtered by SLC points, logic zones, annunciators, releasing zones, special zones, and trouble zones.
- u. Local Mode: If communication is lost to the central processor the system shall provide added survivability through the intelligent loop control modules. Inputs from devices connected to the SLC and loop control modules shall activate outputs on the same loop when the inputs and outputs have been set with point programming to participate in local mode or when the type codes are of the same type: that is, an input with a fire alarm type code shall activate an output with a fire alarm type code.
- v. Resound based on type for security or supervisory: The system shall indicate a Security alarm when a monitor module point programmed with a security Type Code activates. If silenced alarms exist, a Security alarm will Resound the panel sounder. The system shall indicate a Supervisory alarm when a monitor module point programmed with a supervisory Type Code activates. If there are silenced alarms, a Supervisory alarm will Resound the panel sounder.
- w. Read status preview - enabled and disabled points: Prior to re-enabling points, the system shall inform the user that a disabled device is in the alarm state. This shall provide notice that the device must be reset before the device is enabled thereby avoiding activation of the notification circuits.

- x. Custom Graphics: When fitted with an LCD display, the panel shall permit uploading of a custom bit-mapped graphic to the display screen.
- y. Multi-Detector and Cooperating Detectors: The system shall provide means to link one detector to up to two detectors at other addresses on the same loop in cooperative multi-detector sensing. There shall be no requirement for sequential addresses on the detectors and the alarm event shall be a result or product of all cooperating detectors chamber readings.
- z. Tracking/Latching Duct (ion and photo): The system shall support both tracking and latching duct detectors either ion or photo types.
- aa. ACTIVE EVENT: The system shall provide a Type ID called FIRE CONTROL for purposes of air-handling shutdown, which shall be intended to override normal operating automatic functions. Activation of a FIRE CONTROL point shall cause the control panel to (1) initiate the monitor module Control-by-Event, (2) send a message to the panel display, history buffer, installed printer and annunciators, (3) shall not light an indicator at the control panel, (4) Shall display ACTIVE on the LCD as well a display a FIRE CONTROL Type Code and other information specific to the device.
- bb. NON-FIRE Alarm Module Reporting: A point with a type ID of NON-FIRE shall be available for use for energy management or other non-fire situations. NON-FIRE point operation shall not affect control panel operation nor shall it display a message at the panel LDC. Activation of a NON-FIRE point shall activate control by event logic but shall not cause any indication on the control panel.
- cc. Security Monitor Points: The system shall provide means to monitor any point as a type security.
- dd. One-Man Walk Test: The system shall provide both a basic and advanced walk test for testing the entire fire alarm system. The basic walk test shall allow a single operator to run audible tests on the panel. All logic equation automation shall be suspended during the test and while annunciators can be enabled for the test, all shall default to the disabled state. During an advanced walk test, field-supplied output point programming will react to input stimuli such as CBE and logic equations. When points are activated in advanced test mode, each initiating event shall latch the input. The advanced test shall be audible and shall be used for pull station verification, magnet activated tests on input devices, input and output device and wiring operation/verification.
- ee. Control By Event Functions: CBE software functions shall provide means to program a variety of output responses based on various initiating events. The control panel shall operate CBE through lists of zones. A zone shall become listed when it is added to a point's zone map through point programming. Each input point such as detector, monitor module or panel circuit module shall support listing of up to 10 zones into its programmed zone map.
- ff. Permitted zone types shall be general zone, releasing zone and special zone. Each output point (control module, panel circuit module) can support a list of up to 10 zones including general zone, logic zone, releasing zone and trouble zone. It shall be possible for output points to be assigned to list general alarm. Non-Alarm or Supervisory points shall not activate the general alarm zone.

- gg. 1000 General Zones: The system shall support up to 1000 general purpose software zones for linking inputs to outputs. When an input device activates, any general zone programmed into that device's zone map will be active and any output device that has an active general zone in its map will be active. It shall also be possible to use general zone as arguments in logic equations.
- hh. 1000 Logic Equations: The system shall support up to 1000 logic equations for AND, OR, NOT, ONLY1, ANYX, XZONE or RANGE operators that allow conditional I/O linking. When any logic equation becomes true, all output points mapped to the logic zone shall activate.
- ii. 10 trouble equations per device: The system shall provide support for up to 10 trouble equations for each device, which shall permit programming parameters to be altered, based on specific fault conditions. If the trouble equation becomes true, all output points mapped to the trouble zone shall activate.
- jj. Control-By-Time: A time based logic function shall be available to delay an action for a specific period of time based upon a logic input with tracking feature. A latched version shall also be available. Another version of this shall permit activation on specific days of the week or year with ability to set and restore based on a 24 hour time schedule on any day of the week or year.
- kk. Multiple agent releasing zones: The system shall support up to 10 releasing zones to protect against 10 independent hazards. Releasing zones shall provide up to three cross-zone and four abort options to satisfy any local jurisdiction requirements.
- ll. Alarm Verification, by device, with timer and tally: The system shall provide a user-defined global software timer function that can be set for a specific detector or indicating panel module input. The timer function shall delay an alarm signal for a user-specified time period and the control panel shall ignore the alarm verification timer if another alarm is detected during the verification period. It shall also be possible to set a maximum verification count between 0 and 20 with the "0" setting producing no alarm verification. When the counter exceeds the threshold value entered, a trouble shall be generated to the panel.

E. Central Processing Unit

1. The Central Processing Unit shall communicate with, monitor, and control all other modules within the control panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the system display by the Central Processing Unit.
2. The Central Processing Unit shall contain and execute all control-by-event (including Boolean functions including but not limited to AND, OR, NOT, ANYx, and CROSSZONE) programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory, and shall not be lost with system primary and secondary power failure.
3. The Central Processing Unit shall also provide a real-time clock for time annotation, to the second, of all system events. The time-of-day and date shall not be lost if system primary and secondary power supplies fail.
4. The CPU shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems that require the use of external programmers or change of EPROMs are not acceptable.

5. Consistent with UL864 standards, the CPU and associated equipment are to be protected so that voltage surges or line transients will not affect them.
6. Each peripheral device connected to the CPU shall be continuously scanned for proper operation. Data transmissions between the CPU and peripheral devices shall be reliable and error free. The transmission scheme used shall employ dual transmission or other equivalent error checking techniques.
7. The CPU shall provide an EIA-232 interface between the fire alarm control panel and the UL Listed Electronic Data Processing (EDP) peripherals.
8. The CPU shall provide two EIA-485 ports for the serial connection to annunciation and control subsystem components.
9. The EIA-232 serial output circuit shall be optically isolated to assure protection from earth ground.
10. The CPU shall provide one high-speed serial connection for support of network communication modules.
11. The CPU shall provide double pole relays for FIRE ALARM, SYSTEM TROUBLE, SUPERVISORY, and SECURITY. The SUPERVISORY and SECURITY relays shall provide selection for additional FIRE ALARM contacts.

F. Display

1. The system display shall provide all the controls and indicators used by the system operator and may also be used to program all system operational parameters.
2. The display assembly shall contain, and display as required, custom alphanumeric labels for all intelligent detectors, addressable modules, and software zones.
3. The system display shall provide a 640-character backlit alphanumeric Liquid Crystal Display (LCD). It shall also provide ten Light-Emitting-Diodes (LEDs), that indicate the status of the following system parameters: AC POWER, FIRE ALARM, PREALARM, SECURITY, SUPERVISORY, SYSTEM TROUBLE, OTHER EVENT, SIGNALS SILENCED, POINT DISABLED, and CPU FAILURE.
4. The system display shall provide a QWERTY style keypad with control capability to command all system functions, entry of any alphabetic or numeric information, and field programming. Two different password levels with up to ten (one Master and nine User) passwords shall be accessible through the display interface assembly to prevent unauthorized system control or programming.
5. The system display shall include the following operator control switches: ACKNOWLEDGE, SIGNAL SILENCE, RESET, DRILL, and LAMP TEST. Additionally, the display interface shall allow scrolling of events by event type including, FIRE ALARM, SECURITY, SUPERVISORY, TROUBLE, and OTHER EVENTS. A PRINT SCREEN button shall be provided for printing the event currently displayed on the 640-character LCD.

G. Loop (Signaling Line Circuit) Control Module:

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1. The Loop Control Module shall monitor and control a minimum of 318 intelligent addressable devices. This includes 159 intelligent detectors (Ionization, Photoelectric, or Thermal) and 159 monitor or control modules.
 2. The Loop Control Module shall contain its own microprocessor and shall be capable of operating in a local/degrade mode (any addressable device input shall be capable of activating any or all addressable device outputs) in the unlikely event of a failure in the main CPU.
 3. The Loop Control Module shall provide power and communicate with all intelligent addressable detectors and modules on a single pair of wires. This SLC Loop shall be capable of operating as a NFPA Style 6 (Class B) circuit.
 4. The SLC interface board shall be able to drive an NFPA Style 6 twisted unshielded circuit up to 12,500 feet in length. The SLC Interface shall also be capable of driving an NFPA Style 6, no twist, no shield circuit for limited distances determined by the manufacturer. In addition, SLC wiring shall meet the listing requirements for it to exit the building or structure. "T"-tapping shall be allowed in either case.
 5. The SLC interface board shall receive analog or digital information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular device. Each SLC Loop shall be isolated and equipped to announce an Earth Fault condition. The SLC interface board software shall include software to automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. The analog information may also be used for automatic detector testing and the automatic determination of detector maintenance requirements.
- H. Enclosures:
1. The control panel shall be housed in a UL-listed cabinet suitable for surface or semi-flush mounting. The cabinet and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.
 2. The back box and door shall be constructed of 0.060 steel with provisions for electrical conduit connections into the sides and top.
 3. The door shall provide a key lock and include a transparent opening for viewing all indicators. For convenience, the door shall have the ability to be hinged on either the right or left-hand side.
 4. The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.
- J. Power Supply:
1. The Addressable Main Power Supply shall operate on 120/240 VAC, 50/60 Hz, and shall provide all necessary power for the FACP.
 2. The Addressable Main Power Supply shall provide the required power to the CPU using a switching 24 VDC regulator and shall incorporate a battery charger for 24 hours of standby power using dual-rate charging techniques for fast battery recharge.

3. The Addressable Main Power Supply shall provide a battery charger for 24 hours of standby using dual-rate charging techniques for fast battery recharge. The supply shall be capable of charging batteries ranging in capacity from 25-200 amp-hours within a 48-hour period.
4. The Addressable Main Power Supply shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults.
5. The Addressable Main Power Supply shall be power-limited per UL864 requirements.

K. System Circuit Supervision

1. The FACP shall supervise all circuits to intelligent devices, transponders, annunciators and peripheral equipment and annunciate loss of communication with these devices. The CPU shall continuously scan above devices for proper system operation and upon loss of response from a device shall sound an audible trouble, indicate which device or devices are not responding and print the information in the history buffer and on the printer.
2. Transponders that lose communication with the CPU shall sound an audible trouble and light an LED indicating loss of communications.
3. Sprinkler system valves, standpipe control valves, PIV, and main gate valves shall be supervised for off-normal position.
4. All speaker and emergency phone circuits shall be supervised for opens and shorts. Each transponder speaker and emergency phone circuit shall have an individual ON/OFF indication (green LED).

L. Field Wiring Terminal Blocks

1. All wiring terminal blocks shall be the plug-in/removable type and shall be capable of terminating up to 12 AWG wire. Terminal blocks that are permanently fixed to the PC board are not acceptable.

O. Controls with associated LED Indicators:

1. Speaker Switches/Indicators
 - a. The speaker circuit control switches/indicators shall include visual indication of active and trouble status for each speaker circuit in the system.
 - b. The speaker circuit control panel shall include switches to manually activate or deactivate each speaker circuit in the system.
2. Emergency Two-Way Telephone Control Switches/Indicators
 - a. The emergency telephone circuit control panel shall include visual indication of active and trouble status for each telephone circuit in the system.
 - b. The telephone circuit control panel shall include switches to manually activate or deactivate each telephone circuit in the system.

P. Remote Transmissions:

1. Provide local energy or polarity reversal or trip circuits as required.
2. The system shall be capable of operating a polarity reversal or local energy or fire alarm transmitter for automatically transmitting fire information to the fire department.
3. Provide capability and equipment for transmission of zone alarm and trouble signals to remote operator's terminals, system printers and annunciators.
4. Transmitters shall be compatible with the systems and equipment they are connected to such as timing, operation and other required features.

Q. System Expansion:

Design the main FACP and required components so that the system can be expanded in the future (to include the addition of twenty percent more circuits or zones) without disruption or replacement of the existing control panel. This shall include hardware capacity, software capacity and cabinet space.

R. Field Programming

1. The system shall be programmable, configurable and expandable in the field without the need for special tools, laptop computers, or other electronic interface equipment. There shall be no firmware changes required to field modify the system time, point information, equations, or annunciator programming/information.
2. It shall be possible to program through the standard FACP keyboard all system functions.
3. All field defined programs shall be stored in non-volatile memory.
4. Two levels of password protection shall be provided in addition to a key-lock cabinet. One level shall be used for status level changes such as point/zone disable or manual on/off commands (Building Manager). A second (higher-level) shall be used for actual change of the life safety program (installer). These passwords shall be five (5) digits at a minimum. Upon entry of an invalid password for the third time within a one minute time period an encrypted number shall be displayed. This number can be used as a reference for determining a forgotten password.
5. The system programming shall be "backed" up via an upload/download program, and stored on compatible removable media. A system back-up disk shall be completed and given in duplicate to the building owner and/or operator upon completion of the final inspection. The program that performs this function shall be "non-proprietary", in that, it shall be possible to forward it to the building owner/operator upon his or her request.
6. The installer's field programming and hardware shall be functionally tested on a computer against known parameters/norms which are established by the FACP manufacturer. A software program shall test Input-to-Output correlations, device Type ID associations, point associations, time equations, etc. This test shall be performed on an IBM-compatible PC with a verification software package. A report shall be generated of the test results and two copies turned in to the engineer(s) on record.

S. Specific System Operations

1. Smoke Detector Sensitivity Adjust: Means shall be provided for adjusting the sensitivity of any or all analog intelligent smoke detectors in the system from the system keypad or from the keyboard of the video terminal. Sensitivity range shall be within the allowed UL window.
 2. Alarm Verification: Each of the Intelligent Addressable Smoke Detectors in the system may be independently selected and enabled to be an alarm verified detector. The alarm verification function shall be programmable from 5 to 50 seconds and each detector shall be able to be selected for verification during the field programming of the system or anytime after system turn-on. Alarm verification shall not require any additional hardware to be added to the control panel. The FACP shall keep a count of the number of times that each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.
- T. System Point Operations:
1. Any addressable device in the system shall have the capability to be enabled or disabled through the system keypad or video terminal.
 2. System output points shall be capable of being turned on or off from the system keypad or the video terminal.
 3. Point Read: The system shall be able to display the following point status diagnostic functions without the need for peripheral equipment. Each point shall be annunciated for the parameters listed:
 - a. Device Status.
 - b. Device Type.
 - c. Custom Device Label.
 - d. Software Zone Label.
 - e. Device Zone Assignments.
 - f. Analog Detector Sensitivity.
 - g. All Program Parameters.
 4. System Status Reports: Upon command from an operator of the system, a status report will be generated and printed, listing all system statuses:
 5. System History Recording and Reporting: The fire alarm control panel shall contain a history buffer that will be capable of storing up to 4000 system events. Each of these events will be stored, with time and date stamp, until an operator requests that the contents be either displayed or printed. The contents of the history buffer may be manually reviewed; one event at a time, and the actual number of activations may also be displayed and or printed. History events shall include all alarms, troubles, operator actions, and programming entries.
 6. The history buffer shall use non-volatile memory. Systems which use volatile memory for history storage are not acceptable.
 7. Automatic Detector Maintenance Alert: The fire alarm control panel shall automatically interrogate each intelligent system detector and shall analyze the detector responses over a period of time.

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8. If any intelligent detector in the system responds with a reading that is below or above normal limits, then the system will enter the trouble mode, and the particular Intelligent Detector will be annunciated on the system display, and printed on the optional system printer. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.
9. The system shall include the ability (programmable) to indicate a "pre-alarm" condition. This will be used to alert maintenance personal when a detector is at 80% of its alarm threshold in a 60 second period.

2.4 SYSTEM COMPONENTS:

A. Programmable Electronic Sounders:

1. Electronic sounders shall operate on 24 VDC nominal.
2. Electronic sounders shall be field programmable without the use of special tools, at a sound level of at least 90 dBA measured at 10 feet from the device.
3. Shall be flush or surface mounted as shown on plans.

B. Speakers:

1. All speakers shall operate on 25 VRMS or with field selectable output taps from 0.5 to 2.0 Watts.
2. Speakers in corridors and public spaces shall produce a nominal sound output of 84 dBA at 10 feet (3m).
3. Frequency response shall be a minimum of 400 HZ to 4000 HZ.
4. The back of each speaker shall be sealed to protect the speaker cone from damage and dust.

C. Strobe lights shall meet the requirements of the ADA, UL Standard 1971, be fully synchronized, and shall meet the following criteria:

1. The maximum pulse duration shall be 2/10 of one second.
2. Strobe intensity shall meet the requirements of UL 1971.
3. The flash rate shall meet the requirements of UL 1971.

D. Manual Fire Alarm Stations

1. Manual fire alarm stations shall be non-code, non-breakglass type, equipped with key lock so that they may be tested without operating the handle.
2. Stations must be designed such that after an actual activation, they cannot be restored to normal except by key reset.
3. An operated station shall automatically condition itself so as to be visually detected, as operated, at a minimum distance of 100 feet (30.5 m) front or side.
4. Manual stations shall be constructed of high impact Lexan, with operating instructions provided on the cover. The word FIRE shall appear on the manual station in letters one half inch (12.7 mm) in size or larger.

E. Conventional Photoelectric Area Smoke Detectors

1. Photoelectric smoke detectors shall be a 24 VDC, two wire, ceiling-mounted, light scattering type using an LED light source.
2. Each detector shall contain a remote LED output and a built-in test switch.
3. Detector shall be provided on a twist-lock base.
4. It shall be possible to perform a calibrated sensitivity and performance test on the detector without the need for the generation of smoke. The test method shall test all detector circuits.
5. A visual indication of an alarm shall be provided by dual latching Light Emitting Diodes (LEDs), on the detector, which may be seen from ground level over 360 degrees. These LEDs shall flash at least every 10 seconds, indicating that power is applied to the detector.
6. The detector shall not go into alarm when exposed to air velocities of up to 3000 feet (914.4 m) per minute.
7. The detector screen and cover assembly shall be easily removable for field cleaning of the detector chamber.
8. All field wire connections shall be made to the base through the use of a clamping plate and screw.

F. Conventional Ionization Type Area Smoke Detectors

1. Ionization type smoke detectors shall be a two wire, 24 VDC type using a dual unipolar chamber.
2. Each detector shall contain a remote LED output and a built-in test switch.
3. Detector shall be provided on a twist-lock base.
4. It shall be possible to perform a calibration sensitivity and performance test on the detector without the need for the generation of smoke.
5. A visual indication of an alarm shall be provided by dual latching Light Emitting Diodes (LEDs) over 360 degrees, on the detector, which may be seen from ground level. This LED shall flash every 10 seconds, indicating that power is applied to the detector.
6. The detector shall not alarm when exposed to air velocities of up to 1,200 feet (365.76 m) per minute. The detector screen and cover assembly shall be easily removable for field cleaning of the detector chamber.
7. All field wire connections shall be made to the base through the use of a clamping plate and screw.

G. Duct Smoke Detectors

Duct smoke detectors shall be a 24 VDC type with visual alarm and power indicators, and a reset switch. Each detector shall be installed upon the composite supply/return air ducts(s), with properly sized air sampling tubes.

H. Automatic Conventional Heat Detectors

1. Automatic heat detectors shall have a combination rate of rise and fixed temperature rated at 135 degrees Fahrenheit (57.2 Celsius) for areas where ambient temperatures do not exceed 100 degrees (37.7 Celsius), and 200 degrees (93.33 Celsius) for areas where the temperature does not exceed 150 degrees (65.5 Celsius).
2. Automatic heat detectors shall be a low profile, ceiling mount type with positive indication of activation.

3. The rate of rise element shall consist of an air chamber, a flexible metal diaphragm, and a factory calibrated, moisture-proof, trouble free vent, and shall operate when the rate of temperature rise exceeds 15 degrees F (9.4 degrees C) per minute.
 4. The fixed temperature element shall consist of a fusible alloy retainer and actuator shaft.
 5. Automatic heat detectors shall have a smooth ceiling rating of 2500 square feet (762 square meters).
- I. Waterflow Indicator:
1. Waterflow Switches shall be an integral, mechanical, non-coded, non-accumulative retard type.
 2. Waterflow Switches shall have an alarm transmission delay time which is conveniently adjustable from 0 to 60 seconds. Initial settings shall be 30-45 seconds.
 3. All waterflow switches shall come from a single manufacturer and series.
 4. Waterflow switches shall be provided and connected under this section but installed by the mechanical contractor.
 5. Where possible, locate waterflow switches a minimum of one (1) foot from a fitting which changes the direction of the flow and a minimum of three (3) feet from a valve.
- J. Sprinkler and Standpipe Valve Supervisory Switches:
1. Each sprinkler system water supply control valve riser, zone control valve, and standpipe system riser control valve shall be equipped with a supervisory switch. Standpipe hose valves, and test and drain valves shall not be equipped with supervisory switches.
 2. PIV (post indicator valve) or main gate valves shall be equipped with a supervisory switch.
 3. The switch shall be mounted so as not to interfere with the normal operation of the valve and adjusted to operate within two revolutions toward the closed position of the valve control, or when the stem has moved no more than one-fifth of the distance from its normal position.
 4. The supervisory switch shall be contained in a weatherproof aluminum housing, which shall provide a 3/4 inch (19 mm) conduit entrance and incorporate the necessary facilities for attachment to the valves.
 5. The switch housing shall be finished in red baked enamel.
 6. The entire installed assembly shall be tamper proof and arranged to cause a switch operation if the housing cover is removed, or if the unit is removed from its mounting.
 7. Valve supervisory switches shall be provided and connected under this section and installed by mechanical contractor.
 - a. This unit shall provide for each zone: alarm indications, using a red alarm a yellow trouble long-life LEDs and control switches for the control of fire alarm control panel functions. The annunciator will also have an ON-LINE LED, local piezo electric signal, local acknowledge/lamp test switch, and custom slide-in zone/function identification labels.
 - b. Switches shall be available for remote annunciation and control of output points in the system, system acknowledge, telephone zone select, speaker select, global signal silence, and global system reset within the confines of all applicable standards.
- K. Portable Emergency Telephone Handset Jack

1. Portable emergency telephone handset jacks shall be flush mounted on stainless steel plates as indicated on plans. Handset jacks shall be approved for emergency telephone system application.
2. Insertion of a remote handset plug into a jack shall send a signal to the fire command center which shall audibly and visually indicate the on-line condition, and shall sound a ring indication in the handset.
3. The two-way emergency telephone system shall support a minimum of seven (7) handsets on line without degradation of the signal.

M. Fixed Emergency Telephone Handset

1. The telephone cabinet shall be painted red and clearly labeled emergency telephone. The cabinets shall be located where shown on drawings.
2. The handset cradle shall have a switch connection such that lifting the handset off of the cradle shall send a signal to the fire command center which shall audibly and visually indicate its on-line (off-hook) condition.
3. The two-way emergency telephone system shall support a maximum of seven (7) handsets on line (off hook) without degradation of the signal.

2.5. SYSTEM COMPONENTS - ADDRESSABLE DEVICES

A. Addressable Devices - General

1. Addressable devices shall provide an address-setting means using rotary decimal switches.
2. Addressable devices shall use simple to install and maintain decade (numbered 0 to 9) type address switches. Devices which use a binary address or special tools for setting the device address, such as a dip switch are not an allowable substitute.
3. Detectors shall be Analog and Addressable, and shall connect to the fire alarm control panel's Signaling Line Circuits.
4. Addressable smoke and thermal detectors shall provide dual (2) status LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the flashing mode operation of the detector LEDs can be programmed off via the fire control panel program.
5. The fire alarm control panel shall permit detector sensitivity adjustment through field programming of the system. Sensitivity can be automatically adjusted by the panel on a time-of-day basis.
6. Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72, Chapter 7.
7. The detectors shall be ceiling-mount and shall include a separate twist-lock base which includes a tamper proof feature.
8. The following bases and auxiliary functions shall be available:
 - a. Sounder base rated at 85 DBA minimum.
 - b. Form-C Relay base rated 30VDC, 2.0A
 - c. isolator base

9. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
10. Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (example: ION, PHOTO, THERMAL).

B. Addressable Manual Fire Alarm Box (manual station)

1. Addressable manual fire alarm boxes shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key.
2. All operated stations shall have a positive, visual indication of operation and utilize a key type reset.
3. Manual fire alarm boxes shall be constructed of Lexan with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches (44 mm) or larger.

C. Intelligent Photoelectric Smoke Detector

1. The detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.

D. Intelligent Ionization Smoke Detector

1. The detectors shall use the dual-chamber ionization principal to measure products of combustion and shall, on command from the control panel, send data to the panel representing the analog level of products of combustion.

E. Intelligent Multi Criteria Acclimating Detector

1. The intelligent multi criteria Acclimate detector shall be an addressable device that is designed to monitor a minimum of photoelectric and thermal technologies in a single sensing device. The design shall include the ability to adapt to its environment by utilizing a built-in microprocessor to determine it's environment and choose the appropriate sensing settings. The detector design shall allow a wide sensitivity window, no less than 1 to 4% per foot obscuration. This detector shall utilize advanced electronics that react to slow smoldering fires and thermal properties all within a single sensing device.
2. The microprocessor design shall be capable of selecting the appropriate sensitivity levels based on the environment type it is in (office, manufacturing, kitchen etc.) and then have the ability to automatically change the setting as the environment changes (as walls are moved or as the occupancy changes).
3. The intelligent multi criteria detection device shall include the ability to combine the signal of the thermal sensor with the signal of the photoelectric signal in an effort to react hastily in the event of a fire situation. It shall also include the inherent ability to distinguish between a fire condition and a false alarm condition by examining the characteristics of the

thermal and smoke sensing chambers and comparing them to a database of actual fire and deceptive phenomena.

F. Intelligent Thermal Detectors

1. Thermal detectors shall be intelligent addressable devices rated at 135 degrees Fahrenheit (58 degrees Celsius) and have a rate-of-rise element rated at 15 degrees F (9.4 degrees C) per minute. It shall connect via two wires to the fire alarm control panel signaling line circuit.

G. Intelligent Duct Smoke Detector

1. The smoke detector housing shall accommodate either an intelligent ionization detector or an intelligent photoelectric detector, of that provides continuous analog monitoring and alarm verification from the panel.
2. When sufficient smoke is sensed, an alarm signal is initiated at the FACP, and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.

H. Addressable Dry Contact Monitor Module

1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panel SLCs.
2. The IDC zone shall be suitable for Style D or Style B operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.
3. For difficult to reach areas, the monitor module shall be available in a miniature package and shall be no larger than 2-3/4 inch (70 mm) x 1-1/4 inch (31.7 mm) x 1/2 inch (12.7 mm). This version need not include Style D or an LED.

I. Two Wire Detector Monitor Module

1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional 2-wire smoke detectors or alarm initiating devices (any N.O. dry contact device).
2. The IDC zone may be wired for Class A or B (Style D or Style B) operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.

J. Addressable Control Module

1. Addressable control modules shall be provided to supervise and control the operation of one conventional NACs of compatible, 24 VDC powered, polarized audio/visual notification appliances.
2. The control module NAC may be wired for Style Z or Style Y (Class A/B) with up to 1 amp of inductive A/V signal, or 2 amps of resistive A/V signal operation.
3. Audio/visual power shall be provided by a separate supervised power circuit from the main fire alarm control panel or from a supervised UL listed remote power supply.

4. The control module shall be suitable for pilot duty applications and rated for a minimum of 0.6 amps at 30 VDC.

K. Addressable Relay Module

1. Addressable Relay Modules shall be available for HVAC control and other building functions. The relay shall be form C and rated for a minimum of 2.0 Amps resistive or 1.0 Amps inductive. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.

L. Isolator Module

1. Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC Class A or Class B branch. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC loop segment or branch. At least one isolator module shall be provided for each floor or protected zone of the building.
2. If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.
3. The isolator module shall not require address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.
4. The isolator module shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

M. Smoke Control Annunciator

1. On/Auto/Off switches and status indicators (LEDS) shall be provided for monitoring and manual control of each fan, damper, HVAC control unit, stairwell pressurization fan, and smoke exhaust fan. To ensure compliance the units supplied shall meet the following UL categories : UUKL, PAZX, UDTZ, QVAX as well as the requirements of NFPA 90A, HVAC, and NFPA 92A & 92B, Smoke Control. The control System shall be field programmable for either 90A operation or 92A/B operation to allow for future use and system expansion.
2. The OFF LED shall be Yellow, the ON LED shall be green, the Trouble/Fault LED shall be Amber/Orange for each switch. The Trouble/Fault indicator shall indicate a trouble in the control and/or monitor points associated with that switch. In addition, each group of eight switches shall have two LEDS and one momentary switch which allow the following functions: An Amber LED to indicate an OFF-NORMAL switch position, in the ON or OFF position; A Green LED to indicate ALL AUTO switch position; A Local Acknowledge/Lamp Test momentary switch.
3. Each switch shall have the capability to monitor and control two addressable inputs and two addressable outputs. In all modes, the ON and OFF indicators shall continuously follow the device status not the switch position. Positive feedback shall be employed to verify correct operation of the device being controlled. Systems that indicate on/off/auto by physical switch position only are not acceptable.

4. All HVAC switches (i.e., limit switches, vane switches, etc.) shall be provided and installed by the HVAC contractor.
5. It shall be possible to meet the requirements mentioned above utilizing wall mounted custom graphic.

B. Serially Connected Annunciator Requirements

1. The annunciator shall communicate to the fire alarm control panel via an EIA 485 (multi-drop) two-wire communications loop. The system shall support two 6,000 ft. EIA-485 wire runs. Up to 32 annunciators, each configured up to 96 points, may be connected to the connection, for a system capacity of 3,072 points of annunciation.
2. An EIA-485 repeater shall be available to extend the EIA-485 wire distance in 3,000 ft. increments. An optional version shall allow the EIA-485 circuit to be transmitted over Fiber optics. The repeater shall be UL864 approved.
3. Each annunciator shall provide up to 96 alarm and 97 trouble indications using a long-life programmable color LED's. Up to 96 control switches shall also be available for the control of Fire Alarm Control Panel functions. The annunciator will also have an "ON-LINE" LED, local piezo sounder, local acknowledge and lamp test switch, and custom zone/function identification labels.
4. The annunciator may be field configured to operate as a "Fan Control Annunciator". When configured as "Fan Control," the annunciator may be used to manually control fan or damper operation and can be set to override automatic commands to all fans/dampers programmed to the annunciator.
5. Annunciator switches may be programmed for System control such as, Global Acknowledge, Global Signal Silence, Global System Reset, and on/off control of any control point in the system.
6. An optional module shall be available to utilize annunciator points to drive EIA-485 driven relays. This shall extend the system point capacity by 3,072 remote contacts.
7. The LED annunciator shall offer an interface to a graphic style annunciator and provide each of the features listed above.

2.6 BATTERIES AND EXTERNAL CHARGER:

A. Battery:

1. Shall be 12 volt, Gell-Cell type.
2. Battery shall have sufficient capacity to power the fire alarm system for not less than twenty-four hours plus 5 minutes of alarm upon a normal AC power failure.
3. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks refilling, spills and leakage shall not be required.

B. External Battery Charger:

1. Shall be completely automatic, with constant potential charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 120/240-volt 50/60 hertz source.
2. Shall be rated for fully charging a completely discharged battery within 48 hours while simultaneously supplying any loads connected to the battery.
3. Shall have protection to prevent discharge through the charger.
4. Shall have protection for overloads and short circuits on both AC and DC sides.

PART 3.0 - EXECUTION

3.1. INSTALLATION:

- A. Installation shall be in accordance with the NEC, NFPA 72, local and state codes, as shown on the drawings, and as recommended by the major equipment manufacturer.
- B. All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage.
- C. All fire detection and alarm system devices, control panels and remote annunciators shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas.
- D. Manual Pull Stations shall be suitable for surface mounting or semiflush mounting as shown on the plans, and shall be installed not less than 42 inches, nor more than 48 inches above the finished floor.

3.4. TYPICAL OPERATION:

- A. Actuation of any manual station, smoke detector heat detector or water flow switch shall cause the following operations to occur unless otherwise specified:
 - 1. Activate all programmed speaker circuits.
 - 2. Actuate all strobe units until the panel is reset.
 - 3. Light the associated indicators corresponding to active speaker circuits.
 - 4. Release all magnetic door holders to doors to adjacent zones on the floor from that the alarm was initiated.
 - 5. Return all elevators to the primary or alternate floor of egress.
 - 6. A smoke detector in any elevator lobby shall, in addition to the above functions, return all elevators to the primary or alternate floor of egress.
 - 7. Smoke detectors in the elevator machine room or top of hoistway shall return all elevators in to the primary or alternate floor. Smoke detectors or heat detectors installed to shut down elevator power shall do so in accordance with ANSI A17.1 requirements and be coordinated with the electrical contractor.
 - 8. Duct type smoke detectors shall, in addition to the above functions shut down the ventilation system or close associated control dampers as appropriate.
 - 9. Activation of any sprinkler system low pressure switch or valve tamper switch shall cause a system supervisory alarm indication.

3.5. TEST:

- A. Provide the service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and tests for the system.

- B. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
 - C. Close each sprinkler system flow valve and verify proper supervisory alarm at the FACP.
 - D. Verify activation of all flow switches.
 - E. Open initiating device circuits and verify that the trouble signal actuates.
 - F. Open signaling line circuits and verify that the trouble signal actuates.
 - G. Open and short notification appliance circuits and verify that trouble signal actuates.
 - H. Ground initiating device circuits and verify response of trouble signals.
 - I. Ground signaling line circuits and verify response of trouble signals.
 - J. Ground notification appliance circuits and verify response of trouble signals.
 - K. Check presence and audibility of tone at all alarm notification devices.
 - L. Check installation, supervision, and operation of all intelligent smoke detectors during a walk test.
 - M. Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and the proper processing of the signal at the FACP and the correct activation of the control points.
 - N. When the system is equipped with optional features, the manufacturer's manual should be consulted to determine the proper testing procedures. This is intended to address such items as verifying controls performed by individually addressed or grouped devices, sensitivity monitoring, verification functionality and similar.
- 3.6 FINAL INSPECTION:
- A. At the final inspection a factory trained representative of the manufacturer of the major equipment shall demonstrate that the systems function properly in every respect.
- 3.7 INSTRUCTION:
- A. Provide instruction as required for operating the system. Hands-on demonstrations of the operation of all system components and the entire system including program changes and functions shall be provided.
 - B. The contractor and/or the systems manufacturer's representatives shall provide a typewritten "Sequence of Operation."

END OF SECTION