

St. Petersburg College

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EpiCenter Technology

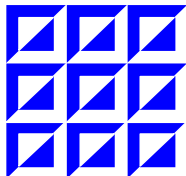
and

Business Development Center:

Ventilation Commissioning

Construction Documents

February 21, 2013



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Matrix Proj. No. 12-0210

DIVISION 23—HEATING, VENTILATING, AND AIR CONDITIONING

23 05 00COMMON WORK RESULTS FOR HVAC

23 09 00INSTRUMENTATION AND CONTROL FOR HVAC

23 29 23VARIABLE-FREQUENCY MOTOR CONTROLLERS

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SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Mechanical sleeve seals.
 - 3. Sleeves.
 - 4. Escutcheons.
 - 5. Grout.
 - 6. HVAC demolition.
 - 7. Equipment installation requirements common to equipment sections.
 - 8. Painting and finishing.
 - 9. Concrete bases.
 - 10. Supports and anchorages.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.
2. Mechanical sleeve seals.

B. Welding certificates.

C. Submit Manufacturer's published technical data, catalog cuts, wiring diagrams, shop drawings, samples and testing and balancing logs for all elements of the HVAC work. Submit under provisions of General Conditions and Supplementary General Conditions.

D. No equipment, piping, ductwork or components shall be fabricated, delivered, erected, or connected other than from shop drawings reviewed and approved by the Engineer.

E. It shall be understood that review of shop drawings by the Engineer does not supersede the requirement to provide a complete and functioning system in compliance with the Contract Documents.

F. Equipment Supports: Submit detailed shop drawings indicating equipment weight and dimensions, support material, connections, anchoring, and vibration isolation.

G. Submittals shall include, but not be limited to the following:

1. All equipment; cooling, heating, plumbing, electrical motors, starters, controls, etc.
2. Voltage, phase, and amps of each electrical item, such as motors, etc.
3. All auxiliary equipment.
4. Pipe, ductwork, valves, insulation, etc.

1.5 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

1.8 INTENT

- A. It is the intention of these specifications and drawings to call for finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete and ready for use."
- B. Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, the same as if herein specified or shown.

- C. The term “Basis of Design” used throughout this document shall be understood to mean a particular manufacturer’s equipment (as scheduled specifically on the drawings or specifications) has been used as the basis by the Design Engineer to establish physical dimensions, quality, and performance required, in addition to providing a basis for interaction with other ancillary components and/or other trades. Therefore, it shall be understood that use of a piece of equipment other than that identified as the Basis of Design may impact performance of an overall engineered system or may require revisions to ancillary interfacing equipment, and thus any manufacturer’s equipment other than that listed as Basis of Design shall require written approval via Addendum prior to bid except where the manufacturer’s name is specifically listed in these specifications as a pre-approved substitute or an accepted manufacturer. All substitutes, pre-approved substitutes, accepted manufacturers, and/or Basis of Design are subject to all requirements of quality, physical characteristics (i.e., dimension, sound, etc), and performance, etc., as set forth in these specifications and contract documents.

1.9 SUBSTITUTIONS

- A. Materials and equipment are specified herein by a single or by multiple Manufacturers to indicate quality and performance required. The drawings are based upon equipment scheduled on drawings and specified. If another Manufacturer is considered for substitution during the bidding process, the Mechanical Contractor shall be responsible for coordinating all electrical, mechanical, structural, or architectural changes. Comparable equipment Manufacturers which are listed below equipment indicated as “Basis of Design” shall be considered as substitutes. Manufacturers other than the Basis of Design shall submit catalog information and 1/4" scale plan and section drawings showing proper fit and all clearances for maintenance items.
- B. Substitutions of other Manufacturer's will be considered for use if, in the Engineers opinion, the item requested for substitution is equal to that specified. The Contractor shall provide to the Engineer a typed comparative list of the basis of design and the proposed substitute. The comparative shall list capacities, pressure drops, horse power, electrical requirements, etc., (refer to Submittal requirements).
- C. Request for approval of substitutions shall be made in writing no less than ten days (unless otherwise directed in Division 01) prior to bid. Substitutions shall not be considered approved unless the approval appears in an Addendum or unless so named in the specifications as a pre-approved substitute. The approval of any substitutions or equals prior to bid shall not be construed as a shop drawing approval. The substitute or equal must be submitted as described in the specifications and meet all the requirements of the specifications and drawings.
- D. All requests for substitutions shall specifically indicate any and all differences or omissions between the product specified as basis of design and the product proposed for substitution. Differences shall include, but shall not be limited to, data as follows for both the specified and substituted products.
1. Principle of operation;
 2. Materials of construction or finishes;
 3. Thickness or gauge of materials;
 4. Weight of item;
 5. Deleted features or items;

6. Added features or items;
 7. Changes in other Contractor's work caused by the substitution;
 8. Physical dimensions;
 9. Electrical requirements.
- E. Where the Contractor proposes to use an item of equipment other than that specified or detailed on the drawing, which requires any redesign of the structure, partitions, foundations, piping, wiring, or any other part of the mechanical or electrical, all such redesign, and all new drawings and detailing required therefore, shall be prepared by the Subcontractor at his own expense and submitted to the Architect/Engineer for approval.
- F. Where such approved deviation requires quantity and arrangement of ductwork, piping, wiring, conduit, and equipment from that specified or indicated on the drawings, the Contractor shall furnish and install any such ductwork, piping, structural supports, insulation, controllers, motors, starters, electrical wiring and conduit, and any other additional equipment required by the system, at no additional cost to the Owner.

1.10 COOPERATION WITH OTHER TRADES

- A. Give full cooperation to other trades and furnish in writing to the General Contractor, with copies to the Architect, any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.
- B. When work installed under this Division will be in close proximity to, or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment. If so directed by the Engineer/Architect, prepare composite working drawings and sections at a suitable scale not less than 1/4" = 1'0", clearly showing how work is to be installed in relation to the work of other trades. If the work is installed before coordinating with other trades, or so as to cause any interference with work of other trades, make all the necessary changes in work to correct the condition without extra charge.
- C. Furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
 2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

PART 3 EXECUTION

3.1 HVAC DEMOLITION

- A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - 3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - 4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
 - 5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - 7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PAINTING

- A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.4 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

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SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The General and Supplementary Conditions and General Requirements apply to the work specified in this section—Automatic Temperature Control System (ATCS).

1.2 SCOPE

- A. Provide materials, equipment, labor and supervision necessary to modify the existing Trane Tracer Summit building management and digital electronic automatic control system to accomplish the outside air ventilation reset scheme detailed on the drawings. Pneumatic controls are not acceptable.
- B. The system shall consist of a distributed processor direct digital control system utilizing electronic actuation. The system shall be fully integrated with the air handling units, VAV boxes, chillers, pumps, cooling towers and boilers. Every DDC control panel shall be listed by underwriters laboratory under "UL Standard 916 Energy Management Equipment".
- C. All electric control and interlock wiring in connection with the controls and instrumentation system shall be furnished by this Contractor. Power wiring to the various control devices shall be provided by the Electrical Contractor, coordinated by this Contractor prior to Bid. Failure of this Contractor to coordinate requirements with other Divisions shall require this Contractor to be responsible for any non-coordinated items. Control power to operate VAV boxes (other than duct heaters or fan power) shall be the responsibility of this Contractor (if applicable). The Electrical Contractor (Division 26) is to provide dedicated 120 VAC power or higher to each control panel.
- D. Control Contractor shall complete all installations including electric and electronic components—not the Mechanical Contractor.

1.3 COORDINATION

- A. Division 15 Mechanical Contractor shall receive, handle, mount and install automatic temperature control valves, separable wells for immersion elements and couplings for flow and pressure switches.
- B. Mechanical Contractor for section 15 or the sheet metal subcontractor shall install all automatic dampers. It shall be the responsibility of the mechanical Contractor or his sheet metal subcontractor to provide and install blank-off plates when the control application requires dampers smaller than duct size.
- C. The direct digital portions and automatic temperature control system shall be installed by the Temperature Control Contractor.
- D. Coordination of all controls items with other trades shall be the responsibility of the Controls Contractor.

1.4 TEST

- A. The Control Contractor shall test the entire system and document point by point operation of all controls. Perform all required continuity testing of conductors prior to final connection to control equipment.

1.5 CALIBRATION AND ADJUSTMENT

- A. After completion of the installation, perform calibration and adjustments of the Automatic Temperature Control equipment provided under this contract, and supply services incidental to the proper performance of the temperature control system under the warranty below.

1.6 SYSTEM WARRANTY

- A. System Warranty

All temperature control devices provided by this Contractor shall be warranted to be free of defects in workmanship and material for a period of one (1) year from the date of the job acceptance (Final Substantial Completion) by the Owner and/or date of beneficial use. Any equipment found to be defective during this period shall be repaired or replaced without expense to the Owner. This work shall be accomplished by the Contractor during normal working hours (8 am to 5 pm, Monday through Friday, excluding holidays).

The Controls Contractor shall be responsible for all defects or failures throughout the warranty period (parts and labor).

- B. Service Organization Qualifications:

The Servicing Contractor shall meet all of the following requirements:

1. Have certified OEM factory-trained technicians experienced on the specific equipment needing repair. Service technicians to be equipped with laptop computers.
2. Provide for two (2) hour response time, 24 hours/day, 7 days/week to inspect down equipment and then repair to make equipment operational.
3. Maintain a complete stock of OEM parts, service, and repair manuals covering types and models of equipment owned by the Owner. It is unacceptable to remove a failed device and return it to the manufacturer for repair. Parts shall be replaced by local stock at the time of service call.
4. Have fully equipped service trucks and other equipment, including that necessary to comply with prudent and regulatory environmental requirements (including CFCs).
5. Maintain software library to support building automation system. Provide and install mandatory upgrades with 30 days of issue. All systems provided shall be the most current version and all units shall be the same version.
6. Provide local training on chillers, air handlers, and automation systems at no cost to Owner as stipulated herein.

1.7 SUBMITTAL REQUIREMENT

A. The following data/information shall be submitted for approval:

1. Complete description of operation. Include an overall system interconnect diagram showing all remote panels and power/surge protection locations.
2. Control system drawings including all pertinent data to provide a functional operating system.
3. Valve, humidifier and damper schedules showing size, configuration, capacity and location of all equipment.
4. Data sheets for all hardware and software control components.
5. A description of the installation materials including conduit, wire, flex, etc.
6. Thermostat/sensor locations.
7. Distributed panel locations.
8. Provide as part of the submittal five copies of all data.
9. Detailed point-to-point diagram of circuitry of all DDC panels, AHUs. Submit on a per distributed panel basis.
10. List of connected data points, including connected control unit and input or output device.
11. System graphics indicating monitored systems, data connected and calculated point addresses, and operator notations, as-built. Graphics shall be demonstrated at the office of the Engineer using live data via modem hook-up to the site. Graphics are to be demonstrated and approved prior to Substantial Completion. Not required at submittal approval time except as listed below.
12. Descriptive data and sequence of operation of operating, user, and application software.
13. Detailed documentation on the specific field equipment to be supplied by the controls Contractor shall be submitted and approved prior to installation; including, but not limited to, actuators, valves, temperature sensors, and damper operators.
14. All schemes and methods proposed to provide lightning protection entering and leaving each building shall be submitted for review and approval.
15. Locations of each control panel, gateway module, override panels on a 24" x 36" drawing or larger floor plan. Submit panel layouts for each.
16. Proposed Graphic Screens shall be submitted for approval with shop drawings. These submittals shall include a schematic of the graphics, all points which will be shown on that screen, whether such points are able to be overridden from the graphics and any such targets or macros to be accessible from that screen.

PART 2 PRODUCTS

2.1 DDC PANELS (MICROPROCESSOR BASED DDC PANELS)

Provide independent, stand alone, microprocessor based control panels in order to provide centralized control of each major piece of HVAC equipment. Provide DDC panels for each air handling unit. These panels shall communicate with the operator via the Communications Network CPU/Graphics Software. Both text and graphics interface shall be provided.

- A. The DDC panel shall contain the necessary hardware and firmware to interface the building input/output devices to the CPU over a communications channel.

Each DDC panel shall be a stand alone in a standard assembly packaged in a NEMA 1 enclosure complete with power supplies, card cage, interface cards and termination points. Each remote shall be capable of accepting combinations of input sensors and output controls. Each remote AHU unit shall have its' own timeclock.

As many DDC panels as required shall be furnished to provide the monitoring and control functions and capabilities specified. The panel shall be strategically located in areas of the building that are easily accessible for maintenance and repair.

Any software edit changes in a DDC panel by the Owner shall be available to the Owner. The Owner shall not be tied to the manufacturer for those changes.

If the manufacturer's panel does not have the ability to provide the minimum point requirement, then additional panels shall be provided adjacent to the first unit in order to meet the intent of the spec. No exception to this statement shall be acceptable in order to protect the Owner's interest for future additions.

Provide at each AHU, chillers and boiler (if applicable) a dedicated DDC panel. A key lock shall protect the internal DDC panel components.

Provide sufficient ROM, for operating system and PID algorithms. Protect processor cards and memory with internal grounding. Store setpoints and default parameters in a non-volatile memory (EEPROM). Battery back-up shall not be acceptable for AHU stand-alone DDC panel control. Locate the panel in the AHU room or at the AHU.

- B. Input/Output Interface

Each point on each interface card is to be characterized as to its point type, sensor range, status, and scale range in the on-line software data base edit. Revisions or modifications to these parameters shall be entered by the system operator through the PC keyboard.

To gather sensor data and interface with controlled equipment, the DDC panel shall use an internal multiplex design. This design shall allow each panel to accommodate different types of points using any of the following input/output options:

- ☐ Digital Input Options—Monitor the open/closed status of a switch or relay.
- ☐ Analog Input Options—Monitor analog values of voltage, current and resistance from temperature, pressure and humidity sensors, etc.
- ☐ Digital Output Options—Control on/off, start/stop relays.
- ☐ Analog Output Options—Supply voltage or current outputs to controllers.

C. Digital Input (DI)

The digital inputs must be isolated contact closures and can either be normally open (NO) or normally closed (NC).

Points must be transient protected on all points to meet IEEE C37.90a-1974.

Digital input points shall monitor the open/close status of switches or relays. Digital inputs must be isolated contact closures, but normally open or normally closed contacts can be intermixed.

Monitoring voltage is 12 VDC at 12 mA per zone. Two #18 AWG wires are required per point. Points are to be transient protected to meet IEEE 472-1974.

D. Analog Input

The analog inputs can be voltage, current or resistance.

The analog input cards monitor values from temperature, pressure, humidity, and other analog sensors.

Analog inputs can be linear or non-linear. Points shall include a 10-bit A/D converter and an analog power supply. All points shall be wired to the card using #18 AWG twisted, shielded pair cables (Belden 8760 or equivalent) or larger.

E. Digital Output

The digital outputs shall drive control on/off, start/stop relays which have low voltage coils. The control relays must have a minimum contract rating of 120 VAC, 5 amp, and 1/3 HP. Provide manual override switches in order to enable the operator to override the control status of each load.

F. Analog Output

The analog outputs supply voltage or current outputs to devices. The analog outputs shall be a standard 4-20 mA proportional signal. The analog output D/A conversion shall have 10-bit resolution minimum. All output points to valves shall read as a percent open.

G. Packaging And Environment

Distributed DDC panel enclosures shall be locking type, metal cabinet, with common keying. The panels have a metal print pocket suitable for storing wiring, service and log information.

The panel, when required, must functionally operate over the temperature range -30 degrees F to 120 degrees F and the humidity range 10 - 90% non-condensing. Storage temperature shall be -50 degrees F to 150 degrees F.

DDC panels shall come with a minimum of six pre-existing available knockouts for ease of wiring during installation. Panels shall have an on/off switch and shall be fused for power protection. AHU DDC panels shall be provided with the required knock-outs.

The electrical requirements shall be provided by this Contractor. Any 120 VAC requirements are to be coordinated with the Division 16 Contractor prior to bid. Power circuit to each panel shall be provided by Division 16 Contractor.

H. Distributed Control Modules (DCMs)

The Distributed Control Module (referred to as DCMs) shall be distributed standalone controller specifically designed to control the various HVAC equipment as specified herein.

Each DCM shall be capable of communicating with main DDC controller panels over a twisted pair of wires. Provide at each panel an operator interface in the form of a front panel liquid crystal display with keypad. The display and keypad shall allow display and local adjustment of DCMs operating parameters and setpoints.

Each DCM shall have a minimum of 6 programmable/configurable PID loops.

The analog inputs shall be individually selectable for resistance inputs, 4 to 20 mA, 200 ohm input impedance and 0 to 10 VDC.

The binary outputs shall drive dry contact low coil voltage relays with normally open and normally closed (Form C) contacts. The contacts shall be rated at 120 VAC, 5 amps.

The analog outputs shall provide a continuous signal and are individually selectable as either 0-10 VDC or a 0-20 mA or 4-20 mA (both into a 500 ohm impedance).

Provide at each DCM address dip switches for setting the communication link address. In addition, provide at each DCM an RS 232 interface port for connection of a DCM edit software for use with a portable laptop computer.

Damper operators shall be of two (2) types; modulating or two-position depending on the sequence of operation. Two-position operators shall be spring return type and the modulating operators shall be capable of accepting a 0-10 VDC or 4-20 mA signal with a gear de-engagement clutch on the operator cover.

I. Main Direct Digital Controller (MDDC)

The Main Direct Digital Controller shall provide the capability for local loop control. The capability for direct digital control to maintain desired setpoints shall be available. The setpoint values shall be determined manually by the operator's input or by an application program. These values shall be established via the operator input locally or be set via the communications link to another MDDC. The MDDC shall be capable of retrieving data and setting data values from connected DCMs.

The MDDC panel shall have in firmware direct digital control PID loop algorithms for calculations to maintain a setpoint accurately. The algorithm shall utilize this desired setpoint value, mode factors, and feedback to maintain the setpoint. The factors for the mode used in the direct digital control process shall include proportional, integral and derivative value. Each MDDC shall have a minimum of 16 PID loops.

See the point list (I/O summary) for the required number and type of points at each piece of equipment.

2.2 TRANSIENT PROTECTION

- A. All communication channels between CPU, MDDC panels, and DCMs whether in conduits or overhead runs, shall have transient suppression networks installed. The transient protection must meet IEEE standard C37.90a-1974. The suppression network shall be automatic, self-restoring and be on duty at all times.

- B. Surge suppression shall comply at minimum with manufacturers requirements and is to include suppression on all lines entering/leaving each building.

2.3 AUXILIARY CONTROL DEVICES

- A. Building Pressure Sensors
 - 1. Provide indoor pressure sensor with LCD display. Sensor shall be BAPI-Box with attached static tube and bottom port connections.
 - 2. Provide outdoor static pressure pickup port with exterior polytubing installed in EMT conduit. Pressure pickup port shall be BAPI Model ZPS-ACC10.

PART 3 INSTALLATION

3.1 CONTROL WIRING

- A. Provide conduit and outlet boxes.
- B. Install remote push-button stations and/or control devices interposed in the control wiring.
- C. Provide over-current protection for all control and interlock wiring as specified in NFPA (70.1971) Art. 240-5 (a), Exception #4 and Art. 430-72, Exception.
- D. Line voltage and exposed low voltage control wiring shall be run in conduit.
- E. No splices will be allowed except at junction boxes and control centers.
- F. No two wires of the same color shall be run in one conduit unless wires of the same color are properly tagged at both ends and any splice points. Do not change colors at splice points.

3.2 INSTALLATION

- A. The control sequences indicated in the specifications herein show the intended sequences of operation of the various control systems and shall be followed completely, deviations are not acceptable.
- B. Each control system shall be complete with all necessary thermostats, valves, relays, switches, accessories, etc., and all interconnections, and so arranged that they will provide the proper automatic sequence of operation between the various control devices as required to maintain the desired temperature, conditions and sequences.
- C. All control equipment shall be fully modulating unless otherwise noted, and relays or accessories not specifically mentioned but required for proper operation shall be included.
- D. The system shall be installed by competent mechanics and electricians regularly employed by the controls Contractor. Installation by mechanical Contractor is not acceptable.
- E. Control and instrument wiring and capillaries are to be secured to building structure—not to ductwork.

- F. The exact location of instruments, panelboards, accessories, etc., not definitely located shall be approved by the Architect/Engineer.
- G. All automatic controls and accessories shall be located in accessible locations.
- H. All non-panel, as well as panel mounted instruments, shall be clearly labeled as to use and system served by means of engraved laminated nameplates.
- I. Where control instruments or accessories are to be installed on covered casings, ductwork, etc., they shall be mounted on the finished surface of the covering. Care shall be taken that there are no leaks around the stems where they pass through the metal work.
- J. All modulating control valves, dampers, etc., shall operate in a slow, gradual manner without any jerking or slamming.
- K. All controls shall operate satisfactorily without any cycling or hunting. The manufacturer shall furnish any necessary additional controls, relays or damping devices as required to correct cycling or hunt that occurs in any part of the control system after the system is in operation.
- L. Automatic control manufacturer shall provide power to all electric actuators requiring external power source whether they are furnished by him or part of other equipment.
- M. Electronic VAV controllers, motors, and sensors shall be provided under this scope of work. The control Contractor shall also include the cost of mounting controllers and motors by the VAV box manufacturer in his price.
- N. The Automatic Control Contractor shall furnish all motorized valves and dampers to the Mechanical Contractor for installation.

3.3 CONTROL MANUFACTURER'S FIELD SERVICES AND INSTRUCTIONAL REQUIREMENTS

- A. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation. On-site training shall not begin until the system has been accepted by the Engineer and field verifications completed.
- B. Local Training (Classroom Training): Local training shall be provided for up to 7 of the Owner's representatives (6 staff members and the Engineer of Record). Local training may be held at the Owner's site or at the local distributors offices at the sole discretion of the Engineer. This training shall be customized to address only specific hardware/software used at the site. A working understanding of documentation formats shall be a part of this training. Course outline and schedule shall be submitted to the Engineer no less than 30 days prior to commencement. Training shall consist of both lecture and hands-on format and must address troubleshooting as well as operation of the system and in accordance with the training syllabus described herein.

The training syllabus shall include as a minimum the following:

- ☐ System Architecture and Overview
 - ☐ Menus
 - ☐ Demo disk/workshop
 - ☐ Building control

- ☐ Scheduling
- ☐ Zone control
- ☐ Trend logs
- ☐ Program priorities
- ☐ Application Troubleshooting
 - ☐ System set-up
 - ☐ Times and dates
 - ☐ Input/output data
 - ☐ Configuration
 - ☐ ICS local programming
 - ☐ Building status/graphics
 - ☐ Maintenance procedures
 - ☐ Troubleshooting procedures

Schedule shall be for no less than four (4) hours of such instruction per individual. Local training shall be completed within 15 days prior to substantial completion, but after field verification. Cost of local training is a part of this contract.

- C. On-site Training: On-site training shall be provided for up to 7 of the Owner's representatives (6 staff members and the Engineer of Record). This training shall be completed in groups of no more than 4 persons per group at one time in one 4-hour session for each group. The training shall focus on the specific installation and shall address both hardware and software. This training shall be completed after local training and after substantial completion. Specific as-built documentation for this project shall be used for reference as a part of this training. Pre-submit course outline to Engineer as stated above.
- D. For all levels of training, a sign-off sheet shall be submitted to the Engineer certifying that each individual has completed such training to acceptance of individual. Hours of instruction received shall be a part of the sign-off sheet.
- E. It shall be the Owner's responsibility to provide adequate time for attendance at all training sessions.
- F. Training Aids: Provide an "Owner's Copy" factory prepared DVD describing in layman's terms the complete operation of the system. This DVD shall be professionally made by the manufacturer of the system. DVDs (home made) locally are not acceptable. Provide a copy of this DVD with the submittal package to the Engineer for approval prior to proceeding.

3.4 DEMONSTRATION

- A. General: Provide field testing and adjustment of the complete EMCS and on-site, operational acceptance test of the complete operational EMCS. The Owner may witness all tests.

- B. Field Test: When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on line. All testing, calibration, adjusting, and final field tests shall be completed by the Controls Manufacturer. Provide a cross check of each control point within the EMCS by making a comparison between the control demand at the Master and field controlled device. Verify that all systems are operable from local controls in the specified failure mode upon EMCS failure or loss of power. Verify that all systems return to EMCS control automatically upon resumption of EMCS operation or return of power. Submit the results of functional, cross and diagnostic tests.
- C. The Controls Manufacturer shall, as a part of the base scope, provide two (2) days of operational verification, on-site, with the design Engineer present throughout. The verification shall be completed during two (2) continuous days during building non-occupancy, at the end of the final phase of project construction. This two (2) day period shall be over a weekend unless otherwise agreed upon in writing by the Controls Manufacturer and Engineer at the end of the two (2) day period.

The punchlist items shall be corrected by the Installer to the satisfaction of the Engineer within a two (2) week period directly following the verification period and shall be demonstrated to the Engineer on a weekend day in order to complete the verification process. This process shall continue until all items have been successfully demonstrated and acknowledged to the Engineer in writing. This must be completed prior to substantial completion.

3.5 ACCEPTANCE AND WARRANTY

- A. An acceptance test of the completed system in the presence of the Owner's representative and the Engineer shall be performed. When the system performance is deemed satisfactory by these observers and all record (as-built) drawings have been received by the Owner, that part of the system shall be accepted for beneficial use and shall be considered complete.
- B. All control hardware, software, and firmware delivered to the Installer by the Controls Manufacturer shall be warranted by the Controls Manufacturer for a period of one (1) year following the date of completion. Defects arising during this warranty period shall be corrected without cost to the Owner.

*** END OF SECTION 23 09 00 ***

SECTION 23 29 23

VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes solid-state, PWM, VFCs for speed control of three-phase, squirrel-cage induction motors.
- B. Related Sections include the following:
 - 1. Division 26 Section "Electrical Power Monitoring and Control" for monitoring and control of motor circuits.
 - 2. Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for low-voltage power, control, and communication surge suppressors.

1.3 DEFINITIONS

- A. BMS: Building management system.
- B. IGBT: Integrated gate bipolar transistor.
- C. LAN: Local area network.
- D. PID: Control action, proportional plus integral plus derivative.
- E. PWM: Pulse-width modulated.
- F. VFC: Variable frequency controller.

1.4 SUBMITTALS

- A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

- B. Shop Drawings: For each VFC.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current rating of integrated unit.
 - d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
 - e. Features, characteristics, ratings, and factory settings of each motor-control center unit.
 - 2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.
- C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- D. Manufacturer Seismic Qualification Certification: Submit certification that VFCs, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Qualification Data: For manufacturer.
- F. Field quality-control test reports.

- G. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Routine maintenance requirements for VFCs and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- H. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- I. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NFPA 70.
- F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver VFCs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.
- B. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

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

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: 0 to 40 deg C.
 - 2. Humidity: Less than 90 percent (noncondensing).
 - 3. Altitude: Not exceeding 3300 feet.
- B. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Owner no fewer than twodays in advance of proposed interruption of electrical service.
 - 2. Indicate method of providing temporary electrical service.
 - 3. Do not proceed with interruption of electrical service without Owner's written permission.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.8 COORDINATION

- A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
- D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Spare Fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.
 - 2. Indicating Lights: Two of each type installed.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Optidrive (for single phase motors only).
 - 2. Trane.

2.2 VARIABLE FREQUENCY CONTROLLERS—3 PHASE

- A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
- B. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.
- C. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- D. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.
- E. Unit Operating Requirements:
 - 1. Input ac voltage tolerance of plus or minus 10 percent.
 - 2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
 - 3. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 4. Minimum Displacement Primary-Side Power Factor: 96 percent.
 - 5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.

6. Starting Torque: 100 percent of rated torque or as indicated.
 7. Speed Regulation: Plus or minus 1 percent.
- F. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
1. Electrical Signal: 4 to 20 mA at 24 V.
- G. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 2 to a minimum of 22 seconds.
 4. Deceleration: 2 to a minimum of 22 seconds.
 5. Current Limit: 50 to a minimum of 110 percent of maximum rating.
- H. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
 2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class [10] [20] [30] performance.
 4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 5. Instantaneous line-to-line and line-to-ground overcurrent trips.
 6. Loss-of-phase protection.
 7. Reverse-phase protection.
 8. Short-circuit protection.
 9. Motor overtemperature fault.
- I. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.
- J. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

- K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
- L. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- M. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- N. Input Line Conditioning: 3%.
- O. VFC Output Filtering: 3%.
- P. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
 - 1. Power on.
 - 2. Run.
 - 3. Overvoltage.
 - 4. Line fault.
 - 5. Overcurrent.
 - 6. External fault.
- Q. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
- R. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
 - 1. Output frequency (Hz).
 - 2. Motor speed (rpm).
 - 3. Motor status (running, stop, fault).
 - 4. Motor current (amperes).
 - 5. Motor torque (percent).
 - 6. Fault or alarming status (code).
 - 7. PID feedback signal (percent).
 - 8. DC-link voltage (VDC).
 - 9. Set-point frequency (Hz).
 - 10. Motor output voltage (V).

S. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
 - a. 0 to 10-V dc.
 - b. 0-20 or 4-20 mA.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 - e. RS485.
 - f. Keypad display for local hand operation.
3. Output Signal Interface:
 - a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).
 - 3) DC-link voltage (VDC).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set-point frequency (Hz).
4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set-point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.

- T. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

- U. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).
- V. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.
- W. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.
- X. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.
- Y. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.3 ENCLOSURES

- A. NEMA 1.

2.4 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Standard Displays:
 - 1. Output frequency (Hz).
 - 2. Set-point frequency (Hz).
 - 3. Motor current (amperes).
 - 4. DC-link voltage (VDC).
 - 5. Motor torque (percent).
 - 6. Motor speed (rpm).
 - 7. Motor output voltage (V).

F. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

G. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.5 FACTORY FINISHES

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

2.6 VARIABLE FREQUENCY CONTROLLERS—SINGLE PHASE

A. Output

1. Frequency 0 to 500Hz

B. Supply Options

1. Frequency 48 - 62 Hz
2. Volts/Phases 100 - 132 volts max, single phase (0.5 - 1.0HP)
180 - 264 volts max, 1-phase (0.5 - 1.5HP)

C. Environment

1. Temperature..... Operating, -10 to 50°C max, storage, -40 to 60°C
2. Altitude 0-2000M, derate 1% per 100M above 1000M
3. Humidity up to 95%, non condensing
4. Ingress..... Basic IP20, Optional IP55 (NEMA12)

D. Control

1. Mode V/F
2. PWM Hz 4 to 32KHz (effective)
3. V/Hz Ratio Linear
4. Boost Automatic boost phase operation
5. Stop Modes Coast / ramp / DC brake

6. Setpoint Ref.....0-10VDC, 4-20mA, 0-20mA, Keypad, Modbus
7. Presets8 preset speeds
8. PI controlDirect & analog input trim
9. Spin StartStarts safely into rotating motor
10. Accel/Decel0 - 600 secs + Ramp stop decel 0 - 600 secs

E. Configurable I/O

1. Input 1Programmable digital input
2. Input/Output 2.....Selectable digital input / output
3. Input 3Configurable analog or digital input
4. Input 4Configurable analog or digital input
5. Output 1.....Configurable analog or digital output
6. Relay 1Normally open relay contact 30VDC 5A, 250VAC 6A

F. Protection

1. Drive TripOver/under volts, over current, external trip,
2. MotorOverload, over temp, short circuit, ground fault
3. Trip MemoryLast 4 trips stored

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

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

3.3 INSTALLATION

- A. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.
- B. Install VFCs on concrete bases.
- C. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- D. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.4 CONCRETE BASES

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.
- B. Concrete base is specified in Division 26 Section "Common Work Results for Electrical," and concrete materials and installation requirements are specified in Division 03.

3.5 IDENTIFICATION

- A. Identify VFCs, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.6 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
 - 2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.7 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Assist in field testing of equipment[including pretesting and adjusting of solid-state controllers.
 - 3. Report results in writing.
- C. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- E. Perform the following field tests and inspections and prepare test reports:
- F. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
 - 1 Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.9 ADJUSTING

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

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 01 Section "Demonstration and Training."

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DIVISION 26—ELECTRICAL

26 05 00COMMON WORK RESULTS FOR ELECTRICAL

26 05 10ELECTRICAL DEMOLITION FOR REMODELING

26 05 19LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

26 05 23CONTROL-VOLTAGE ELECTRICAL POWER CABLES

26 05 26GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

26 05 29HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

26 05 33RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

26 09 23LIGHTING CONTROL DEVICES

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SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Basic electrical requirements specifically applicable to Division 26 Electrical.

1.2 SECTION INCLUDES

- A. Basic Electrical Requirements specifically applicable to Division 26 Sections, in addition to Division 01 General Requirements.

1.3 INTENT

- A. It is the intention of these specifications and drawings to call for finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete and ready for use."
- B. Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, the same as if herein specified or shown.

1.4 DRAWINGS

- A. Drawings are diagrammatic and indicate the general arrangement of systems and work included in the contract. Drawings are not to be scaled. The architectural drawings and details shall be examined for exact location of fixtures and equipment. Where they are not definitely located, this information shall be obtained from the Architect.
- B. If directed by the Architect or Engineer, the Contractor shall, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the work.
- C. At the time of each shop drawing submission, the Contractor shall call the Engineer's attention (in writing) to, and plainly mark on shop drawings, any deviations from the Contract Documents.
- D. Samples, drawings, specifications, catalogs, submitted for approval, shall be properly labeled indicating specific service for which material or equipment is to be used, location, section and article number of specifications governing, Contractor's name, and name of job. All equipment shall be labeled to match labeling on contract documents.
- E. Catalogs, pamphlets, or other documents submitted to describe items on which approval is being requested, shall be specific and identification in catalog, pamphlet, etc. of item submitted shall be clearly made in ink. Data of a general nature will not be accepted.

- F. Approval rendered on shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings are approved, said approval does not mean that drawings have been checked in detail; said approval does not in any way relieve the Contractor from his responsibility or necessity of furnishing material or performing work as required by the contract drawings and specifications.
- G. All shop drawings shall be submitted to the A/E by Contractor no later than 30 days from the day of contract award.
- H. Failure of the Contractor to submit shop drawings in ample time for checking shall not entitle him to an extension of contract time, and no claim for extension by reason of such default will be allowed.
- I. Submit all Division 16 submittals at one (1) time in one (1) integral group. Piece-by-piece submission of individual items will not be acceptable. Engineer may check contents of each submittal set upon initial delivery; if not complete as set forth herein, submittal sets may be returned to Contractor without review and approval and will not be accepted until made complete.
- J. At the close of the job, prior to final review, five (5) bound copies of the following shall be submitted by transmittal letter to the Engineer for review and acceptance.
 - 1. Equipment warranties
 - 2. Contractor's warranty
 - 3. Parts list and manuals for all equipment
 - 4. Operating Instructions (in writing)
 - 5. Written instructions on maintenance and care of the system

1.5 REFERENCES

- A. ANSI/NFPA 70—National Electrical Code.
- B. State Requirements for Educational Facilities (SREF), Chapter 4, Section 423, of the Florida Building Code.
- C. NFPA 101—Life Safety Code.
- D. Florida Department of Education Accessibility Guidelines and Requirements.

1.6 SUBMITTALS

- A. Submit under provisions of Division 1.
- B. Proposed Products List: Include Products specified in the following Sections, but not limited to:
 - 1. Section 26 05 19Low-Voltage Electrical Power Conductors and Cables.
 - 2. Section 26 05 23Control-Voltage Electrical Power Cables.

- 3. Section 26 05 33Raceway and Boxes for Electrical Systems.
- 4. Section 26 09 23Lighting Control Devices.
- C. It shall be understood that review of shop drawings by the Engineer does not supersede the requirement to provide a complete and functioning system in compliance with the Contract Documents.

1.7 SUBSTITUTIONS

- A. Materials and equipment are specified herein by a single or by multiple Manufacturers to indicate quality and performance required. The drawings are based upon equipment scheduled on drawings and specified. If another Manufacturer is considered for substitution during the bidding process, the Electrical Contractor shall be responsible for coordinating all electrical, mechanical, structural, or architectural changes. Comparable equipment Manufacturers which are listed as equals shall be considered as substitutes. Manufacturers other than the basis of design shall submit a catalog information and 1/4" scale plan and section drawings showing proper fit and all clearances for maintenance items.
- B. Substitutions of other Manufacturer's will be considered for use if, in the Engineers opinion, the item requested for substitution is equal to that specified. The Contractor shall provide to the Engineer a typed comparative list of the basis of design and the proposed substitute.

Request for approval of substitutions or equals prior to bid must be made in writing. The approval of any substitutions or equals prior to bid shall not be construed as a shop drawing approval. The substitute or equal must be submitted as described in the specifications and meet all the requirements of the specifications and drawings.
- C. All requests for substitutions shall be submitted as described in paragraph 1.07, B., and specifically indicate any and all differences or omissions between the product specified as basis of design and the product proposed for substitution.
- D. Where the Contractor proposes to use an item of equipment other than that specified or detailed on the drawing, which requires any redesign of the structure, partitions, foundations, piping, wiring, or any other part of the mechanical or electrical, all such redesign, and all new drawings and detailing required therefore, shall be prepared by the Subcontractor at his own expense and submitted to the Architect/Engineer for approval.
- E. Where such approved deviation requires quantity and arrangement of equipment from that specified or indicated on the drawings, any other additional equipment required by the system, at no additional cost to the Owner.

1.8 COOPERATION WITH OTHER TRADES

- A. Give full cooperation to other trades and furnish in writing to the General Contractor, with copies to the Architect, any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.

- B. When work installed under this Division will be in close proximity to, or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment. If so directed by the Engineer/Architect, prepare composite working drawings and sections at a suitable scale not less than 1/4" = 1'0", clearly showing how work is to be installed in relation to the work of other trades. If the work is installed before coordinating with other trades, or so as to cause any interference with work of other trades, make all the necessary changes in work to correct the condition without extra charge.
- C. Furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

1.9 PROTECTION

- A. Protect all work and material provided under this Division from damage. All damaged equipment work or material provided under this Division shall be replaced with new. Rebuilds are not acceptable.
- B. Protect all work and equipment until inspected, tested, and accepted. Protect work against theft, injury, or damage; and carefully store material and equipment received on site which are not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of obstructing material.

1.10 REMOVAL OF RUBBISH

- A. This Contractor shall at all times keep premises free from accumulations of waste materials or rubbish caused by his employees or work. At completion of work he shall remove all his tools, scaffolding, materials, and rubbish from the building and site. He shall leave the premises and his work in a clean, orderly, and acceptable condition.

1.11 SAFETY

- A. This Contractor shall comply with Section 107 of the Contract Work Hours and Safety Standards Act (40 U.S.C.333), Title 29—Labor, Chapter XIII, Bureau of Standards, Department of Labor, Part 1518—Safety and Health Regulations for Construction; and that his housekeeping and equipment be maintained in such a manner that they comply with the Florida Industrial Commission Safety Code and Regulations of the Federal Williams—Steiger Occupational Safety and Health Act of 1970 (OSHA), wherein it states that the Contractor shall not require any laborer or mechanic employed in the performance of the contract to work in surroundings or under working conditions which are unsanitary, hazardous, or dangerous to his health and safety.

1.12 SUPERVISION

- A. This Contractor shall provide a competent, experienced, full time superintendent who is acceptable to the Architect/Engineer and Owner, and who is authorized to make decisions on behalf of the Contractor.

1.13 MATERIAL AND WORKMANSHIP

- A. All materials and apparatus required for the work, except as specifically specified otherwise, shall be new, of first-class quality, and shall be furnished, delivered, erected, connected and finished in every detail, and shall be so selected and arranged as to fit properly into the building spaces. Where no specific kind or quality of material is given, a first-class standard article as approved by the Engineer shall be furnished. Refer to substitutions in this Section.
- B. Unless otherwise specifically indicated on the plans or specifications, all equipment and materials shall be installed with the approval of the Architect and Engineer in accordance with the recommendations of the Manufacturer. This includes the performance of such tests as the Manufacturer recommends.

1.14 QUIET OPERATION AND VIBRATION

- A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer and the Owner. In case of moving machinery, sound, or vibration noticeable outside of room in which it is installed, or annoyingly noticeable inside its own room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer and the Owner shall be corrected in an approved manner at no additional expense to the Owner.

1.15 REGULATORY REQUIREMENTS

- A. Conform to applicable Codes and Standards as follows:
 - 1. Standard:
 - a. Certain standard materials and installation requirements are described by reference to standard specifications. These standards are as follows:

NEMA..... National Electrical Manufacturers Association.

UL Underwriters Laboratories.

ANSI..... American National Standards Institute.

For additional standards and requirements see other sections of the specifications.

Whenever a reference is made to a standard, installation and materials shall comply with the latest published edition at the time project is bid unless otherwise specified herein.
 - 2. Codes and Rules:
 - a. All material furnished and all work installed shall comply with the following codes as they apply to this project:

➡ NFPA 70 and NFPA 101.

➡ Regulations of the Florida Industrial Commission Concerning Safety.

- ⇒ Applicable County, State, and Local Building Codes.
- ⇒ Local and State Fire Marshal Rules and Regulations.
- ⇒ Chapter 4A-47, Florida Administrative Code - Uniform Fire Safety Standards for Elevators.
- ⇒ Occupational Safety and Health Agency Standards (OSHA).
- ⇒ Florida State Board of Health Rules and Regulations.
- ⇒ Florida Building Code.
- ⇒ State Requirements for Educational Facilities (SREF), Chapter 4, Section 423, of the Florida Building Code.

Applicable codes shall be those adopted by the authority having jurisdiction at the time project is bid.

3. Permits, Fees and Inspections

- a. The Contractor shall give all necessary notices, obtain all permits and pay all government fees, sales taxes and other costs, including utility connections or extensions, in connection with this work; file all necessary approvals of all governmental departments having jurisdiction.
- b. Obtain all required certificates of inspection for his work and deliver to the Owner/Engineer the same certificates before request for acceptance and final payment for the work.
- c. The Contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, apparatus and drawings required to comply with all applicable laws, ordinances, rules and regulations.
- d. The Contractor shall inform the Engineer of any work or materials which conflict with any of the applicable codes, standards, laws and regulations before submitting his bid.

- B. Conform to Florida Department of Education Accessibility Guidelines and Requirements.

1.16 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of Architect/Engineer before proceeding.
- C. The Contractor shall inform the Engineer of any work or materials which conflict with any of the applicable codes, standards, laws and regulations before submitting his bid.

- D. The scope of the work included under this Division of the Specifications shall include complete electrical systems as shown on the plans and as specified herein. The General Conditions and Special Conditions of these specifications shall form a part and be included under this Section of the Specifications. Provide all supervision, labor, material, equipment, machinery, factory trained personnel, and any and all other items necessary to complete the electrical systems. All items of equipment are specified in the singular; however, provide and install the number of items of equipment as indicated on the drawings, and as required for complete systems.

1.17 SEQUENCING AND SCHEDULING

- A. Construct Work in sequence under provisions of Division 1.

1.18 LICENSE

- A. The Subcontracting Firm for the electrical and systems installation shall be licensed by the State of Florida and the local authorities, regularly engaged in the installation of electrical systems and other related equipment. The Subcontracting Firm shall be familiar with all local conditions including interpretations, codes and shall have at least 5 years of successful installation experience on similar projects of the same magnitude and scope.

The Subcontracting Firm shall list at least three projects it has successfully completed over the last five years for proof of experience of this caliber. This list shall be included with submittals for review by Architect/Engineer. The Subcontracting Firm shall hold a Florida State Certified Electrical Contractor license for this project. The Subcontracting firm for the fire alarm system shall be a certified "EF" installer.

1.19 AS-BUILT DRAWINGS

- A. This Contractor shall provide AutoCad as-built drawings and copies of each AutoCad file on CD before final payment will be issued.

*** END OF SECTION 26 05 00 ***

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SECTION 26 05 10

ELECTRICAL DEMOLITION FOR REMODELING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Electrical Demolition.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: As specified in individual Sections.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify field measurements and circuiting arrangements are as shown on drawings.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents. Report discrepancies to the Architect/Engineer before disturbing existing installation.
- D. Beginning of demolition means installer accepts existing conditions.

3.2 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.
- B. Coordinate utility service outages with utility company and school facility.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Existing Electrical Service and Distribution System: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from the Owner at least one week before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Demolish and extend existing electrical work under provisions of Division 1 and this Section.

- B. Prior to any demolition, this Contractor shall survey the building and paint a large red 'R' on the equipment to be removed as coordinated with the architectural and HVAC plans and roofer. If any item(s) is incorrectly tagged, then this Contractor shall clean off the paint so there is no confusion.
- C. If any conflicts arise in the field as to which equipment, ductwork, etc., is to be removed, then this Contractor shall notify the Owner/Engineer in writing and shall include a sketch and description of the field conflict for further direction.
- D. In areas where demolition is required of this Contractor, then this Contractor shall be responsible for all phases of demolition, including, but not limited to, removal, storage, and reinstallation of items to remain.
- E. Remove, relocate, and extend existing installations to accommodate new construction.
- F. Remove abandoned wiring to source of supply.
- G. Remove exposed, abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors and patch surfaces.
- H. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed or remove boxes for wall to be patched.
- I. Disconnect and remove abandoned panelboards and distribution equipment.
- J. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- K. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
- L. Repair adjacent construction and finishes damaged during demolition and extension work.
- M. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.
- N. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.
- O. Coordinate with roofer and assist in removal of all roof mounted electrical conduit devices, equipment, etc., to be removed as indicated on the roofing drawings and HVAC drawings.

3.4 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment which remain or are to be reused.
- B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

3.5 INSTALLATION

- A. Install relocated materials and equipment under the provisions of Division 1.

*** END OF SECTION 26 05 10 ***

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SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. Sleeves and sleeve seals for cables.
 - 4. Conductor sizes are based on copper.
- B. Related Sections include the following:
 - 1. Section 26 05 33Raceway And Boxes For Electrical Systems.

1.3 REFERENCES

- A. ANSI/NFPA 70—National Electrical Code.
- B. NEMA WC5—Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

1.4 DEFINITIONS

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

1.5 SUBMITTALS

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

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70 where wire and cable is not shown.

1.7 COORDINATION

- A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- B. Determine required separation between cable and other work.

PART 2 PRODUCTS

2.1 CONDUCTORS AND CABLES

- 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. Alcan Products Corporation; Alcan Cable Division.
 - 2. American Insulated Wire Corp.; a Leviton Company.
 - 3. General Cable Corporation.
 - 4. Senator Wire & Cable Company.
 - 5. Southwire Company.
- C. Copper Conductors: Comply with NEMA WC 70.
- D. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN and XHHW.
- E. Multiconductor Cable: Comply with NEMA WC 70 for Type SO with ground wire.

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. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

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:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Pipeline Seal and Insulator, Inc.
- C. 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. Service Entrance: Type THHN-THWN-XHHW, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- E. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.
- F. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway.
- G. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- J. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.
- K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- L. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- M. Class 2 Control Circuits: Type THHN-THWN-TFFN, in raceway.

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. Concealed Dry Interior Locations: Use only building wire and cable (all types) in raceway.
- E. Exposed Dry Interior Locations: For feeders, branch circuits, and class 1 remote control circuits, use only building wire in raceway. For class 2 or 3 control cable and power limited fire protective signaling cables run in raceway.
- F. Above Accessible Ceilings: For feeders, branch circuits and class 1 remote control cables use only building wire in raceway. For class 2 or 3 remote control cables run exposed. For power limited fire protective signaling cables run in raceway.
- G. Wet or Damp Interior Locations: For feeders, branch circuits and class 1 remote control cables use only building wire in raceway. For class 2 or 3 remote control cable and power limited fire protective signaling cables run in raceway.
- H. Exterior Locations: For feeders, branch circuits and class 1 remote control cables use only building wire run in raceway. For class 2 or 3 remote control cables and fire protective signaling cables run in raceway.
- I. Underground Installations: For feeders, branch circuits and class 1 remote control cables use only building wire run in raceway. For class 2 or 3 remote control cables and for power limited fire protective signaling cables run in raceway.
- J. Use wiring methods indicated on Drawings.
- K. Each computer/clean power receptacle and lighting circuits shall have a dedicated neutral conductor.
- L. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet.
- M. Use 10 AWG conductors for 20 ampere, 277 volt branch circuits longer than 200 feet.

- N. All conductors size #6 and smaller shall be color coded insulation. Equipment grounding conductors #6 and smaller to have green or bare exterior finish per NEC 250-119(A). Grounded conductors (neutral) #6 and smaller to have a white or grey exterior finish per NEC 200-6. Conductors size #4 and larger shall be color code by use of colored plastic tape applied within 6" of each conductor end. All color coding shall be with the same color being used with its respective phase or bus through the entire job as follows:

208/120 VOLTS	277/480 VOLTS
Phase A.....Black	Phase A.....Brown
Phase B.....Red	Phase B.....Orange
Phase C.....Blue	Phase CYellow
Neutral..... White	Neutral.....Gray
GroundGreen	GroundGreen

- O. Grounding conductors shall be identified with a continuous outer finish that is either green, or green with one or more yellow stripe.
- P. Protect exposed cable from damage.
- Q. Support cables above accessible ceiling, using spring metal clips or plastic cable ties to support cables from structure. Do not rest cable on ceiling panels.
- R. Neatly train and lace wiring inside boxes, equipment, and panelboards.
- S. Clean conductor surfaces before installing lugs and connectors.
- T. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
- U. Use split bolt connectors for copper conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor.
- V. Use solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.
- W. Terminate spare conductors with electrical tape.
- X. Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.
- Y. Splice only in accessible junction boxes.
- Z. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

- 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. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. 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.
- E. Cut sleeves to length for mounting flush with both wall surfaces.
- F. Extend sleeves installed in floors 2 inches above finished floor level.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
- 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 07 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 07 Section "Penetration Firestopping."
- 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 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 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 07 Section "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

- B. Perform tests and inspections and prepare test reports.
- C. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
 - a. Subpanels.
 - b. Mechanical equipment with service of 200 amps and greater.
 - 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 on equipment and connections identified by the Engineer. Remove box and equipment covers so splices are accessible to portable scanner.
 - a. 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.
- D. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- E. Remove and replace malfunctioning units and retest as specified above.

*** END OF SECTION 26 05 19 ***

SECTION 26 05 23

CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. UTP cabling.
 - 2. 50/125 or 62.5/125-micrometer, multimode optical fiber cabling.
 - 3. RS-232 cabling.
 - 4. RS-485 cabling.
 - 5. Low-voltage control cabling.
 - 6. Control-circuit conductors.
 - 7. Identification products.

1.3 DEFINITIONS

- A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
- B. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.
- C. EMI: Electromagnetic interference.
- D. IDC: Insulation displacement connector.
- E. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- F. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- G. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- H. RCDD: Registered Communications Distribution Designer.
- I. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.

- J. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
- K. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - 1. Vertical and horizontal offsets and transitions.
 - 2. Clearances for access above and to side of cable trays.
 - 3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - 4. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.
- C. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Maintenance Data: For wire and cable to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
 - 2. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
 - 3. Test each pair of UTP cable for open and short circuits.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install UTP and optical fiber cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 PRODUCTS

2.1 PATHWAYS

- A. All control wiring shall be run in a raceway.
- B. Support of Open Cabling: NRTL labeled for support of Category 5e cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - 1. Support brackets with cable tie slots for fastening cable ties to brackets.
 - 2. Lacing bars, spools, J-hooks, and D-rings.
 - 3. Straps and other devices.

2.2 BACKBOARDS

- A. Description: Plywood, fire-retardant treated, ¾" by width and length required for terminations, equipment, and punchdowns. Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry."

2.3 UTP CABLE

- 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:
 - 1. Belden CDT Inc.; Electronics Division.
 - 2. Berk-Tek; a Nexans company.
 - 3. CommScope, Inc.

4. Draka USA.
5. Genesis Cable Products; Honeywell International, Inc.
6. KRONE Incorporated.
7. Mohawk; a division of Belden CDT.
8. Nordex/CDT; a subsidiary of Cable Design Technologies.
9. Superior Essex Inc.
10. SYSTIMAX Solutions; a CommScope, Inc. brand.
11. 3M.
12. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: 100-ohm, four-pair UTP.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 5e.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications, General Purpose: Type MPP, Type CMP, Type MPR, Type CMR, Type MP, or Type MPG.
 - b. Communications, Plenum Rated: Type CMP or Type MPP, complying with NFPA 262.
 - c. Communications, Riser Rated: Type CMR, Type MPP, Type CMP, or Type MPR; complying with UL 1666.
 - d. Communications, Limited Purpose: Type MPP, Type CMP, Type MPR, Type CMR, Type MP, Type MPG, Type CM, or Type CMG.
 - e. Multipurpose: Type MPP or Type MPR.
 - f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
 - g. Multipurpose, Riser Rated: Type MPR or Type MPP, complying with UL 1666.

2.4 UTP CABLE HARDWARE

- 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:
1. American Technology Systems Industries, Inc.

2. Dynacom Corporation.
 3. Hubbell Premise Wiring.
 4. KRONE Incorporated.
 5. Leviton Voice & Data Division.
 6. Molex Premise Networks; a division of Molex, Inc.
 7. Nordex/CDT; a subsidiary of Cable Design Technologies.
 8. Panduit Corp.
 9. Siemon Co. (The).
 10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
- B. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
- C. Connecting Blocks: 110 style for Category 5e. Provide blocks for the number of cables terminated on the block, plus 25 percent spare; integral with connector bodies, including plugs and jacks where indicated.

2.5 RS-232 CABLE

- A. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 2. Plastic insulation.
 3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 4. Plastic jacket.
 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
 6. Flame Resistance: Comply with NFPA 262.

2.6 RS-485 CABLE

- A. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 2. Fluorinated ethylene propylene insulation.
 3. Unshielded.

4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.7 LOW-VOLTAGE CONTROL CABLE

- A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
 2. PVC insulation.
 3. Unshielded.
 4. PVC jacket.
 5. Flame Resistance: Comply with NFPA 262.
- B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
 2. Fluorinated ethylene propylene insulation.
 3. Unshielded.
 4. Plastic jacket.
 5. Flame Resistance: NFPA 262, Flame Test.

2.8 CONTROL-CIRCUIT CONDUCTORS

- A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, complying with UL 83.
- B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, power-limited tray cable, in cable tray, power-limited cable in raceway when concealed in building finishes, complying with UL 83.
- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

2.9 IDENTIFICATION PRODUCTS

- 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:
 1. Brady Corporation.
 2. HellermannTyton.
 3. Kroy LLC.

4. Panduit Corp.
- B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.10 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
- C. Factory test UTP cables according to TIA/EIA-568-B.2.
- D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
- E. Cable will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

PART 3 EXECUTION

3.1 COORDINATION

- A. Refer to Division 27 Drawings and Specifications for interbuilding backbone cabling.

3.2 INSTALLATION OF PATHWAYS

- A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
- B. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- C. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.
- D. Install manufactured conduit sweeps and long-radius elbows if possible.
- E. Pathway Installation in Equipment Rooms:
 1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.
 2. Install cable trays to route cables if conduits cannot be located in these positions.
 3. Secure conduits to backboard if entering room from overhead.
 4. Extend conduits 3 inches above finished floor.

5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- F. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
 1. Comply with TIA/EIA-568-B.1.
 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets and terminals.
 4. Cables may not be spliced. Secure and support cables at intervals not exceeding 60 inches and not more than 12 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. UTP Cable Installation:
 1. Comply with TIA/EIA-568-B.2.
 2. Install 110-style IDC termination hardware unless otherwise indicated.
 3. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.
- D. Installation of Control-Circuit Conductors:
 1. Install wiring in raceways. Comply with requirements specified in Division 26 Section "Raceway and Boxes for Electrical Systems."
- E. Optical Fiber Cable Installation:
 1. Comply with TIA/EIA-568-B.3.

2. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.

F. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings but as tight to the structure as possible by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

G. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 REMOVAL OF CONDUCTORS AND CABLES

- A. Remove abandoned conductors and cables.

3.5 CONTROL-CIRCUIT CONDUCTORS

- A. Minimum Conductor Sizes:
 - 1. Class 1 remote-control and signal circuits, No 14 AWG.
 - 2. Class 2 low-energy, remote-control, and signal circuits, No. 16.
 - 3. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12.

3.6 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Penetration Firestopping."
- B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.7 GROUNDING

- A. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Provide continuous grounding conductor along with control circuit conductors within raceway.

3.8 IDENTIFICATION

- A. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Visually inspect cable placement, cable termination, grounding and bonding.

2. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
3. Optical Fiber Cable Tests:
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
 - 2) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
- D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

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SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment.
 - 1. Underground distribution grounding.
 - 2. Common ground bonding with lightning protection system.

1.3 SYSTEM DESCRIPTION

- A. Ground the electrical service system neutral at service entrance equipment to metallic water service, concrete encased rebar, building steel, and to supplementary grounding electrodes.
- B. Ground each separately-derived system neutral to nearest effectively grounded metallic water pipe, concrete encased rebar, nearest effectively grounded building structural steel member, and separate grounding electrode.
- C. Provide communications system grounding conductor at point of service entrance and connect to separate grounding electrode.
- D. Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.
- E. Install lightning surge protection on all service entrances as shown on drawings. Lightning surge protector shall have a minimum withstand rating of a Class "C" test.
- F. Bond metallic gas piping with #4 AWG copper conductor.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Other Information Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.

3. Ground rings.
 4. Grounding arrangements and connections for separately derived systems.
 5. Grounding for sensitive electronic equipment.
- C. Qualification Data: For testing agency and testing agency's field supervisor.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NETA MTS.
 - a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
 - b. Include recommended testing intervals.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with UL 467 for grounding and bonding materials and equipment.
- D. Grounding system resistance shall not exceed 10 ohms.
- E. Use suitable test instrument to measure resistance to ground of system. Perform testing in accordance with test instrument manufacturer's recommendations using the fall-of-potential method. Submit test results to Engineer for review and approval immediately upon completing the test and prior to energizing new utility service. The testing shall include sufficient ground resistant data readings from distances up 100 feet away from the ground triad in order to plot a distinct plateau between two distinctive slopes.

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 in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 4 inches in cross section, unless otherwise indicated; with insulators, length as required for number of terminations plus 25 percent future capacity.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. 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; sectional type, 3/4 inch by 10 feet in diameter, two (2) rods coupled together for overall length of 20 feet.

PART 3 EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Ring Conductors: Install bare-copper conductor, No. 4/0 AWG minimum when indicated on the drawings to provide.
 - 1. Bury at least 24 inches below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- C. 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.
- D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 1 inch, minimum, from wall, 6 inches above finished floor, unless otherwise indicated.
- E. 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: Clamp connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.

- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 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.
- C. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
 - 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- D. Metal and Concrete Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors. Provide ground rod at each location.

3.4 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. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- C. 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. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- D. Report measured ground resistances that exceed the following values:
 - 1. Main service equipment and distribution gear.
 - 2. Separately derived system (i.e., transformers, uninterruptible power supply, engine generators).
 - 3. Grounding system resistance shall not exceed 10 ohms.

- E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect/Engineer promptly and include recommendations to reduce ground resistance.
- F. Supplement by adding additional ground rods to achieve 10 ohms.

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SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.
 - 3. Supports/safety wire and chains for light fixtures and equipment.
- B. Related Sections include the following:
 - 1. Division 26 Section "Interior Lighting and Theatrical Lighting."

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.
 - 2. Nonmetallic slotted support systems.

- B. Shop Drawings: Signed and sealed by a qualified professional engineer. 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. Nonmetallic slotted channel systems. Include Product Data for components.
 - 4. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

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

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

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:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Shall not be used.
 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. After fabrication shall be coated with hot-dipped galvanized with a minimum of 1.50 oz/ft on all sides.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.
- C. Field cuts shall be zinc coated.

2.3 SAFETY WIRE, CABLES, AND CHAIN

- A. Chain, General Specifications: Equivalent to Campbell Chain Company's specified system of steel, electrically welded standard finish (do not galvanize or electroplate), in continuous lengths. Comply with Manufacturer's recommendations.
- B. Drop Forged Chain Fittings (eye bolts, pad eyes, links, chain shackles, snaps, anchor shackles, swivels, turn buckles): Of the same materials and finish as the chain and of the same or greater working load limits, of the same manufacturer or as may be specifically recommended by the chain manufacturer.
- C. General Specifications for Wire: 8-gauge galvanized annealed steel wire (multiple strands of lesser gauge will not be considered acceptable). Each wire shall, itself, be looped through the building structural framing above and not to other wiring systems. The angle of the wires shall be kept as vertical as possible and not over 45 degrees from the vertical.
- D. Cable for Exposed-to-Public-View-Applications: Where suspended chandeliers, light fixtures, or special equipment occurs, stainless steel flexible aircraft cable or stainless steel flexible marine cable, 302/304, as manufactured by Paulsen, or equal, or Sailbryte as manufactured by Macwhyte corrosion resistant stainless steel or better, right regular lay, in continuous lengths, shall be used. Comply with manufacturer's recommendations.
- E. Forged and other stainless steel fittings for stainless steel aircraft or marine cable (turnbuckles, swagings, Nicro-Press sleeves, wire rope clips, use only in concealed positions), connecting links shoulder rivets, jaw fittings, eye fittings, lifting eyes, thimbles, swivels, eye nuts, heavy thimbles, clevis nuts, eye pads, shoulder pins); of same material, of same or greater working loads limits as the cable, of the same manufacturer or as recommended by the cable manufacturer, of type 304/316 electro-polished finish, drop forged, non-magnetic (when available for particular fitting). Manufactured by Merrill or equal. See Workmanship paragraph below.
- F. Stainless steel cable for loads (per cable) not exceeding 100 lbs.: 3/32" 7x19 with tensile load limit of 920 lbs. minimum.

- G. Stainless steel cable for loads (per cable) not exceeding 500 lbs.: 3/16" 7x19 with tensile load limit of 3,700 lbs. minimum.
- H. Workmanship: Stainless steel cable is required to be used only in areas where such is exposed to "public view" therefore only fittings designed for cold swaging or Nicro-Press fittings or swagless terminals such as Macwhyte Norseman Terminals are to be used whereby no wire ends, nuts, pins, or cotter keys, or clips are visible. Swaging shall be done only with a rotary swager (not a roll swager.) Manufacturer's recommendations and specifications shall be adhered to. Pertinent portions of the booklet Wire Rope Facts published by Banks Wire Rope and Sling, Inc. (available in Tampa) and Construction Care and Maintenance of Marine Rigging by Macwhyte Wire Rope Company (available at the Lazzerette Company) which may pertain also to stainless steel cable, shall be adhered to.

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 in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted 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 conduit clamps.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. 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.
- C. 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 Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 3. To Existing Concrete: Expansion anchor fasteners.
 - 4. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

5. To Light Steel: Sheet metal screws.
 6. 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].
 7. Do not drill structural steel members.
- D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 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.
- B. Touchup: Comply with requirements in Division 09 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 26 05 29 ***

SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections include the following:
 - 1. Section 26 05 53Identification for Electrical Systems.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. ENT: Electrical nonmetallic tubing.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. FMC: Flexible metal conduit.
- E. IMC: Intermediate metal conduit.
- F. LFMC: Liquidtight flexible metal conduit.
- G. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: All raceway types, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Custom enclosures and cabinets.
 - 2. For handholes and boxes for underground wiring, including the following:
 - a. Duct entry provisions, including locations and duct sizes.
 - b. Frame and cover design.

- c. Grounding details.
 - d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
 - e. Joint details.
- C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Structural members in the paths of conduit groups with common supports.
 - 2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

1.5 QUALITY ASSURANCE

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

PART 2 PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Alfex Inc.
 - 3. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 4. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 5. Electri-Flex Co.
 - 6. Manhattan/CDT/Cole-Flex.
 - 7. Maverick Tube Corporation.
 - 8. O-Z Gedney; a unit of General Signal.
 - 9. Wheatland Tube Company.
- B. Rigid Steel Conduit: ANSI C80.1. Zinc coated $\frac{3}{4}$ " minimum.
- C. Aluminum Rigid Conduit: ANSI C80.5.

- D. IMC: ANSI C80.6.
- E. EMT: ANSI C80.3. ¾" minimum.
- F. LFMC: Flexible steel conduit with PVC jacket.
- G. 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. Steel set screw or steel compression. One inch (1") and smaller shall be insulated throughout.
 - 2. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 3. Fittings for EMT: Steel, set-screw or compression type.
 - 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.
- H. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 3. Arnco Corporation.
 - 4. CANTEX Inc.
 - 5. CertainTeed Corp.; Pipe & Plastics Group.
 - 6. Condux International, Inc.
 - 7. ElecSYS, Inc.
 - 8. Electri-Flex Co.
 - 9. Lamson & Sessions; Carlon Electrical Products.
 - 10. Manhattan/CDT/Cole-Flex.
 - 11. RACO; a Hubbell Company.
 - 12. Thomas & Betts Corporation.
- B. ENT: NEMA TC 13.

- C. RNC: NEMA TC 2, Type EPC-40-PVC and EPC-80-PVC. $\frac{3}{4}$ " minimum.
- D. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Arnco Corporation.
 - 2. Endot Industries Inc.
 - 3. IPEX Inc.
 - 4. Lamson & Sessions; Carlon Electrical Products.
- B. Description: Comply with UL 2024; flexible type, approved for plenum installation.

2.4 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:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman.
 - 3. Square D; Schneider Electric.
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type or screw-cover type, as indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.5 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:
 - 1. Hoffman.
 - 2. Lamson & Sessions; Carlon Electrical Products.

- B. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.
- 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.

2.6 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect/Engineer.
 - 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:
 - 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:
 - 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.

2.7 BOXES, ENCLOSURES, AND CABINETS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 - 2. EGS/Appleton Electric.
 - 3. Erickson Electrical Equipment Company.
 - 4. Hoffman.
 - 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 - 6. O-Z/Gedney; a unit of General Signal.
 - 7. RACO; a Hubbell Company.
 - 8. Robroy Industries, Inc.; Enclosure Division.
 - 9. Scott Fetzer Co.; Adalet Division.
 - 10. Spring City Electrical Manufacturing Company.
 - 11. Thomas & Betts Corporation.
 - 12. Walker Systems, Inc.; Wiremold Company (The).
 - 13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Metal Floor Boxes: Cast metal, fully adjustable, rectangular. Hubbell B-4236 Series, Walker 880CS Series.
- E. Floor Box Covers: Polished solid brass.
- 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.

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.
6. Plywood backboard, marine-grade, ¾" thick.
7. Copper Ground Bar with #6 Copper Grounding: Electrode conductor to building steel.
8. Terminal Blocks: ANSI/NEMA ICS 4: UL listed. Channel mounted tubular pressure screw connectors, rated 300 volts.

2.8 SLEEVES FOR RACEWAYS

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.9 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:
 1. Advance Products & Systems, Inc.
 2. Calpico, Inc.
 3. Metraflex Co.
 4. Pipeline Seal and Insulator, Inc.
- B. 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 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 or EMT.
 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.
 6. Application of Handholes and Boxes for Underground Wiring:
 - a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete. SCTE 77, Tier 15 structural load rating.
 - b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units, SCTE 77, Tier 8 structural load rating.
 - c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
- B. Comply with the following indoor applications, unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage: EMT.
 2. 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.
 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 5. Damp or Wet Locations: Rigid steel conduit.
 6. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable in raceway or EMT.
 7. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: EMT.
 8. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable in raceway; Riser-type, optical fiber/communications cable in raceway. Outside Plant, Plenum-type, optical fiber/communications cable in RGC or IMC.
 9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch 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.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.
- E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- F. Do not install aluminum conduits in contact with concrete.

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 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 26 Section "Hangers and Supports for Electrical Systems."
- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- F. Install no more than the equivalent of four 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: Metallic raceways shall be coated with Bitumastic.
 - 1. Run conduit 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 Type EPC-40-PVC to rigid steel conduit or IMC before rising above the floor.
- I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- K. Install pull wires in empty raceways. Use #12 insulated conductor or polypropylene line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
 - 1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
 - 2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
 - 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.
- M. 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.
- N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet.
 - 1. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.

2. 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.
- O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed 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.
- P. 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.
- Q. Set metal floor boxes level and flush with finished floor surface.
- R. Install insulated bushing on all conduits. Install grounded metal bushing with lug on all mains, sub-feeders, switchboards, panelboards, transformers, chillers, disconnects, starters, and equipment rated at 100 amps and above.
- S. Do not install flush mounting boxes back to back in walls. Provide minimum 12 inch separation. Provide 24 inch minimum separation in acoustic rated walls.
- T. Install boxes to preserve fire resistance rating of partitions and other elements using materials and methods that are UL listed and tested.
- U. Use stamped steel bridges to fasten flush mounted outlet box between studs.
- V. Existing Walls, Public Areas, Classrooms, Offices, Restrooms, Hallways, etc.: Conduit and boxes shall be concealed. Saw cut walls and floor slab. Make arrangements with General Contractor to patch all areas.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- 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. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. 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.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.4 SLEEVE-SEAL INSTALLATION

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

3.5 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 07 Section "Penetration Firestopping."

3.6 PROTECTION

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

*** END OF SECTION 26 05 33 ***

SECTION 26 09 23

LIGHTING CONTROL DEVICES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following lighting control devices:
 - 1. Indoor occupancy sensors.
 - 2. Lighting contactors.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
 - 1. Interconnection diagrams showing field-installed wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

1.6 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 PRODUCTS

2.1 OCCUPANCY SENSORS

- A. Manufacturers
 - 1. DLM by WattStopper.
 - 2. nLight by Sensor Switch.
- B. Provide a lighting control design using the occupancy sensor types indicated below in the application suitable for the given lighting area to be controlled. Refer to the Electrical Lighting Drawings for the areas and lighting circuits to be controlled. Submit shop drawings indicating the layout and sensor type applicable to the area of coverage and size/type room to be controlled.
- C. Coordinate with the Division 23 Control Contractor for interface to the HVAC Automation System. Occupancy sensor shall be wired to the Automatic Control System (Reference Section 23 09 00 Instrumentation and Control for HVAC) through a network bridge relay as an input into the controller. This input shall be used by the Control System to reduce the rooms minimum airflow setpoint to zero (adjustable) as a Energy Efficiency Measure.
- D. Dual Technology Sensor (Ceiling and Wall Type)
 - 1. The Dual Technology sensor shall be capable of detecting presence in the control area by detecting doppler shifts in transmitted ultrasound and passive infrared heat changes.
 - 2. Sensor shall utilize Dual Sensing Verification Principle for coordination between ultrasonic and PIR technologies. Detection verification of both technologies must occur in order to activate lighting systems. Upon verification, detection by either shall hold lighting on.
 - 3. Sensor shall have a retrigger feature in which detection by either technology shall retrigger the lighting system on within 5 seconds of being switched off.
 - 4. Ceiling mounted sensors shall have a flat, unobtrusive appearance and provide 360° coverage.
 - 5. To avoid false ON activations and to provide immunity to RFI and EMI, Detection Signature Analysis shall be used to examine the frequency, duration, and amplitude of a signal, to respond only to those signals caused by human motion.
 - 6. Provide complete with digital room controller and low voltage light switch as required for operation and compatibility with lighting system.
 - 7. Sensors shall have a time delay that is adjusted automatically or shall have a fixed time delay of 5 to 30 minutes, set by DIP switch.
 - 8. Sensors shall feature a walk-through mode, where lights turn off 3 minutes after the area is initially occupied if no motion is detected after the first 30 seconds.
 - 9. The sensors shall feature RJ45 port for low voltage wiring, which makes installation easier.

10. Each sensing technology shall have an LED indicator that remains active at all times in order to verify detection within the area to be controlled. The LED can be disabled for applications that require less sensor visibility.
11. Sensors shall have standard 5 year warranty and shall be UL listed.

E. Wall Switch Sensor

1. These sensors are only permitted in rooms that are less than 200 square feet and each space shall be evaluated by the Engineer during submittal review for appropriate coverage.
2. The passive infrared sensor shall be a completely self contained control system that replaces a standard toggle switch. Switching mechanism shall be a latching air gap relay, compatible with electronic ballasts, compact fluorescent, and inductive loads. Triac and other harmonic generating devices shall not be allowed. Sensor shall have ground wire and grounded strap for safety.
3. Sensor shall be capable of detecting presence in the control area by detecting changes in infrared energy. Small movements shall be detected, such as when a person is writing while seated at a desk.
4. Sensor shall have a time delay that is adjusted automatically or shall have a fixed time delay of 5, 10, 15, 20 or 30 minutes, walk-through mode, or test mode, set by DIP switch. In walk-through mode, lights shall turn off 3 minutes after the area is initially occupied if no motion is detected after the first 30 seconds.
5. Sensor shall have the choice of light flash alert and/or audible alert of impending light shut off, selectable with DIP switch.
6. Sensor shall have sensitivity adjustment that is set to either automatic or reduced sensitivity, and is set with DIP switch.
7. Sensor shall have a built-in light level feature selectable with DIP switch. During set up of light level control, sensor shall learn desired hold-off level, requiring only one step.
8. Sensor shall have automatic-ON or manual-ON operation adjustable with DIP switch.
9. Sensor shall operate at universal voltages of 120, 230, or 277 VAC; 50/60 Hz.
10. Sensor shall have no minimum load requirement and shall be capable of switching 0 to 800 watts fluorescent/incandescent or 1/6 hp @ 120VAC, 50/60 Hz; 0 to 1200 watts fluorescent or 1/6 hp @ 230/277VAC, 50/60 Hz.
11. Sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options.
12. Sensor shall utilize a temperature compensated, dual element sensor, and a multi-element Fresnel lens.

13. For vandal resistance, Fresnel lens shall be made of hard, 1.0mm Poly IR 2 material that offers greater sensitivity to motion and superior detection performance. Lens shall have grooves facing in to avoid dust and residue build up which affects IR reception.
14. To assure detection at desktop level uniformly across the space, sensor shall have a 2 level, 28 segment, multi-element Fresnel lens system.
15. Sensor shall cover up to 300 sq ft for walking motion, with a field of view of 180 degrees.
16. Adjustments and mounting hardware shall be concealed under a removable, tamper resistant cover to prevent tampering of adjustments and hardware.
17. For safety, sensor shall have a 100% off switch with no leakage current to the load.
18. Sensor shall not protrude more than 3/8" from the wall and shall blend in aesthetically.
19. Sensor shall have standard 5 year warranty and shall be UL listed.

F. Spare Sensors and Parts

1. Provide ten (10) percent spare of each sensor type, power pack and device installed in the facility or five of each type, whichever is greater.

2.2 LIGHTING CONTACTORS

- A. Manufacturers: Subject to compliance with requirements, provide products 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).

13. Siemens.
 - B. Description: Electrically operated and mechanically held, as scheduled, 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. Enclosure: Comply with NEMA 250.
 3. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.
 - C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.
 1. Monitoring: On-off status.
 2. Control: On-off operation.
 - D. EMS Interface: Provide hardware interface to enable the EMS to control lighting contactors.

2.3 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 26 Section "Low-Voltage Electrical Power 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 26 Section "Low-Voltage Electrical Power 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 26 Section "Low-Voltage Electrical Power 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.

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 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch.
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-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 26 Section "Identification for Electrical Systems."
 - 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.

3.6 ADJUSTING

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

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

*** END OF SECTION 26 09 23 ***