

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Requirements, products, procedures, performance requirements, and methods of execution relating to the Building Automation System (BAS) terminal devices and field hardware.
2. Refer to related sections for other technical requirements, products, and methods of execution relating to the controls system for monitoring and control of mechanical systems.

B. Related Sections: Refer to Section 255000 - Building Automation System

1.2 REFERENCES

A. Refer to Section 255000 - Building Automation System.

1.3 SYSTEM DESCRIPTION

A. Refer to Section 255000 - Building Automation System.

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 255000 - Building Automation System.

1.5 SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.6 CLOSEOUT SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

## 1.8 QUALITY ASSURANCE

- A. Refer to Section 255000 - Building Automation System.

## 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 255000 - Building Automation System.

## 1.10 WARRANTY

- A. Refer to Section 255000 - Building Automation System.

## PART 2 - PRODUCTS

## 2.1 TEMPERATURE SENSOR

- A. Digital room sensors:

1. Temperature monitoring range: 55/95 degrees F.
2. Network jack.
3. Output signal: Changing resistance.
4. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
5. Wall Mounted unit with finished cover:

- a. Private offices and rooms:

- 1). LCD display, day/night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment.
- 2). Set Point and Display Range: 55 degrees to 95 degrees F.

- b. Public Spaces: Blank Cover.

- B. Duct (single point) temperature:

1. Temperature monitoring range: 20/120 degrees F.
2. Output signal: Changing resistance.
3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
4. Sensing element shall be located a minimum of 25 percent across duct width.

- C. Duct Average temperature:

1. Temperature monitoring range: 20/120 degrees F.
2. Output signal: 4-20 mA DC.
3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
4. Sensor Probe Length: 25 feet.

## 2.2 WALL MOUNTED SENSOR GUARD

- A. Heavy-duty wire cage type with mounting plate.
- B. Cast Aluminum Guard and mounting bracket.
- C. Clear or opaque butyrate plastic guard, key lock, mounting plate.

## 2.3 MEDICAL GAS ROOM HYDRONIC UNIT HEATER THERMOSTAT AND ROOM TEMPERATURE MONITORING

- A. Unit Heater Thermostat: Amperage capacity sufficient to cycle fan without need for contactor.
- B. Provide a blank face BAS temperature sensor for monitoring of medical gas room temperatures.

## 2.4 BOILER ROOM HYDRONIC UNIT HEATER THERMOSTAT

- A. Unit Heater Thermostat: Amperage capacity sufficient to cycle fan without need for contactor.

## 2.5 DIGITAL STATUS POINTS

- A. Digital status shall be monitored by sensing normally closed contacts (contact closed in alarm conditions). The addition of the monitoring relay shall not affect the operation of the systems involved.

## 2.6 DIGITAL COMMAND POINTS

- A. Command relays shall be momentary, automatic, maintained, or magnetic latch fail/safe as required. Maintained contacts located in occupied spaces or plenum spaces shall be mechanically latched. Relays shall be plug in and field replaceable. Contact ratings shall be in accordance with service.

## 2.7 CURRENT SENSOR

- A. Provide current sensors that convert AC current to a proportional (4-20 mA) DC current.
- B. Provide reverse voltage and high over current capacity.
- C. Provide red LED light to indicated relay status and power.
- D. Temperature operating range: 5 to 140 degrees F.
- E. Provide UL Listed device.

## 2.8 CURRENT SENSING RELAY

- A. Provide solid-state, self-calibrating, current operated relay suitable for equipment status monitoring. Provide a relay that changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.
- B. Provide red LED light to indicated relay activation.
- C. Temperature operating range: minus 30 to 140 degrees F.
- D. Provide UL Listed device that is rated for plenum installation.

## 2.9 RELAYS

- A. Applications: Relays external to the controls shall include (but not be limited to) the following:
  - 1. Control relays for start/stop or open/close control of equipment.
  - 2. Monitoring relays for electrical circuit on/off or open/closed status detection.
  - 3. Interposing relays to provide interface between solid state circuitry and ac-driven control relays.
- B. Requirements: Relays shall be housed in dust-tight cases conveniently located for wiring and inspection:
  - 1. Control Relay: Control relays shall be suitable for continuous operation of 120 VAC and be able to interrupt the control circuits of various HVAC equipment. The number of contacts required for the relay shall be determined from the number of independent equipment to be controlled. The number of control relays required for the motor start/stop circuit shall be determined from examination of the equipment to be controlled.
  - 2. Monitoring Relay: Monitoring relays shall be suitable for continuous operation at the voltages of the circuits to be monitored. The monitoring relays shall be connected in such a way that the operation of the relay contact shall represent the change of status of the monitored circuit (i.e. ON/OFF, etc.) or duplicate the operation of the existing alarm circuit (i.e. high/low, etc.). The addition of the monitoring relay shall not affect the operation of the systems involved.
  - 3. Interposing Relay: Interposing relays shall be DC driven and be utilized to provide interface between solid state circuitry and ac-driven control relays as required.

## 2.10 CONTROL VALVE

- A. Control Valve: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- B. Globe Valve 2 inch and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and sweat ends.
- C. Globe Valve 2-1/2 inch and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.

## D. Hydronic system globe valve shall have the following characteristics:

1. Rating: ANSI Class 125 for service at 125 PSIG and 32/250 degrees F operating conditions.
2. Internal Construction:
  - a. Replaceable plugs and seats of stainless steel or brass.
  - b. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
  - c. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
3. Sizing: 3 PSIG maximum pressure drop at design flow rate.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.
5. Select heating valves shall fail to a Normally Open to heat position, unless otherwise indicated. Select cooling valves to normally closed to cooling position.
6. Three-way valves: Mixing type, unless otherwise indicated.

## 2.11 CONTROL DAMPER

## A. Rectangular:

1. Frame: Five inches by one inch by minimum 0.125 inch 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.
2. Blades: Provide airfoil-shaped, single-piece blades made of heavy-duty 6063-T5 extruded aluminum. Maximum six inch blade width.
3. Bearings: Molded synthetic sleeve, turning in hole in frame.
4. Seals:
  - a. Blade: Extruded vinyl type for ultra-low leakage from minus 50 degrees F. to 350 degrees F. Mechanically attached to blade edge.
  - b. Jamb: Flexible metal compression type.
5. Linkage: Concealed in frame.
6. Axles: Minimum 1/2-inch diameter plated steel, hex-shaped, mechanically attached to blade.
7. Finish: Mill aluminum.
8. Performance Data:
  - a. Temperature Rating: Withstand minus 50 degrees F. to 350 degrees F.
  - b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions:
    - 1). Closed Position: Maximum pressure of 13 inches W.C. at a 12-inch blade length.
    - 2). Open Position: Maximum air velocity of 6,000 feet per minute.

- c. Leakage: Maximum 2.0 cubic feet per minute per square foot at 1.0 W.C. for sizes 24 inches wide and above.
    - d. Pressure Drop: Maximum 0.03 inch W.C. at 1,500 feet per minute across 24 inch by 24 inch damper.
  9. Manufacturer: Ruskin CD50, Louvers and Dampers, Air Balance, Pottorff, or equal.
- B. Round:
  1. Frame:
    - a. Under 6 inches Diameter: 2 inches by 1/2 inch minimum 12 gage galvanized steel tube.
    - b. 6 thru 12 inches Diameter: 2 inches by 1/2 inch by minimum 14 gage galvanized steel channel.
    - c. Above 12 thru 24 inches Diameter: 2 inches by 1/2 inch by minimum 1/8 inch galvanized steel channel.
    - d. Above 24 inches Diameter: 2 inches by 1 inch by minimum 3/16 inch galvanized steel channel.
  2. Blade: Provide single-piece construction made of the following material:
    - a. 18 inches diameter and smaller: Minimum 12 gage galvanized steel.
    - b. Over 18 inches diameter: Minimum 10 gage galvanized steel, stiffeners as required.
  3. Blade Seals: Closed cell polyethylene foam rubber fully encompassing and mechanically attached to blade edge.
  4. Bearings: Self-lubricating stainless steel sleeve.
  5. Axles:
    - a. 22 inches Diameter and smaller: Minimum 1/2 inch diameter, full length, plated steel, mechanically attached to blade.
    - b. Over 22 inches Diameter: Minimum 3/4 inch diameter, full length, plated steel, mechanically attached to blade.
  6. Finish: Mill.
  7. Performance Data.
    - a. Temperature Rating: Withstand maximum 250 degrees F.
    - b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.
      - 1). Closed Position: Maximum pressure of 10 inches W.C.
      - 2). Open Position: Maximum air velocity of 4,000 feet per minute /min.
    - c. Leakage: Maximum 10 cubic feet per minute total at 1 inch W.C.
    - d. Pressure Drop: Maximum 0.05 inch W.C. at air volume of 7,000 cubic feet per minute through 24 inch diameter damper.
  8. Manufacturer: Ruskin CDR25, Louvers and Dampers, Air Balance, Pottorff, or equal.

## 2.12 VALVE AND DAMPER ACTUATORS

## A. General:

1. Provide electronic direct-coupled actuation for control valves and dampers.
2. Proportional actuators shall accept a 0-10 VDC or 0-20 mA control input and provide a 2-10 VDC or 4-20 mA operating range. Damper actuators and control valve actuators serving valves larger than 3/4" shall provide a 2-10 VDC position feedback signal. The feedback signal shall be independent of the input signal.
3. Actuators indicated by Normally Closed or Normally Open designation on drawings or in sequence of operation shall be spring return type.
4. The actuator shall have electronic overload circuitry to prevent damage to the actuator.
5. Provide actuators listed by Underwriters Laboratories Standard 873 Standard for Safety Temperature-Indicating and -Regulating Equipment.

## B. Damper Actuator:

1. Provide damper actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage.
2. Spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.
3. Non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose.
4. Provide actuators in sufficient size, quantity and type to match application. Provide a minimum of one damper actuator for each 24 square feet of damper area. Damper areas shall not exceed manufacturer's ratings.
5. Outside air and return air dampers on mixing boxes shall be linked such that one opens while the other closes. It shall not be possible to close both dampers simultaneously.
6. Dampers: Size for minimum running torque calculated as follows:
  - a. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper.
  - b. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper.
  - c. Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft. of damper.
  - d. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
  - e. Dampers with 2 to 3 Inches WC of Pressure Drop or Face Velocities of 1000 to 2500 FPM: Multiply the minimum full-stroke cycles above by 1.5.
  - f. Dampers with 3 to 4 Inches WC of Pressure Drop or Face Velocities of 2500 to 3000 FPM: Multiply the minimum full-stroke cycles above by 2.0.
  - g. Values noted above do not include normally open or normally closed open spring return dampers. Provide additional torque as required.
7. Size operators with ample power to overcome friction of damper linkage and air pressure acting on the damper blades.

## C. Valve Actuator:

1. Provide actuators with enough torque and force required for proper valve close-off against the system pressure.

- 2. The valve actuator shall be sized based on valve manufacturer’s recommendations for flow and pressure differential.
- D. Actuators shall be of the following types, unless noted otherwise on the drawings or in the sequences of operation:

Service	Type (1)
Exhaust Air Damper	NC
Air handler/MUA units with outside air:	
Heating Coil valves	NO
Cooling Coil Valves	NC
Air Terminal Units Heating Coil Valves	Floating
Reheat Coil Valves	Floating
Glycol Loop Control valve	NO
Heating Zone Temperature Control Valve	NO
Fan Coil Units	NO

(1) NC = Normally closed. NO = Normally open

2.13 INSTRUMENT ENCLOSURE

- A. Steel construction with hinged and lockable doors.
- B. NEMA 12 construction only in areas where panels are subject to moisture damage.
- C. Wiring connections including I/O and power shall be extended to a numbered, color-coded, and labeled terminal strip for ease of maintenance and expansion.
- D. Provide labeling and color coding for wiring. Wiring shall follow a common format typical for the entire facility. Terminal strip color coding and numbering shall follow a common format. Wiring shall be neatly installed in plastic trays or tie-wrapped.
- E. Line voltage wiring shall be segregated from I/O wiring and shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
- F. Provide a convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers. Provide convenience receptacle for enclosures containing equipment that can be configured or adjusted with a portable computer.

2.14 POWER SUPPLY

- A. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75 percent of the rated capacity of the power supply.



- B. Input: 120 VAC plus 10 percent, 60Hz.
- C. Output: 24 VDC.
- D. Line Regulation: Plus 0.05 percent for 10 percent line change.
- E. Load Regulation: Plus 0.05 percent for 50 percent load change.
- F. Provide an appropriately sized fuse and fuse block shall be provided and located next to the power supply.
- G. Provide a power disconnect switch shall be provided next to the power supply.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

##### A. Special Techniques:

##### 1. Wiring:

- a. The HVAC Control Contractor shall provide conduit, wiring, accessories, and wiring connections required for the installation of the control system, as herein specified, unless specifically shown in Divisions 26, 27 and 28.
- b. Conduit and wiring shall comply with the requirements of applicable portions of Divisions 26, 27 and 28 and local and national electric codes, unless specified otherwise in this section.
- c. System input wiring shall be twisted shielded pair, minimum 20 gauge wire. System analog output wiring shall be twisted shielded pair/3-wire as required, minimum 20 gauge wire. Preconfigured cables between Terminal Unit Controllers and Thermostats are acceptable, minimum 24 gauge.
- d. Internal panel device wiring for binary outputs and pilot relay shall be minimum 16 gauge wire.
- e. Provide separate conduit for control system power wiring including but not limited to 120 VAC and greater. I/O sensor wiring and data communication cabling shall be segregated from 120 VAC control system power wiring.
- f. Wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size 3/4 inch. One half inch conduit may be used for thermostats and valve stub-ups where conduit contains only a single pair.

##### 2. Temperature Sensors:

- a. Temperature sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.
- b. Outdoor installations shall be of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.

- c. Wall Mounted Sensor and Thermostats:
    - 1). Install wall mounted room sensors at a height of 44 inches above finish floor level.
    - 2). Locate sensors as shown on the Drawings.
    - 3). Provide insulated base for sensors mounted on sheet metal, steel columns or exterior walls. Wire penetrations shall be caulked airtight to prevent thermal convection.
    - 4). Provide heavy-duty guards for sensors and thermostats in public areas and as shown on the Drawings.
  - d. Duct Temperature Sensor: The sensor shall measure the representative temperature of the entire cross-section of the duct or plenum. Sensors in ducts shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces. Ductwork shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.
  - e. Fluid Temperature Sensors: Provide sensors with thermal wells fabricated and installed for the intended service. Wells shall be non-corrosive to the medium being measured and shall have sufficient physical strength to withstand all pressures, (including test pressures) and velocities to which they are subjected. Well shall not restrict flow area to less than 70 percent of line-size-pipe normal flow area. Where piping is smaller than the length of the well or exceeds the area requirements, the well shall be installed at an elbow and installed to effect uniform flow across the well. Sensors installed in wells shall be installed in horizontal piping below the pipe centerline.
  - f. Low Temperature Detection Thermostats: Mount sensor element similar to Mixed Air Temperature Sensors.
3. Current Sensors:
    - a. Provide flow proof for constant volume fans and pumps with a current sensor connected to the motor wiring at the starter. Set upper alarm limit to the maximum rated current of the motor, or as advised by the TAB Agency. Set lower alarm limit at 1/2 the motor running amps.
    - b. Provide flow proof for variable speed control system through utilization of the variable speed drive serial communication option. Drive will communicate directly with BAS system.
  4. Digital Status, Digital Command Points, Lighting Controls:
    - a. Provide relays in a separate instrument enclosure or control panel adjacent to the monitored or controlled equipment. The relays shall mounted and connected in a manner that does not violate controlled equipment listing or code requirements.
    - b. Provide relays that operate in conjunction with the motor control system. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
    - c. Coordinate motor control requirements with Divisions 26, 27 and 28.
    - d. Coordinate lighting control requirements with Divisions 26, 27 and 28.

## 5. Identification:

- a. Panel and Instrument Enclosure Identification: Panels and instrument enclosures shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.
- b. Field Devices: Field devices shall be identified by a typed (not handwritten) securely attached tag label.
- c. Panel or Instrument Enclosure Devices: Devices shall be identified by a typed label securely fastened to the backplane of the local control panel or instrument enclosure.
- d. Wall Mounted Temperature Sensors: Device covers shall be identified by a typed label securely fastened to the front cover. The label shall indicate the terminal unit zone identification tag.
- e. Raceway Identification: The covers to junction and pull boxes of the control system raceways shall be painted blue or have identification labels stating "Control System" affixed to the covers. This requirement includes control system tubing. Labels shall be typed, not hand written.
- f. Wire Identification: Low and line voltage control wiring shall be identified by a number, as referenced to the associated control diagram, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed.

## 3.2 SYSTEM STARTUP

- A. Commissioning: Perform tests and verification procedures required for the commissioning process as requested by the Owner and directed by the Owner's Commissioning Authority.

## 3.3 MAINTENANCE

- A. Arrange work so that wherever possible serviceable or operable products are located within mechanical or electrical spaces and are accessible.

END OF SECTION 253000

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## PART 1 - GENERAL

## 1.1 SUMMARY

- A. Section Includes: Requirements for solid-state, pulse-width modulated (PWM) Adjustable Frequency Drives, herein referred to as AC Drives, for use with NEMA design AC motors. The term “VSD” (Variable Speed Drive) is also used in this specification.
- B. Related Sections:
1. 019100 - Commissioning
  2. 200000 - Mechanical General Requirements
  3. 200529 - Mechanical Hangers and Supports
  4. 200548 - Mechanical Vibration and Seismic Control
  5. 200553 - Mechanical Identification
  6. 230593 - Testing, Adjusting and Balancing
  7. 232123 - Hydronic Pumps
  8. 233400 - HVAC Fans
  9. 237413 - Packaged Rooftop Units
  10. 253000 - Building Automation System Field Devices
  11. 255000 - Building Automation System
  12. 259000 - Sequence of Operations

## 1.2 REFERENCES

- A. Codes and Standards:
1. See Section 200000 - Mechanical General Requirements.
  2. Institute of Electrical and Electronic Engineers (IEEE): IEEE 519-2014.
  3. Underwriters Laboratories (as appropriate): UL 508, 508A, 508C, UL 61800, 61800-5-1, 61800-5-2, UL 1995.
  4. The Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA): NEMA ICS 7-2014, Adjustable Speed Drives.
  5. National Electric Code (NEC): NEC 430.120, Adjustable-Speed Drive Systems.
  6. CSA Group: CSA C22.2 No. 274.
  7. International Building Code (IBC): IBC 2018 Seismic – referencing ASCE 7-16 and ICC AC-156.
- B. Abbreviations, Acronyms and Definitions:
1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
  2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
  3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

## 1.3 SYSTEM DESCRIPTION

- A. This specification is for a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with both asynchronous and permanent magnet motors.
- B. The drive manufacturer shall supply the drive and all necessary options as specified. drives installed on this project shall be from the same manufacturer and have a common user interface (control panel). Drives that are manufactured by a third party and “brand labeled” shall not be acceptable.
- C. This specification is intended to supplement a drive schedule. The drive schedule identifies the optimized BOM for the project and includes quantity, size, voltage, enclosure rating, options, and harmonic mitigation requirements of the drives. IEEE 519-2014 is an electrical system standard for harmonic mitigation. Drives are a major source of harmonics, therefore the VFD manufacturer shall conduct a harmonic analysis for this particular jobsite to verify compliance with IEEE 519-2014.

## 1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

## 1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Submittals shall include the following information:
  - 1. Outline dimensions, conduit entry locations and weights. Customer connection and power wiring diagrams.
  - 2. Complete technical product description with complete list of options provided. Any portions of this specification not met shall be clearly indicated or the Contractor shall be liable to provide all additional components required to meet this specification.
  - 3. Submit shop drawings showing specific VSD mounting arrangements. Include verification that mounting of VSD complies with IBC chapter 16 requirements.
  - 4. Clearly note any exceptions/deviations to this specification with the submittal.
  - 5. Submit information from harmonic analysis demonstrating that the drives have proper internal harmonic mitigation and will not take the system out of compliance with IEEE Standard 519. Notify the Contracting Agency if additional mitigation measures are indicated.
  - 6. Submit the following information:
    - a. Combined harmonic content of all drives and combined harmonic content of all drives to be operated on generator.
    - b. Amount of regenerated power put back into the distribution system from each drive (include drives operated on generator and drives only operated on normal power).
- C. Closeout

1. Furnish two complete sets of Installation, Operation and Maintenance Manuals and other information necessary for the operation and maintenance of the system unless otherwise noted.
  2. Submit Startup Service test results as specified under Start-up Service below.
- D. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

#### 1.6 QUALITY ASSURANCES

- A. See Section 200000 - Mechanical General Requirements.
- B. Drives shall be UL labeled as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR when installed in accordance with the manufacturer's guidelines.
- C. The base drive shall be CE and meet EN 61800-3 for the First Environment restricted distribution (Category C2).
- D. The base drive shall be seismically certified per 2018 International Building Code (IBC) with a seismic importance factor of 1.5, and minimum 2.5 SDS rating.
- E. The base drive shall be SEMI-F47 certified. The drive must tolerate voltage sags to 50 percent for up to 0.2 seconds, sags to 70 percent for up to 0.5 seconds, and sags to 80 percent for up to one second.

#### 1.7 DELIVERY, STORAGE AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

#### 1.8 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.
- B. Warranty shall be 24 months from the date of certified startup. The warranty shall include all parts, labor, travel time and expenses. There shall be 24/365 support available via a toll free phone number.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Acceptable Manufacturers are limited to the following:
  1. ABB ACH 580 Series (basis of design).
  2. Yaskawa.

3. Siemens SED2.

## 2.2 VARIABLE FREQUENCY DRIVES

- A. The drive package as specified herein and defined on the drive schedule shall be enclosed in a NEMA Type 12 enclosure.
- B. The drive shall provide full rated output from a line of +10 percent to -15 percent of nominal voltage across an ambient temperature range of -15 to 40 degrees C (5 to 104 degrees F).
- C. Drives shall utilize the same Advanced Control Panel (keypad) user interface.
  1. Plain English text:
    - a. The display shall be in complete English words for programming and fault diagnostics.
    - b. Safety interlock and run permissive status shall be displayed using predetermined application specific nomenclature, such as: Damper end switch or vibration trip. Customized terms, such as: AHU-1 End Switch or CT-2 Vibration shall also be available.
  2. The control panel shall include at minimum the followings controls:
    - a. Four navigation keys (Up, Down, Left, Right) and two soft keys.
    - b. Hand-Off-Auto selection, Fault Reset, and manual speed control.
    - c. A Help key shall include assistance for programming and troubleshooting.
  3. There shall be a built-in time clock in the control panel with 10-year battery backup.
  4. I/O Summary display with a single screen shall indicate and provide:
    - a. The status/values of all analog inputs, analog outputs, digital inputs, and relay outputs.
    - b. The function of all analog inputs, analog outputs, digital inputs, and relay outputs.
    - c. The ability to force all inputs and outputs to either a high, low, or specific value.
  5. The drive shall automatically backup parameters to the control panel. The drive shall allow two additional unique manual backup parameter sets to be stored.
  6. The control panel shall be removable, capable of remote mounting.
  7. The drive shall be able to support a Bluetooth Advanced Control Panel. The Bluetooth control panel shall be FCC and QDL (Qualified Design Listing) certified.
    - a. A free app (iOS and Android) shall replicate the control panel on a mobile device or tablet. The control panel's programming and control functionality shall function on the device. Customizing text, such as AHU-1 End Switch, shall be supported by the device's keyboard.
    - b. Bluetooth connectivity shall allow uploading, downloading, and emailing of parameters.
    - c. Bluetooth connectivity shall include two pairing modes: Always discoverable with a fixed passcode, and manual discovery with a unique generated passcode every pairing.



## D. Drives shall have the following hardware features/characteristics as standard:

1. Two (2) programmable analog inputs, two (2) programmable analog outputs, six (6) programmable digital inputs, and three (3) programmable Form-C relay outputs.
2. The drive shall include an isolated USB port for interface between the drive and a laptop.
3. An auxiliary power supply rated at 24 VDC, 250 mA shall be included.
4. At a minimum, the drives shall have internal impedance equivalent to 5 percent to reduce the harmonics to the power line. 5 percent impedance may be from dual (positive and negative DC link) chokes, or AC line reactor. Drives with only one DC link choke shall add an AC line choke integral to the drive enclosure. Reference the required harmonic analysis to determine if additional harmonic mitigation is required for the system to comply with IEEE 519-2014.
5. The combined harmonic content of all the drives on the project shall be small enough to not interfere with an emergency generator's voltage regulator. The impact of drives capable of regeneration on applications with a generator shall be verified. On projects where drives will be operated on generator include detailed information in submittals for both of these items to allow verification of impacts on generator operation.
6. The drive shall have variable speed primary cooling fans.
7. The overload rating of the drive shall be 110 percent of its normal duty current rating for 1 minute every 10 minutes, 130 percent overload for 2 seconds every minute.
8. The input current rating of the drive shall not be greater than the output current rating.
9. Circuit boards shall be coated per IEC 60721-3-3; Chemical gasses Class 3C2 and Solid particles Class 3S2.
10. Coordinated AC transient surge protection system consisting of 4 MOVs (phase-to-phase and phase-to-ground), a capacitor clamp, and internal chokes. The MOVs shall comply with UL 1449 4<sup>th</sup> Edition.
11. The drive shall include a robust DC bus to provide short term power-loss ride through. An inertia-based ride through function should help maintain the DC bus voltage during power loss events. Drives with control power ride through only, are not acceptable.

## E. Drives shall have the following software features as standard:

1. A Fault Logger that stores the last 16 faults in non-volatile memory. The most recent 5 faults save at least 9 data points, including but not limited to: Time/date, frequency, DC bus voltage, motor current, DI status, temperature, and status words.
2. An Event Logger that stores the last 16 warnings or events that occurred, in non-volatile memory. Events shall include, but not limited to: Warning messages, checksum mismatch, run permissive open, start interlock open, and automatic reset of a fault.
3. Programmable start methods: Flying-start, Normal-start, and Brake-on-start.
4. Programmable loss-of-load (broken belt / coupling) indication. This function to include a programmable time delay to eliminate false loss-of-load indications.
5. Motor heating function to prevent condensation build up in the motor. Motor heating adjustment, via parameter, shall be in "Watts."
6. There shall be a run permissive circuit for damper or valve control.
7. Four separate start interlock (safety) inputs shall be provided. The control panel will display the specific safety(s) that are open.
8. The drive shall include a switching frequency control circuit that reduces the switching frequency based on actual drive temperature. It shall be possible to set a minimum and a target switching frequency.
9. The ability to automatically restart after non-critical faults.

10. PID functionality shall be included in the drive.
11. Drive shall be compatible with an accessory that allows the control board to be powered from an external 24 VDC/VAC source.
12. A computer-based software tool shall be available to allow a laptop to program the drive. The drive shall be able to support programming without the need for line voltage. All necessary power shall be sourced via the laptop USB port.
13. The drive shall include a fireman's override mode.

F. Security Features:

1. The drive manufacture shall clearly define cybersecurity capabilities for their products.
2. The drive shall include password protection against parameter changes. There shall be multiple levels of password protection including: End User, Service, Advanced, and Override.
3. A checksum feature shall be used to notify the owner of unauthorized parameter changes made to the drive.
4. The "Hand" and "Off" control panel buttons shall have the option to be individually disabled (via parameter) for drives mounted in public areas.

G. Network Communications:

1. The drive shall have an EIA-485 port with removable terminal blocks. The onboard protocols shall be BACnet MS/TP, Modbus, and Johnson Controls N2. Optional communication cards for BACnet/IP and LonWorks shall be available.
2. The drive shall have the ability to communicate via two protocols at the same time, one onboard protocol and one option card-based protocol.
3. The drive shall not require a power cycle after communication parameters have been updated.
4. The embedded BACnet connection shall be a MS/TP interface. The drive shall be BTL Listed to Revision 14 or later.

H. Disconnect:

1. A circuit breaker type disconnect shall be provided.
2. The disconnect shall be door interlocked and padlockable.
3. Drive input fusing shall be included on all packaged units that include a disconnecting means.
4. Disconnect configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

I. A manual bypass system is not desired or required.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Verify that jobsite conditions for installation meet factory-recommended and code-required conditions for VSD installation prior to start-up. These shall include as a minimum:

1. Clearance spacing.
2. Temperature, contamination, dust, and moisture of the environment.
3. Conduit installation of the motor wiring and power wiring separation.

### 3.2 INSTALLATION

- A. VSDs shall be furnished under Division 25 and installed under Division 26. The contractor shall install the drive in accordance with the recommendations of the VSD manufacturer as outlined in the installation manual.
- B. Power wiring shall be provided under Division 26. The contractor shall complete wiring in accordance with the recommendations of the VSD manufacturer as outlined in the installation manual.
- C. Verify that the location is ready to receive work and the dimensions are as indicated.
- D. Do not install VSD until the building environment can be maintained within the service conditions required by the manufacturer. Before and during the installation, the VSD equipment shall be protected from site contaminants. The VSD shall be covered and protected from construction dust and contamination until the environment is cleaned and ready for operation. The VSD shall not be operated while the unit is covered.
- E. Details of the installation shall comply with the manufacturer's applicable instructions.
- F. Minimize the length of conductors between the drive and the motor to avoid motor damage from reflected wave phenomenon.
- G. Mounting of VSD shall be suitable for seismic anchorage and/or restraints as required by International Building Code.

### 3.3 WIRING

- A. Conductors feeding Variable Frequency Drives (VFDs) and between VFDs and equipment supplied by the VFDs shall be Type XHHW-2.

### 3.4 CONTROL WIRING

- A. Control wiring and control devices shall be provided under the specification section in which the controlled equipment is specified. Coordinate related work.
- B. Control wiring shall be routed completely separately from power wiring.

### 3.5 PRODUCT SUPPORT

- A. Factory trained application engineering and service personnel that are thoroughly familiar with the VSD products offered shall be locally available at both the specifying and installation locations. A 24/365 technical support line shall be available on a toll-free line.

- B. A computer based training CD shall be provided to the owner at the time of project closeout. The training shall include installation, programming and operation of the VSD and serial communication.

3.6 FIELD QUALITY CONTROL

- A. Start up: Certified factory startup shall be provided for each drive by a factory authorized service center. A certified startup form shall be filled out for each drive with copies submitted and included in the O&M Manuals, and a copy kept on file by the manufacturer.
- B. Training: Onsite training shall be provided as part of the startup service. The training shall include installation, programming, and operation of the VSD and serial communication.
- C. Document each installation and operational step utilizing the approved PC/FC checklists in accordance with Section 01 9100 - Commissioning.

3.7 ADJUSTING

- A. Coordinate hydronic and ventilation system static pressure control set points with Section 23 0593 - Testing, Adjusting and Balancing. Make necessary corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.8 CLEANING

- A. Upon completion of installation and prior to initial operation, vacuum clean and wipe down VSD enclosures. Remove debris for interior of enclosures.

END OF SECTION 254000

## PART 1 - GENERAL

## 1.1 SUMMARY

- A. Section Includes: This section describes requirements, products, and methods of execution relating to the building automation controls system for the project.
- B. Related Sections: Refer to related sections for other technical requirements, products, and methods of execution relating to the controls system for monitoring and control of mechanical systems.
1. 019100 - Commissioning
  2. 200000 - Mechanical General Requirements
  3. 226300 - Medical Gas Systems
  4. 230593 - Testing, Adjusting and Balancing
  5. 232113 - Hydronic Piping and Specialties
  6. 232113 - Hydronic Pumps
  7. 233100 - Ducts and Accessories
  8. 233400 - HVAC Fans
  9. 233600 - Air Terminal Units
  10. 235216 - Condensing Boilers and Accessories
  11. 237416 - Packaged Rooftop Units
  12. 238123 - Dedicated Air-Conditioning Units
  13. 238200 - Terminal Heating and Cooling Units
  14. 253000 - Building Automation System Field Devices
  15. 259000 - Sequence of Operations
  16. Divisions 26, 27 and 28 - Electrical

## 1.2 REFERENCES

- A. Codes and Standards. Perform work in accordance with applicable national, state and local codes to include:
1. See Section 200000 - Mechanical General Requirements.
  2. ANSI-C2, National Electrical Safety Code - NESC.
  3. Underwriters Laboratory (UL) or approved equal.
  4. Institute of Electrical and Electronics Engineers - IEEE.
  5. National Electrical Manufacturers' Association - NEMA.
- B. Abbreviations and Acronyms:
1. Building Automation System (BAS).
  2. Direct Digital Control (DDC).
- C. Definitions:

1. ASHRAE: The American Society of Heating, Refrigerating and Air-Conditioning Engineers.
2. BACnet: A Data Communication Protocol for Building Automation and Control Networks, ANSI/ASHRAE Standard 135-current edition, developed under the auspices of ASHRAE.
3. Bridge: A device that routes messages or isolates message traffic to a particular segment, sub-net, or domain of the same physical communication media.
4. Building Automation System (BAS): Collection of sensors, operators, controllers, and interconnecting wiring that control the operation of the building mechanical and electrical systems as described in these specifications.
5. Field device or field control device: A physical component such as a temperature sensor, pressure sensor, contact, motor operated valve, and motor operated damper. Generally considered to bring only one point to a controller.
6. Gateway: A hardware/software package that allows communication between dissimilar (“foreign”) systems and different protocols. Gateways are typically custom built, configured, and used only for transmitting and receiving data between different systems. System programming through gateways is not possible within the scope of this definition.
7. LonTalk: An open protocol for communication developed privately by the Echelon Corporation in Palo Alto, California.
8. Operator workstation: The central personal computer for the user to implement day to day operation of the system.
9. Router: A device for connecting different local-area network segments within a network. Routers that are used between networks with different protocols are limited. Point mapping in this type of router is automatic and requires less than one hour to configure. This device is not capable of storing point map information.
10. TCP/IP (Transmission Control Protocol/Internet Protocol): The communication language or protocol that defines the Internet. TCP/IP can also be used as a communication protocol in private networks.
11. Terminal Unit Controller: A device to control very specific applications such as a VAV box, cabinet unit heater, fan terminal unit and the like. These units may have predefined operating sequences with limited custom programming available. (Also called an “application specific controller”).

### 1.3 SYSTEM DESCRIPTION

#### A. Design Requirements:

1. The HVAC Control System will consist of a flat, open architecture based upon BACNet meeting the requirement of ANSI/EIA 709.1 and ASHRAE Standard 135. Provide necessary BACnet-compliant hardware and software to meet the system’s functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.
2. The system shall operate as a low-voltage multiplexed data system. The controls and instrumentation specified herein shall be integrated and installed as a complete package by the Contractor.
3. The completed system shall be integrated such that graphics, reports, and system interfaces from the Operators workstation appears as if there is one system.
4. No BAS system components requiring the use of gateways will be accepted.

5. To provide future flexibility, router domains shall not exceed nominally 75 percent of the maximum number of devices in the domain, unless specified otherwise.

B. Performance Requirements:

1. This section specifies the requirements for the BAS to be installed in conjunction with this project.
2. Controls contractor shall furnish and install an integrated building automation system, incorporating DDC for energy management, equipment monitoring and control, and subsystems as herein specified. Controls contractor will complete the temperature control system as specified herein.
3. Materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. Systems and components shall have been thoroughly tested and proven in actual use for at least two years.
4. Controls contractor shall be responsible for BAS and temperature control wiring for a complete and operable system. Wiring shall be done in accordance with Divisions 26, 27 and 28 of this specification and local and national codes.
5. Control and monitoring for mechanical systems installed under this Contract, including:
  - a. Building ventilation systems.
  - b. Building heating systems.
  - c. Domestic water heater trouble/alarm monitoring.
  - d. Dental air and vacuum system trouble/alarm monitoring.
6. The Work under this Section includes furnishing and installing wiring, conduit, connectors, terminal strips, and any other equipment required to interface each sensor or control point to the control system.
7. Provide control system and subsystem network cabling, routers, and other devices required for the systems shown and specified, except as specifically noted or shown on the drawings.
8. Providing sequences of operation described in Section 259000 - Sequence of Operations.
9. Installation of control instrumentation and hardware specified in Section 253000 - Building Automation System Field Devices, necessary for a complete system of controls.
10. Integrating the controls under this Contract with the Owner's HVAC Supervisory System.
11. Commissioning support activities as required in 019100 - Commissioning, including requirements in development of commissioning checklists, phased commissioning, installation examination and performance test activities, training and IO&M requirements. BAS contractor shall provide field and office support of commissioning activities.
12. System functional requirements include, but are not limited to:
  - a. BAS system shall provide all normal and off-normal control functionality without reliance upon PC file server or workstation.
  - b. Programming information, graphics, databases, and other information required to restore the entire system in the event of equipment failure or malfunction or human error shall be protected with a centralized back-up system.
  - c. Systems shall be designed to maximize multiple-vendor flexibility to replace or modify any portion of the system.
13. Software upgrades for PC and control network operating systems, the supervisory system, web browser, programming/binding tools, etc., without limitation shall be provided at no additional charge for a period of one year after Substantial Completion of the BAS.

14. A training program shall be provided to include: Data acquisition and report generation on the Operator's workstation.
15. The cost of providing power from the building electrical system shall be included in the bid. Power sources are subject to submittal requirements, and review and approval.

#### 1.4 PREINSTALLATION MEETINGS

- A. Coordinate installation of the building automation system with trades responsible for portions of this and any other related sections of the Project Manual prior to installation of any components.

#### 1.5 SUBMITTALS

- A. Refer to Section 200000 - Mechanical General Requirements for general submittal requirements.

- B. Product Data:

1. Provide manufacturer's literature that demonstrates compliance with the manufacturing methods, appurtenances and salient features specified.
2. Equipment tagging method specifically listing each device and the identification tag to be applied.
3. Sequence of Operations.
4. Riser Diagrams.
5. Control Diagrams.
6. Panel layouts.
7. Valve and Damper schedules.
8. Point Summary Report.
9. Blank (Reserved for Enhanced Alarm Report).
10. Blank (Reserved for Commented PPCL).
11. Blank (Reserved for Trend Logs).
12. Blank (Reserve for Electronic Plans Room file).

- C. Shop Drawings:

1. Riser Diagrams.
2. Control Diagrams.
3. Panel layouts.
4. Valve and Damper schedules.

- D. Quality Control Submittals:

1. Pre-functional Installation (PC) and Functional Performance Test (FT) Checklists in accordance with Section 019100 - Commissioning.
2. Incorporate BAS control requirements into the applicable equipment PC/FT checklists.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Contracts: Include information on any maintenance contract with Owner.



- B. Operation and Maintenance Data. The O&M Manuals will consist of the following (Progression from Submittal to O&M Manual takes place using the same binders):
1. Sequence of Operations.
  2. Riser Diagrams.
  3. Control Diagrams.
  4. Panel layouts.
  5. Valve and Damper schedules.
  6. Point Summary Report.
  7. Enhanced Alarm Report.
  8. Commented PPCL (Program Code).
  9. Trend Logs.
  10. Product Data including items reused from existing control system as noted.
  11. Electronic Plans Room file.

## 1.7 QUALITY ASSURANCE

### A. Qualifications:

1. Manufacturers: Companies specializing in manufacturing the products specified in this section with a minimum of three (3) years documented experience.
2. Installers: Minimum three (3) years' experience in the installation, programming and start-up of building automaton systems.
3. Testing Agencies: Regulatory requirements for products requiring electrical connection – Listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the MOA.

## 1.8 DELIVERY, STORAGE, AND HANDLING

### A. Delivery and Acceptance Requirements:

1. Verify equipment and associated appurtenances are delivered in original factory packaging/crating and are free from damage and corrosion.
2. Replace equipment delivered to job site that does not comply with above requirements at no expense to the Owner.

### B. Storage and Handling Requirements:

1. Store products in covered storage area, protected from the elements, outside the general construction area until installed.
2. Handle items carefully to avoid breaking, chipping, denting, scratching, or other damage.
3. Replace damaged items with same item in new condition.

## 1.9 WARRANTY

### A. Manufacturer Warranty:

1. Provide in accordance with Section 200000 - General Mechanical Requirements.

2. Provide maximum 4 hour response time to service/warranty calls from the Owner during the warranty period.
- B. Special Warranty:
1. The warranty shall consist of a commitment by controls contractor to provide, at no cost to the Owner, parts and labor as required to repair or replace such parts of the control system that prove inoperative due to defective materials or installation practices.
  2. The warranty expressly excludes routine service such as instrument calibration.

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. Existing facility Building Automation System is Johnson Controls.
1. Building Automation System for this project shall match existing.
- B. Management Level Network (MLN). Acceptable manufacturers are limited to the following:
1. Johnson Controls.
  2. No Alternate Brand Request; no Substitution Request.
- C. Building Level Network (BLN). Acceptable manufacturers are limited to the following:
1. Johnson Controls.
  2. No Alternate Brand Request; no Substitution Request.
- D. Floor Level Network (FLN). Acceptable manufacturers are limited to the following:
1. Johnson Controls.
  2. No Alternate Brand Request; no Substitution Request.

### 2.2 APPLICATION SPECIFIC CONTROLLER (ASC)

- A. General Requirements:
1. Application Specific Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
  2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
  3. The ASC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.

4. ASC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement.

B. ASC Interface Software:

1. General: ASC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of ASC shall not be required for configuration.
2. ASC shall provide a selection of control applications performable through configuration of the device. Download of new application should not be required for one of these applications.

C. ASC Device Software:

1. General: An ASC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage network communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.

## 2.3 APPLICATION GENERIC CONTROLLER (AGC)

A. General Requirements:

1. Application Generic Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. The AGC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.
4. AGC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. Network and power wiring shall allow for 'pass-thru' of signal when electronic boards are removed.

B. AGC Interface Software:

1. General: AGC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of AGC shall not be required for configuration.

2. AGC shall provide a selection of control applications performable through configuration of the device. Download of new applications from network management tool shall be possible, but not required.

## 2.4 CUSTOM APPLICATION CONTROLLER (CAC)

### A. General Requirements:

1. Custom Application Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. CAC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.
4. CAC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. The complete CAC including accessory devices such as relay, transducers, power supplies, etc. shall be factory-mounted, wired and housed in a NEMA 1 enclosure or as required by the location and local code requirements.
5. Equip CAC's with diagnostic indicators for the following:
  - a. Transmit.
  - b. Receive.
  - c. Power up test.
  - d. Power up fail.
  - e. Power up test okay.
  - f. Bus error.

### B. CAC Software:

1. General: A CAC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage CAC to OI communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.
3. Input/Output Point Processing Software shall include:
  - a. Continuous update of input and output values and conditions. Connected points are to be updated at a minimum of one-second intervals.
  - b. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32 bit floating point format. Both the maximum and minimum values sensed for each analog input are to be retained in memory. It shall be possible to input subsets of standard sensor

ranges to the A/D converter and assign gains to match the full-scale 32-bit conversion to achieve high accuracy readout.

- c. A reasonability check on analog inputs against the previously read value and discard those values falling outside pre-programmed reasonability limits.
  - d. Assignment of proper engineering units and status condition identifiers to analog and digital input and outputs.
  - e. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and actual alarm) to an input or to assign a set of floating limits (alarm follows a reset schedule or control point) to the input. Each alarm shall be assigned a unique differential to prevent a point from oscillating into and out of alarm. Alarm comparisons shall be made each scan cycle.
  - f. Debounce of digital inputs to prevent nuisance alarms. Debounce timing shall be adjustable from two seconds to two minutes in one second increments.
4. Alarm lockouts:
- a. Alarm lockout software shall be provided to prevent nuisance alarms. on initial start-up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period is to be programmable on a per point basis from 0 to 90 minutes in one minute increments.
  - b. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when true alarm is dependent on the condition of an associated point. Hard lockout points and lockout initiators are to be operator programmable.
  - c. Design the power supply to accommodate the power requirements of all components (or nodes) connected, plus 50 percent.
5. Run Time Totalization or Point Trending:
- a. Run time shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Run time counts shall be resident in non-volatile memory and have CAC resident run time limits assignable through the operator's terminal.
  - b. Totalized run time or trended data shall be batch downloaded using FTP to the SS on a daily or weekly basis. Trended data shall reside on the SS database server. The automatic update of this data shall be determined by the SS and facility management application requirements.
6. Transition Counting:
- a. A transition counter shall be provided to accumulate the number of times a device has been cycled on or off.
  - b. Counter is to be non-volatile and be capable of accumulating 600,000 switching cycles.
  - c. Limits shall be assignable to counts to provide maintenance alarm printouts.
7. Custom Direct Digital Control (DDC) Loops:
- a. Custom DDC programs are to be provided to meet the control strategies as called for in the sequence of operation sections of these specifications.

- b. Each CAC shall have residential in its memory and available to the programs a full library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences:
  - 1). Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning): The adaptive control algorithm shall be used on control loops, as indicated in I/O summary, where the controlled medium flow rate is variable (such as VAV units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that on system shutdown and restart, the learning process starts from where it left off and not from ground zero. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.
  - 2). DDC setpoints, gains and time constants associated with DDC programs shall be available to the operator for display and modification via the SS operator interface.
  - 3). The execution interval of each DDC loop shall be adjustable from 2 to 120 seconds in one-second increments.
  - 4). DDC control programs shall include an assignment of initialization values to outputs to assure that controlled devices assume a fail-safe position on initial system start-up.

## 2.5 VAV CONTROLLERS

- A. Provide manufacturer's thermostat matched to controller. Refer to Section 253000 - Building Automation System Field Devices, for requirements.
- B. Coordinate with Section 233600 - Air Terminal Units to have VAV controllers factory mounted on the VAV terminal unit.
- C. For applications requiring consistent airflow for space pressure control, provide VAV controllers with an auto-zero module to allow for periodic airflow sensor calibration without interruption of airflow.

## 2.6 ROUTERS, BRIDGES, REPEATERS AND TRANSCEIVERS

- A. Routers, Bridges and Repeaters:
  1. Equip each router and bridge with a network transceiver on each network port (inbound and outbound) as dictated by the network type (Type 1 - FTT, Type 2 - TP, Type 3 - PL, Type 4 - LP, Type 5 - RF).
  2. The network router shall be designed to route messages from a segment, sub-net, or domain in full duplex communication mode.
  3. Routers with TCP/IP capability shall be provided where TCP/IP backbone is used.

4. Routers, bridges and repeaters shall be fully programmable and permit a systems integrator to define message traffic, destination, and other network management functions.
5. The routers, bridges, and repeaters shall be capable of DIN rail or panel mounting and be equipped with status LED lights for Network traffic and power.

B. Transceivers:

1. Type 1 Network Transceiver, Free Topology, Twisted Pair: Provide a transformer isolated, twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:
  - a. Differential Manchester encoded signaling for polarity insensitive network wiring.
  - b. Transformer isolated for common mode rejection.
  - c. 78 Kbps network bit rate up to distances of 2000m.
  - d. Free topology supports star, home run, multi drop and loop wiring topologies.
  - e. Complies with FCC and VDE requirements.
  - f. UL recognized component.
2. Type 2 Network Transceiver, Twisted Pair: Provide a transformer isolated twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:
  - a. Differential Manchester encoded signaling for polarity insensitive network wiring.
  - b. Transformer isolation for common mode rejection.
  - c. 1.25 Mbps network bit rate up to distances of 1000 meters.
  - d. Unpotted construction.
  - e. Less than 1 mA power consumption with +5VDC input voltage.
  - f. FCC and VDE Level B requirements compliance.
  - g. UL Listed.
3. Type 3 Network Transceiver, Power Line:
  - a. Provide a direct sequence, spread spectrum power line transceiver which is equipped with the following signal processing and error correction capabilities to provide robust and error free communications.
    - 1). Forward Error Correction (FEC) to enable the system to read and reconstruct corrupted packets without sacrificing throughput. The FEC shall require only six percent overhead for error correction.
    - 2). Automatic sensitivity adjustment algorithm that dynamically changes the receiver sensitivity based on noise characteristics.
    - 3). Oversampling correlation filter and adaptive data recovery algorithm to synchronize instantaneously to incoming packets.
    - 4). Tri-state power amplifier/filter combination to provide a powerful output signal with a minimum number of components.
  - b. The transceiver shall be able to operate using the controller power supply and coupling circuit. Provide the following general features as a minimum:
    - 1). Packaged in a rugged, potted module.
    - 2). Programmable clock output (1.25, 2.5, 5 or 10 Mhz).

- 3). 10 Kbps network transmission rate.
  - 4). Packet detect output to drive a status indicator LED.
  - 5). Minus 20 to plus 85 degrees C. operating temperature range.
  - 6). UL Listed.
4. Type 4 Network Transceiver, Link Power: Provide a twisted pair transceiver that utilizes the twisted pair communication media to provide power for Controller(s). The transceiver shall meet the following specifications:
- a. Free single-in-line package (SIP) construction.
  - b. Send both network data and power on a twisted wire pair.
  - c. Differential Manchester encoded signaling for polarity insensitive network wiring.
  - d. 78 Kbps network bit rate up to distances of 320 meters.
  - e. Supports star, home run, multidrop, and loop wiring.
  - f. Supplies +5VDC @ 100 mA maximum for node power.
  - g. Compliance with FCC and VDE requirements.
  - h. UL Listed.
5. Type 5 Network Transceiver, Radio Frequency: Provide a direct sequence, spread spectrum RF transceiver that meets the following specifications:
- a. 100 meter open field range.
  - b. Wireless communications extends network between buildings and to vehicles and portable devices.
  - c. FCC type certifiable, 48 MHz.
  - d. Low-cost miniature circuit board, SMT components.
  - e. Carrier detect output to drive a status indicator LED.
  - f. Plus 7 to plus 15VDC input voltage.
  - g. Minus 20 to plus 60 degrees C. operating temperature range.

## 2.7 OPERATOR WORKSTATION

- A. The central personal computer for the user to implement day to day operation of the system. The workstation is generally capable of allowing the operator to accomplish the following functions:
1. Operate in a network environment.
  2. Monitor the entire control system.
  3. Change set points.
  4. Maintain, set, and monitor alarms.
  5. Maintain and monitor operating schedules.
  6. Control interactively using graphical representations of the system.
  7. Manually command points.
  8. Trend the behavior of selected points.
  9. Archive history.
  10. Backup data.
  11. Print results.
  12. Modify custom programs and sequences of operation.



## 2.8 PERSONAL COMPUTER OPERATOR WORKSTATION HARDWARE

- A. A new graphical operator workstation “client” shall be provided as specified in this section. The new client workstation shall communicate directly with the existing controls database server. Communication shall take place over the Owner’s existing Wide Area Network. Programming, graphics and databases created as part of this project shall be incorporated into the existing controls system. Provide a complete, secure backup of the host database at the completion of this project.
- B. Provide one graphical operator workstation for command entry, information management, network alarm management and database management functions. The workstation shall communicate seamlessly with the existing Alerton controls system.
  - 1. Provide one workstation of equal or greater capability located as indicated on the contract documents.
  - 2. Workstation shall consist of a personal laptop computer with minimum Windows 10 Pro, 11<sup>th</sup> Generation Intel Core i7 processor (8 Cores), 16GB RAM, 1 TB solid state hard drive, minimum 16” screen size, video card capable of supporting 1920 × 1080 or above, integrated webcam, USB 3.0 (Type-A and Type-C), WiFi 6, Gigabit network interface card, trackpad, Bluetooth mouse and Kensington combination laptop lock with tamper resistant desk mount anchor point.

## 2.9 WORKSTATION OPERATOR INTERFACE

- A. Basic Interface Description:
  - 1. Operator workstation interface software shall minimize operator training through the use of English language prompting, 30-character English language point identification, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 Building Level Networks and share data between any of the 4 networks. The software shall provide, as a minimum, the following functionality:
    - a. Real-time graphical viewing and control of environment.
    - b. Scheduling and override of building operations.
    - c. Collection and analysis of historical data.
    - d. Point database editing, storage and downloading of controller databases.
    - e. Alarm reporting, routing, messaging, and acknowledgment.
    - f. Display dynamic data trend plot.
    - g. Definition and construction of dynamic color graphic displays.
    - h. Program editing.
    - i. Transfer trend data to third party software.
    - j. Scheduling reports.
    - k. Operator Activity Log.
  - 2. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.
  - 3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The operator shall be able to work in Microsoft Word,

Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information.

4. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported).
5. Scheduling and Override: Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key.
6. Collection and Analysis of Historical Data: Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

B. Dynamic Color Graphic Displays:

1. Create at least one color graphic display for each piece of mechanical equipment, including air handling units, hot water boiler systems, and room level terminal units. Provide floor plans to facilitate navigation. Point information to be displayed on the graphics shall be provided by the BAS contractor to optimize system performance and analysis and to speed alarm recognition.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of submittal AutoCAD drawings and scanned pictures for use in the system.
3. Dynamic temperature values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
4. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
5. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
6. A dynamic display of the site-specific architecture showing status of controllers, PC workstations and networks shall be provided.

C. System Configuration and Definition:

1. Network wide control strategies shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
2. Provide automatic backup and restore of DDC controller databases on the workstation hard disk. In addition, database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and

downloaded to the appropriate DDC Controller. Changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

D. Alarm Management:

1. Alarm Routing shall allow the user to send alarm notification to selected PC locations based on time of day, alarm severity, or point type.
2. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.
3. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

E. 3 (BLN) and DDC Controller floor level local area networks (FLN). Access to the system shall be totally transparent to the user when accessing data or developing control programs.

F. Management Level Network:

1. PCs shall simultaneously direct connect to the Ethernet and Management Level Network without the use of an interposing device.
2. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
3. Simultaneous user access to network limited to number of sight licenses issued to user.
4. When appropriate, any DDC controller residing on the peer-to-peer building level network shall connect to Ethernet network without the use of a PC.
5. Any PC on the Ethernet Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet as well as directly connected building level networks. Any PC shall be able to interrogate any controller on the building level network in addition to being able to download program changes to individual controllers.
6. The Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.
7. Access to the system database shall be available from any client workstation on the Management Level Network.

G. Peer-to-Peer Building Level Network (BLN):

1. The system shall have the ability to support integration of third party systems (fire alarm, security, lighting, variable speed drives, PLCs, condensers, boilers) via a panel mounted open protocol processor. This processor shall exchange data between the two systems for inter-process control. Exchange points shall have full system functionality as specified herein.
2. Data transfer via Ethernet.

H. Floor Level Network (FLN): This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data.

## 2.10 CONTROL PANELS

- A. Terminal Equipment Controllers will be mounted in enclosed control panels with screwed, removable covers.
- B. Control devices located in exposed areas subject to outside weather conditions or near circulator pumps (spray due to shaft seal failures) shall be mounted inside weatherproof enclosures. Location of each panel shall be convenient for adjustment service.
- C. Nameplates shall be provided beneath each panel face mounted control device describing the function of each device. Nameplates shall have white letters engraved on blue Lamicoid, or approved equal.
- D. Control panels shall bear a UL label compatible with the application.
- E. Electrical devices within the panel shall be pre-wired to terminal strips, with inter-device wiring within the panel completed prior to installation of the system.
- F. BLN level controllers shall be provided with standby/emergency power to provide power quality and minimum 15 minutes operation.

## 2.11 UNINTERRUPTIBLE POWER SUPPLY

- A. Acceptable manufactures are limited to the following:
  - 1. Powerware.
  - 2. Alternate Brand Request or Substitution Request required.

## 2.12 ACCESS PANELS

- A. Access panels provided by Section 083113.
- B. Coordinate access panel location with the Owner's Representative and Section 083113. Provide access to concealed control devices.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Special Techniques:
  - 1. Mount damper operators and other control devices secured to insulated ductwork on brackets such that the device is external of the insulation. See Section 200529 - Hangers and Supports.
  - 2. Do not install control devices in locations where they are subject to damage or malfunction due to normally encountered ambient temperatures.

3. Identification: Permanently tag controllers, switches, relays, thermostats and actuators for identification using the tagging format shown on the BAS control drawings.
4. Sensors and Switches:
  - a. Pump flow or fan flow, etc., shall be sensed using current switch unless indicated otherwise. Calibrate current switch to distinguish between loaded or unloaded motor condition due to belt or coupler breakage.
  - b. Protect averaging or capillary tubes where they penetrate duct with rubber grommet and seal with clear silicon. Support with capillary clips and maintain minimum 1 inch tubing bending radius.
5. Wiring:
  - a. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. Install wiring in exposed or inaccessible areas in EMT conduit. Plenum-rated cable may be used in concealed, accessible areas only.
  - b. Provide wiring between thermostats and unit heater motors, and control and alarm wiring.
  - c. Provide conduit and wiring between the BAS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit or plenum-rated cable.
  - d. Provide conduit and control wiring for devices specified in this Section.
  - e. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in BAS panels located in the vicinity of motor control centers.
  - f. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contactors, and BAS panels, as shown on the drawings or as specified.
  - g. Wiring shall be compliant with the Divisions 26, 27 and 28 requirements and the NEC.
  - h. Provide electrical wall boxes and conduit sleeves for wall-mounted devices. Mount thermostats at 44 inches AFF unless otherwise noted.
  - i. Ethernet drop at or near designated BAS control panel(s), and as needed.

B. Interface with Other Work:

1. The Contractor is responsible to furnish and install complete and operational systems. The following breakdown is recommend; carefully coordinate work between subcontractors.
2. Products furnished by BAS contractor for installation by the mechanical contractor:
  - a. Control valves.
  - b. VAV box controllers.
3. Products furnished and installed by mechanical contractor:
  - a. VAV boxes. BAS contractor shall furnish VAV box controls to the VAV box manufacturer for factory installation at the expense of the box manufacturer.
  - b. VAV box controller enclosures will be provided by box manufacturer.

- c. Gauges, thermometers and thread-o-lets for BAS contractor furnished control sensor wells.
  - d. Airflow measuring stations.
  - e. Control and balancing dampers.
  - f. Smoke and fire/smoke dampers actuators.
4. Electrical contractor (Div. 26) provides:
- a. Wiring of power feeds through disconnect starters to electrical motors.
  - b. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by controls contractor.
  - c. Duct smoke detectors including installation and wiring.
  - d. Power wiring of smoke/fire dampers provided by Divisions 20, 21, 22, 23, 25.
  - e. Stand-alone packaged controls and wiring of stand-alone packaged controls to their remote sensors and devices.
- C. System Integration. Products to receive integration under this section:
- 1. Fire Alarm/Life Safety System:
    - a. The BAS shall communicate with the fire alarm/life safety system via an alarmable point in the form of a dry contact.
    - b. The device will be provided and terminated by Divisions 26, 27 and 28. This section will provide wiring to the termination device.

### 3.2 PROGRAMMING

- A. Programming and graphics shall be included to implement the controls sequences specified in Section 259000 - Sequence of Operations, and to implement the systems and features included in Facility Services Divisions 20-28. It shall not be necessary for the Contracting Agency to further program the system.
- B. Provide licensed copies of software tools and programming aids used to install, develop and troubleshoot the controls system to the Contracting Agency. Assist the Contracting Agency in registering the software in Contracting Agency's name.
- C. Implement the control sequences for the equipment on this project as contained in Section 259000 - Sequence of Operations.
- D. Point identifiers shall be chosen for easy identification of the actual equipment being controlled or monitored. They shall include equipment tag identifiers shown on the drawings, and may include additional characters to identify floor, area, etc. Maintain a listing of identifiers used in this project, with their plain English names. Submit the listing for review and information.

### 3.3 GRAPHICS

- A. Graphical Mechanical Displays: Create graphical displays of major mechanical equipment for this project and install graphics on the PC-based workstations. At a minimum, these graphical displays shall include building floor plans derived from architectural AutoCAD representations and graphical representations of the equipment controlled under this contract.

1. Plans:
  - a. Provide a central site plan for the entire facility and immediate surroundings. As a minimum indicate the following:
    - 1). Area designation.
    - 2). Number of levels on each area.
    - 3). Adjacent street names.
    - 4). North arrow.
  - b. Provide floor overall floor plans for each level of the facility. As a minimum indicate the following:
    - 1). Area designation and level.
    - 2). Mechanical and electrical rooms.
    - 3). Control panel locations.
    - 4). North arrow.
  - c. Provide individual floor plans for the facility. As a minimum indicate the following:
    - 1). Walls, doors, and general floor plan arrangement.
    - 2). Mechanical and electrical rooms.
    - 3). Temperature sensors.
    - 4). Temperature control zones.
    - 5). Control panel locations.
    - 6). North arrow.
    - 7). List of major HVAC systems serving the area including but not limited to the following:
      - a) Air handling systems.
      - b) Exhaust fans.
      - c) Toilet exhaust fans.
      - d) Heating systems.
      - e) Cooling systems.
  - d. As a minimum provide the following functional links on for each floor plan:
    - 1). Provide links back and forth between the plan screens noted above.
    - 2). On floor plan with temperature sensor, provide dynamic color coding for each sensor as follows:
      - a) Blue indicates space temperatures less than 65 degrees F.
      - b) Green indicates space temperatures between 66 degrees and 74 degrees F.
      - c) Red indicates space temperatures above 75 degrees F.
    - 3). Provide a link to each VAV terminal unit from the associated temperature sensor.
    - 4). Provide a link to each major mechanical system serving the temperature sensor.
2. Room Reheat coils:

- a. Indicate the following information for each unit:
  - 1). Room Temperature.
  - 2). Coil valve position percent.
  - 3). Fintube valve position percent.
3. Air Handling: Indicate the following information for each AHUs/MAUs, relief/exhaust fans, and toilet exhaust fans:
  - a. Put control points and adjustable set points on the screen.
  - b. Define action of dampers and valves ( N/O or N/C);
  - c. Fan schedule override commands.
  - d. Reset schedules.
  - e. Outside air CFM and minimum requirement.
  - f. Duct static set point.
- B. Use approved designations for room names, spaces, equipment tags, etc.

### 3.4 SITE QUALITY CONTROL

- A. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.
- B. Programming BAS to provide system operation and monitoring in accordance with Section 259000 - Sequence of Operation and other referenced sections.
- C. Trend Logs:
  1. Prepare trend logs for all points required to demonstrate BAS calibration, control and stability.
  2. Trend logs shall document building operation after applicable PC/FT checklists are completed and building site commissioning is satisfactorily completed.
  3. Set points, valve positions, etc. may be temporarily adjusted to artificially induce the intended sequences to occur.

### 3.5 CLOSEOUT ACTIVITIES

- A. Demonstration:
  1. Provide demonstrations in accordance with Section 017900 - Demonstrations and Training.
  2. Demonstrate the proper operation and control of systems controlled and monitored by the BAS.
  3. The demonstration shall include, but not necessarily be limited to, the following:
    - a. Review of the Trend Logs.
    - b. Complete and proper operation of control systems including simulations.
    - c. Access to devices for required maintenance.
    - d. Review of associated graphics on Host.



B. Training:

1. Provide training in accordance with Section 017900 - Demonstrations and Training.
2. In addition, provide eight (8) hours of on-site instruction by BAS contractor to familiarize operating personnel with the control system. Instructions will include:
  - a. A brief description of the controls' sequence of operation.
  - b. A discussion and explanation of alarms, switches and gauges.
  - c. A summary and explanation of steps to be taken in response to specific alarms or control malfunctions.
  - d. Building walk-through to physically locate and examine control devices and demonstrate control setpoint adjustment procedures.
  - e. Instructions regarding adjustment procedures shall emphasize methods for continual building "fine-tuning".

END OF SECTION 255000

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PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: This section describes the building automation system (BAS) control sequences for the heating, ventilating, and air-conditioning (HVAC) systems, electrical systems and plumbing systems provided for this project.
- B. Related Sections: Refer to Section 255000 - Building Automation System

1.2 REFERENCES

- A. Refer to Section 255000 - Building Automation System.

1.3 SYSTEM DESCRIPTION

- A. Refer to Section 255000 - Building Automation System.

1.4 PREINSTALLATION MEETINGS

- A. Refer to Section 255000 - Building Automation System.

1.5 SUBMITTALS

- A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.
- B. Product Data:
  - 1. Provide BAS manufacturers' product literature, clearly annotated to indicate performance criteria to include the following:
    - a. Building level to floor level network controller riser diagrams. Include building locations and equipment controlled by each controller.
    - b. Sequences of operation for HVAC, electrical and plumbing systems.
    - c. Process control diagrams to support each sequence of operation. Show field mounted control device locations and circuit routing.
    - d. Complete electrical and pneumatic BAS points list.
- C. Quality Assurance/Control Submittals:
  - 1. Installation and Functional Performance Test Letter.
    - a. Provide a letter certifying that the building automation system hardware is completely installed and sequences of operation have been programmed,

operationally tested, with physically verification, to comply with the sequences of operation as specified. The installer(s), sub-contractor(s) and the Contractor must sign the letter.

- b. Include as an attachment, a list of programming deviations from the specified sequences of operation with justification to support each deviation.
- c. Include as an attachment, a table of final adjustable setpoint values for each applicable control point.

D. Installation, Operation and Maintenance Data:

- 1. Refer to Section 200000 – Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
- 2. Provide approved submittal information, revised to reflect the actual installation as addressed in the attachments provided with the Installation and Functional Performance Test Letter, for inclusion within the project IO&M Manual.

1.6 CLOSEOUT SUBMITTALS

- A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. Refer to Section 255000 - Building Automation System.
- B. Qualifications of Installers/Programmers: Minimum 3 years' experience in the installation and programming of direct digital control systems.

1.9 WARRANTY

- A. Refer to Section 255000 - Building Automation System.

PART 2 - PRODUCTS - Not Used

## PART 3 - EXECUTION

## 3.1 MEDICAL GAS ROOM EXHAUST FAN (EF-3) AND ROOM TEMPERATURE CONTROLS

## A. Exhaust Fan:

1. Fan operates continuously 24 hours per day and 7 days per week.
2. Monitor fan operating status via current sensor and generate trouble alarm if fans fail to run when commanded.
3. Manually activated emergency shut down switch and manually activated audible and visual room alarm for medical gas storage rooms by Division 28 as noted on drawings. Coordinate with Divisions 26, 27, and 28.

## B. Room Temperature Controls and Monitoring:

1. Set room temperature at 60 degrees F (adjustable).
2. Provide room temperature monitoring and alarming capabilities via the BAS system to generate alarm if room temperature drops below 45 degrees F (adjustable).

## 3.2 GENERAL BUILDING EXHAUST FAN OPERATION (EF-2)

## A. Exhaust fan EF-2 provides general building exhaust for toilet rooms, lab, closed dental treatment rooms, sterile processing department, locker rooms, etc. throughout the building. Operate exhaust fan as follows:

1. Open motor operated exhaust fan backdraft damper and start exhaust fan at 6 a.m. (adjustable).
2. Stop exhaust fan and shut motor operated backdraft damper at 9 p.m. (adjustable).
3. Monitor exhaust fan motor and generate a fan specific "EF-2 Trouble" alarm when exhaust fan fails to operate when commanded.

## 3.3 VENTILATION SYSTEM (RTU-1)

## A. General Ventilation System Description:

1. The ventilation systems consist of two centralized roof top air-handling units (RTU-1 and RTU-2) located on the roof. The roof top units serve the following areas:
  - a. RTU-1: Basement, Level 1, and a portion of Level 2.
  - b. RTU-2: A portion of Level 2 and Level 3.
2. RTU-1 and RTU-2 utilize a variable air volume (VAV) control strategy incorporating variable speed drive motor controllers to modulate supply fan speed. During periods of low system demand, supply fans automatically reduce speed, minimizing fan horsepower and conserving electrical energy.
3. Supply air from RTU-1 and RTU-2 is transferred to their respective variable air volume (VAV) terminal units through a system of medium pressure ductwork. Each VAV terminal unit, equipped with a hydronic reheat coil, controls supply airflow rate (CFM) and temperature to maintain zone setpoint temperature.

4. Return air from RTU-1 and RTU-2 flows back to each roof top unit through above ceiling plenums and two return air shafts. Once inside the RTU, return air is either re-circulated through the building, or is relieved from the RTU through the relief air dampers.
- B. Control the system to the following typical sequences:
1. VAV Motor Monitoring.
  2. VAV Air-Handling Unit Fan Speed Control.
  3. Minimum Motor Run Timer.
  4. Air Filter Monitoring.
  5. Smoke Detector Shutdown.
  6. Fire Alarm System Interface.
  7. Duct Static Pressure Monitoring and Shutdown.
  8. Low temperature shutdown.
  9. Zone VAV Temperature Control with Reheat.
  10. Zone Temperature Monitoring.
- C. Full Shutdown Mode:
1. Supply fan off.
  2. Mixing box outdoor air damper and relief air damper shut.
  3. Mixing box return air damper fully open.
  4. Heating coil hydronic control valve modulating to maintain 55 degrees F. (adjustable) minimum mixing box air temperature.
  5. Cooling coil off.
- D. Occupied Mode (6 a.m. to 11 p.m., adjustable):
1. Control to the typical sequences.
  2. Heating Coil (HC-1) control: Modulate the heating coil control valve to maintain a 55 degrees F supply air temperature (adjustable) whenever the outside air temperature is 55 degrees F or colder (adjustable) and Mixed Air Temperature is below 55 degrees F. Optimize the Supply Air Temperature (SAT) as follows:
    - a. The optimum setpoint is a dynamic floating value of 55 degrees F. or more as required to satisfy the cooling demand of the critical zone.
    - b. Definition: The critical zone is defined as that zone which requires the largest percentage of its zone terminal unit cooling capacity to maintain zone setpoint temperature.
    - c. Find the critical zone by polling the condition status of each zone terminal unit and the demand for cooling from each zone thermostat. Ignore zone terminal unit serving storage rooms and similar small incidental spaces when searching for the critical zone.
    - d. Dynamically optimize the SAT setpoint to the highest temperature possible (above 55 degrees F.) to satisfy the critical zone cooling requirement. Allow SAT to increase until the critical zone is operating with its zone terminal unit control damper at the 95 percent open position and zone setpoint temperature is being maintained within setpoint tolerance.

3. Cooling Coil (CC-1) control: Modulate the DX unit to maintain a 55 degrees F. supply air temperature (adjustable) during the cooling season whenever the outside air temperature is 57 degrees F. or warmer (adjustable) and the cooling system is enabled (through BAS).
  4. Building Static Pressure Control: Modulate relief dampers to maintain RTU zone static pressure.
- E. Unoccupied Mode (11 p.m. to 6 a.m., adjustable):
1. Air handling unit is initially operating in Occupied Mode.
  2. The system operates the same as occupied mode, except:
    - a. Cooling coil control is disabled.
    - b. Outside air dampers are shut.
- F. DX Cooling System:
1. On call for cooling by the cooling coil:
    - a. Maintain supply air temperature set point with packaged controls via the interface with the BAS.
    - b. Modulation of the cooling coil output shall be through the control system, either through an analog signal from the BAS or through an acceptable interface.
    - c. When cooling is satisfied, disable cooling coil.
- G. Building Static Pressure Control:
1. Pressure Sensing:
    - a. Provide two outdoor ambient static pressure reference heads located above the roof line on opposing corners of the building.
    - b. Provide an indoor ambient static pressure reference head in the following general location. See drawings for specific sensor location:
      - 1). Level 1 dental reception area.
    - c. Provide differential pressure analog signals to the BAS between the average of the 2 outdoor ambient static pressure reference heads and each indoor ambient static pressure reference head.
  2. Relief Fan Operation:
    - a. Open lead relief fan damper and start lead relief fan. Increase relief fan speed to maintain negative 0.1" PSID differential pressure setpoint (adjustable) between the fan room and averaged outdoor ambient pressure.
    - b. If the lead relief fan speed increases to 100 percent and the differential pressure setpoint has not been reached, continue to start additional relief fans in series until setpoint is established. Modulate speed of last fan operating to maintain fan room differential pressure setpoint.
    - c. Monitor building zone differential pressure. Reset fan room differential pressure to maintain a slightly positive (0.05 inch W.C., adjustable) building pressure.

- d. When ventilation system shifts to Unoccupied Mode, stop relief fans, and shut relief fan dampers. Disable Building Static Pressure Control sequence.
- e. Rotate lead relief fan daily.

H. Maintenance and Alarm Monitoring:

- 1. See Typical Sequences.
- 2. RTU Flow monitoring:
  - a. Provide BAS monitoring of variable speed drive enable/disable contacts, analog speed controller, and trouble contacts.
  - b. Generate “VSD Fault” alarm if the VSD fan motor controller goes into fault.
  - c. Monitor fan motor and generate a fan specific “RTU-X off” critical alarm if RTU-X fails to operate.

3.4 VENTILATION SYSTEMS (RTU-2)

- A. Existing sequences to remain.

3.5 NEW AIR TERMINAL UNITS AND ZONE TEMPERATURE CONTROLS

- A. Project revises existing air terminal units and zone temperature controls on level 1 and level 2 areas of work. Match existing control sequences and add programming for unoccupied minimum air terminal unit airflow settings for new level 1 dental clinic zones and level 2 optometry clinic zones as noted on drawings.

3.6 NEW DENTAL GAS AND VACUUM SYSTEMS MONITORING

- A. Project adds new dental compressed air, vacuum, and medical gas equipment. Match existing sequences for equipment trouble status monitoring via the BAS.

3.7 FIRE ALARM PANEL MONITORING – EXISTING SEQUENCE TO REMAIN, SEQUENCE PROVIDED FOR REFERENCE

- A. Monitor the building fire alarm panel alarm (common alarm, common trouble, and common sprinkler alarm) conditions.

3.8 TYPICAL SEQUENCES

- A. Setpoints and delays shall be adjustable. Delays shall be incorporated to prevent short cycles to account for system "inertia", equipment and control device operations, and control system sampling frequency for specified sequence of operations.
- B. Equipment and system operating conditions used for control shall be field adjusted during testing, adjusting, and balancing, and field verified during commissioning.
- C. Typical Circulating Pump Rotation:



1. For lead/standby and lead/lag pump systems, alternate lead pump monthly. Operate pumps with lead pump in "run" and standby (lag) pump in "standby."
  2. If lead pump fails to start disable lead pump and start standby (lag) pump.
- D. Typical Fan and Pump Constant Speed Motor Monitoring:
1. Monitor motor current and generate an independent maintenance alarm if fan fails when it has been commanded "On" by the BAS. Current type switches are not acceptable.
  2. Determine normal and motor inrush currents. Set high and low alarm setpoints based upon normal operating currents. Provide a time delay to reduce nuisance alarms due to motor start inrush currents.
  3. Generate a "<Unit tag> low current motor fault" alarm if the motor current falls below low alarm setpoint whenever the device has been commanded on.
  4. Generate a "<Unit tag> high current motor fault" if the motor current is above high alarm setpoint whenever the device has been commanded on.
  5. Points: See specific control sequence.
- E. Typical Fan and Pump Variable Speed Drive (VSD) Motor Monitoring:
1. Monitor Variable Speed Drive (VSD) and alarm if the fan or pump or VSD fails when it has been commanded "On" by the BAS.
  2. Set high and low alarm setpoints based upon VSD operating current parameters.
  3. Generate a "<Unit tag> low current motor fault" alarm if the motor current falls below low alarm setpoint whenever the device has been commanded on.
  4. Generate a "<Unit tag> high current motor fault" if the motor current is above high alarm setpoint whenever the device has been commanded on.
  5. Limit speed when Emergency Generator is running. Refer to the Generator sequence of operations.
- F. Typical Fan and Pump Variable Speed Drive (VSD) Motor Speed: Motor shall be set to run at minimum of 30 percent speed, unless noted otherwise.
- G. Typical Minimum Motor Run Timer: Provide adjustable system run time of 10 minutes (minimum) and adjustable system off time of 5 minutes (minimum).
- H. Typical VAV Air-Handling Unit Fan Speed Control:
1. Locate duct static pressure sensors in main supply air duct, approximately 3/4 the distance between the AHU supply outlet and most remote zone variable air volume (VAV) terminal unit branch duct connection. Suggested locations are shown on the drawings (two on level 1).
  2. Compare branch duct pressure readings for each air handling system and control supply fan speed, through the variable speed drive (VSD) controller, to maintain the lowest branch pressure at 1.5-inch W.C. (adjustable) setpoint pressure.
  3. Program VSD such that the air handling unit goes into Full Shutdown Mode in the event of VSD failure. Require manual position on VSD keypad to restart the system. The supply fan operates at 75 percent speed during manual mode.
- I. Typical Safety Shutdowns:

1. “Hardwire” system safety shutdowns to provide safe, reliable operation in the event of Building Automation System (BAS) failure.
  2. Where equipment is provided with packaged stand-alone controls, capable of operating the equipment independently from the BAS, provide control logic which shifts the equipment to stand-alone operation in the event of BAS failure.
- J. Typical Smoke Detector Shutdown:
1. Provide smoke detector in the main return duct / at return air damper assembly immediately upstream of AHU cabinet for all air handling units larger than 2,000 CFM.
  2. Hardwire supply-duct smoke detectors directly to the building’s fire alarm panel. Refer to Section 28 31 00 – Addressable Fire Alarm for sequence of operation.
  3. Provide fan starter with hardwire relay for smoke detector. Stop fan motor on smoke detection from smoke detector.
  4. Provide BAS monitoring of smoke detector status. Generate "<Unit tag> Smoke Alarm" alarm on smoke detection and shut down fan as follows:
    - a. Verify supply fan is off. If supply fan is still running, stop fan.
    - b. Close outside air dampers and reposition return air damper to 100 percent open.
- K. Typical Fire Alarm System Interface:
1. On “General Alarm” from fire alarm panel, the BAS shall:
    - a. Verify air handling unit fans are off. If fans are operating, stop fans.
    - b. Shut IAQ and economizer cooling dampers. Reposition return air damper to 100 percent open.
    - c. Stop relief fans and shut relief fan dampers.
    - d. Stop exhaust fans and shut exhaust fan dampers.
    - e. Close relief air hoods.
- L. Typical Duct Static Pressure Monitoring and Shutdown:
1. Duct Static Pressure Monitoring:
    - a. Generate “<Unit tag> Duct Static Pressure High/Low” maintenance alarm if duct pressure falls outside setpoint tolerance, plus or minus 0.05 inches W.C.
    - b. Provide three-minute alarm time delay (adjustable) to prevent spurious alarms.
  2. If ventilating system duct supply static pressure increases to High Duct Static Pressure alarm point (3.0 inches W.C. adjustable):
    - a. Command the applicable ventilating system to Full Shutdown Mode.
    - b. Provide “<Unit tag> High Static Pressure” alarm.
  3. Provide BAS software reset to reinitiate AHU ventilation system restart sequence.
- M. Typical Low Temperature Shutdown:
1. Stop fan and close outside air damper if discharge supply temperature is less than 40 degrees F.

2. Provide "<Unit tag> Low Temperature" alarm to BAS.
3. Provide BAS software reset to initiate the system restart sequence.

N. Typical Air Filter Monitoring:

1. Provide differential pressure sensor across each filter bank. Provide high pressure alarms at set point (adjustable) as indicated in the sequences or as directed.
2. Pre-Filter Banks:
  - a. Differential pressure range is 0.28 inches W.C. (clean) to 0.90 inches W.C. (dirty) at 500 feet per minute.
  - b. Generate "<Unit tag> High Filter Differential Pressure" alarm at 0.80 inch W.C.
3. Final Filter Banks:
  - a. Differential pressure range is 0.38 inches W.C. (clean) to 1.5 inches W.C. (dirty) at 300 feet per minute.
  - b. Generate "<Unit tag> High Filter Differential Pressure" alarm at 1.30 inch W.C.

O. Typical Zone VAV Temperature Control with Reheat:

1. Zone Sensors: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.
2. Provide duct-mounted supply-air temperature sensors downstream of each reheat coil.
3. Occupied Mode Operation:
  - a. Cooling Mode: Modulate the VAV terminal unit control damper between minimum CFM and maximum cooling CFM to maintain zone normal setpoint temperature plus or minus one degree F. Reheat coil control valves remain shut.
  - b. Heating Mode: Modulate the VAV terminal unit control damper between minimum CFM and maximum heating CFM to maintain zone normal setpoint temperature plus or minus one degree F. Modulate VAV reheat coil control valve in parallel with control damper.
  - c. Limit the discharge air temperature to 20 deg F greater than the room temperature.
4. Unoccupied Mode Operation:
  - a. Heating Mode: When AHU is operating, modulate VAV terminal unit control damper between Minimum CFM and maximum heating CFM to maintain zone setback temperature plus zero, minus three degrees F. Modulate VAV reheat coil control valve in parallel with control damper.
  - b. Cooling Mode: Ventilation system remains off regardless of zone temperature.

P. Typical Zone Temperature Monitoring:

1. Generate "<location> Zone Temperature High/Low" maintenance alarm if any zone temperature is not being maintained within setpoint band tolerance.

## 3.9 MECHANICAL ROOM VENTILATION SYSTEM

- A. Existing sequence to remain.

## 3.10 TELECOMMUNICATIONS &amp; ELECTRICAL ROOMS AIR-CONDITIONING SYSTEMS (AC-1/CU-1, AC-2/CU-2)

- A. Operate air conditioning systems utilizing package microprocessor control systems. Monitor general fault alarm through BAS.

## 3.11 HYDRONIC HEATING SYSTEM OPERATION

- A. General System Description:

1. The hydronic heating system consists of two identical condensing hydronic boilers (BLR-1 and BLR-2) each sized for approximately 60 percent of the building's and parking garage's design heating load.
2. Heating loop lead/standby pumps PMP-1/PMP-1A provide variable speed circulation to VAV box reheat coils, cabinet unit heaters, unit heaters, radiant ceiling panels, and fin tube throughout the facility. Each pump is sized to handle 100 percent system zone flow.
3. Water heater loop lead/standby circulation pumps PMP-2/PMP-2A provide heating glycol fluid to the domestic water heaters (WH-1, WH-2). Each pump is sized to handle 100 percent system flow.
4. Boiler circulation pumps PMP-3/PMP-3A provide circulation to each of the boilers.

- B. Coordination with Packaged Boiler Controls:

1. Coordinate connection of the BAS to the packaged controller.
2. Provide boiler plant enable/disable control via the BAS. Boiler sequencing is controlled by the Aerco Boiler Control System (ACS).

- C. Full Shutdown Mode (Initial conditions):

1. Both boilers off.
2. Heating pumps off (PMP-1/PMP-1A).
3. Water heater loop circulator pumps off (PMP-2/PMP-2A).
4. Boiler circulator pumps off (PMP-3/PMP-3A).

- D. Operating Mode:

1. System Enable and Startup:
  - a. Enable heating system pumps to run.
  - b. Start lead loop circulator pump (PMP-1 or PMP-1A).
  - c. After loop flow has been established for 10 minutes, enable boiler operation via boiler controller (ACS).

2. Boiler and Pump Control:

- a. Boiler lead-lag and staging control is provided by the ACS.
- b. Provide lead/standby control for loop circulators (PMP-1/ PMP-1A). Alternate lead pump during the heating season. Operate pumps with lead pump in "run" and standby pump in "standby." If lead pump fails to start as determined by analog current sensor, disable lead pump and start standby pump.

3. Boiler Operation:

- a. Supply temperature is determined by the BAS and sent to the ACS.
- b. Hydronic heating system supply temperature is reset according to the following table.

<b>Hydronic System Temperature Reset Schedule</b>	
<b>Outside Air Temperature</b>	<b>Heating Loop Water Temperature Setpoint</b>
60 Degrees F.	120 Degrees F.
10 Degrees F.	160 Degrees F.

- c. Monitor facility heating zones:
  - 1). If any zone is in 100 percent heating and cannot maintain zone setpoint temperature, reset Hydronic System Supply Temperature Setpoint up 2 degrees every 15 minutes until zone's heating calculation stabilizes at 80 percent.
  - 2). Record final Hydronic System Supply Temperature Setpoint and outside air temperature. Adjust Hydronic System Supply Temperature Reset Schedule to new outside air temperature and Hydronic System Supply Temperature Setpoint (adaptive learning routine).
- d. Boilers fire under the control of the boiler on-board combustion management system to maintain remote header temperature setpoint.
- e. Sequencing of individual boilers within the boiler plant is controlled by the ACS.
- f. Flow through standby boilers is isolated from the system loop via 2-way motorized isolation valves controlled by boiler manufacturer's control panel.
- g. Connect boiler supply and return header temperature sensors to the ACS.
- h. Connect boiler supply and return header temperature sensors to the BAS.
- i. Connect ACS outside air temperature sensor to the panel for use in the building hydronic heating supply water temperature reset control.
- j. Establish original boiler reset schedule within the ACS. This schedule will be used by the ACS if communication with the BAS is lost. This schedule will not be reset by the BAS adaptive learning routine.
  - 1). Coordinate with boiler manufacturer's representative and adjust setpoints and time constants in accordance with manufacturer's recommendations.
  - 2). Coordinate with Section 23 5216 and connect the ACS to the BAS through the BAS interface furnished with the ACS.

- k. Coordinate with boiler manufacturer's representative and adjust setpoints and time constants in accordance with manufacturer's recommendations.
  - l. Coordinate with Section 23 5216 and connect the ACS to the BAS through the BAS interface furnished with the ACS.
4. System Shutdown:
- a. Initiate Full Shutdown Mode in the following events:
    - 1). Manual "off" mode.
    - 2). Low water cutoff shutdown of any boiler.
- E. Variable Speed Hydronic Pump Control (PMP-1 and PMP-1A):
1. Provide and locate separate differential pressure sensors as indicated on the drawings (two sensors).
  2. Adjust VSD controller output to modulate pump speed between 30 percent and 100 percent flow to maintain the lowest-reading differential pressure sensor at setpoint pressure. Initial pressure setpoint is 5 PSIG. Setpoint to be adjusted during Testing, Adjusting and Balancing.
  3. In the event of VSD failure, enable and run standby pump.
- F. Hydronic System Monitoring and Alarm:
1. Boiler safeguard alarms (BLR-1 and BLR-2): Generate a separate "BLR-X Flame Failure" alarm if any boiler is shut down by its flame safeguard control system.
  2. Display Status and Alarms obtained through the ACS interface. Translate Fault Codes into English Language description of fault.
    - a. Header Temperature.
    - b. Outside Air Temperature.
    - c. Fire Rate Out.
    - d. Header Setpoint Temp.
    - e. Total Boilers Fired.
    - f. Fault/Message Code.
    - g. Lead Boiler Number.
    - h. Boiler 1 Status.
    - i. Boiler 2 Status.
    - j. Return Sensor Temperature.
    - k. Net Boiler 1 Outlet Temp.
    - l. Net Boiler 2 Outlet Temp.
    - m. Net Boiler 1 Code (Fault).
    - n. Net Boiler 2 Code (Fault).
  3. Heating loop pump trouble alarms (PMP-1/PMP-1A):
    - a. Monitor current for each pump through VSD. Refer to Typical VSD sequence.
    - b. Generate an alarm if pumps fail to operate in their normal sequence, i.e. alarm if:
      - 1). Both pumps are off when system is in operating mode.
      - 2). Lead pump fails to operate and system switches to standby pump.

- 3). Both pumps are running.
  4. Heating water temperature alarm: Generate an alarm if heating water supply temperature is not maintained within 5 degrees F (adjustable; averaged over a 15 minute period).
  5. Hydronic system low pressure alarm:
    - a. Monitor both the heating loop and the glycol heating loop systems pressures with analog sensor pressure sensors.
    - b. Generate a separate low-pressure alarm if any system pressure falls below 10 PSIG.
- G. Domestic Water Heating Loop System (PMP-2/PMP-2A):
1. General System Description:
    - a. System provides heated glycol to the indirect water heater heating coils.
    - b. System consists of variable speed pumps (PMP-2/PMP-2A) with each sized for 100 percent of system flow through the water heaters. Lead/standby pumps PMP-2/PMP-2A circulate heated glycol through the indirect water heater heating coils.
  2. System Shutdown (Initial conditions):
    - a. System circulator pumps off (PMP-2/PMP-2A).
    - b. Refer to Hydronic System Full Shutdown Mode.
  3. Operating Mode:
    - a. Normal system operation:
      - 1). Variable speed glycol circulation pumps (PMP-2/PMP-2A):
        - a) Enable lead pump when an WH is operating and calls for heat.
        - b) Adjust ECM controller output to modulate pump speed between 30 percent and 100 percent flow to maintain the water heater setpoint. Initial differential pressure 5 PSIG.
        - c) In the event of ECM failure, switch to the standby pump.
  4. Monitoring and Alarms:
    - a. Pump trouble alarms (PMP-2/PMP-2A).
      - 1). Monitor current for each pump through the ECM.
      - 2). Generate an alarm if pumps fail to operate in their normal sequence, i.e. alarm if:
        - a) Both pumps are off when system is in operating mode.
        - b) Lead pump fails to operate and system switches to standby pump.
        - c) Both pumps are running.

## 3.12 SNOWMELT SYSTEM

- A. Existing sequence to remain.

## 3.13 HYDRONIC HEATING SYSTEM DEVICES

- A. Air Handler Heating Coils (RTU-1 and RTU-2): See ventilation system control sequences.
- B. Zone VAV Terminal Reheat Coils (RTU-1): See ventilation system control sequences.
- C. Zone VAV Terminal Reheat Coils (RTU-2): Existing ventilation system control sequences to remain.
- D. Hydronic Unit Heaters:
  - 1. At 60 degrees F. (adjustable) and decreasing, start recirculating fan and open two-way hydronic control valve.
  - 2. At 62 degrees F. (adjustable) and increasing, stop recirculating fan and shut two-way hydronic control valve.
- E. Radiant Ceiling Panels:
  - 1. At 68 degrees F. (adjustable) and decreasing, open two-way hydronic control valve.
  - 2. At 70 degrees F. (adjustable) and increasing, shut two-way hydronic control valve.

## 3.14 PLUMBING

- A. Domestic Hot Water Circulation Pump (PMP-4):
  - 1. Turn pump on at 6 a.m. (adjustable).
  - 2. Turn pump off at 9 p.m. (adjustable).
  - 3. Monitor status of circulator pump and generate a pump specific alarm if the pump fails to operate in its normal sequence.
- B. Domestic Water Heater (WH-1 and WH-2).
  - 1. Utilize packaged water heater controls.
  - 2. Set aquastat to 140 degrees F. (adjustable).
- C. Industrial Water Heater and Circulation Pump (WH-3 and PMP-9).
  - 1. Utilize packaged water heater controls.
  - 2. Set aquastat to 125 degrees F. (adjustable).
  - 3. Operate pump based on in-line aquastat, set to energize pump at 118 degrees F. (adjustable) and deenergize pump at 124 degrees F. (adjustable).
  - 4. Monitor status of circulator pump and generate a pump specific alarm if the pump fails to operate in its normal sequence.

END OF SECTION 259000



## PART 1 - GENERAL

### 1.1 SUMMARY

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications Sections, apply to this Section.
- B. This section describes specific requirements, products, and methods of execution, which are typical throughout the electrical work of this project. Additional requirements for the specific systems may modify these requirements.
- C. This Section applies to all Divisions 26, 27 and 28 and is part of all other Divisions 26, 27 and 28 Sections.
- D. Index of Electrical Specifications:
  - 1. 260000 - Electrical General Requirements
  - 2. 260519 - Low Voltage Electrical Power Conductors and Cables
  - 3. 260526 - Grounding and Bonding for Electrical Systems
  - 4. 260529 - Hangers and Supports for Electrical Systems
  - 5. 260533 - Raceway and Boxes for Electrical Systems
  - 6. 260553 - Identification for Electrical Systems
  - 7. 260943 - Network Lighting Controls
  - 8. 262726 - Wiring Devices
  - 9. 262800 - Low Voltage Circuit Protective Devices
  - 10. 262816 - Enclosed Switches and Circuit Breakers
  - 11. 262900 - Low Voltage Controllers
  - 12. 265000 - Lighting Fixtures
  - 13. 272010 - Telecom Distribution System
  - 14. 281300 - Security Access System
  - 15. 283100 - Addressable Fire Alarm System

### 1.2 REFERENCES

- A. Codes: Perform work in strict accordance with applicable national, state and local codes; including, but not limited to the latest legally enacted editions of the following specifically noted requirements:
  - 1. NFPA 70, National Electrical Code - NEC.
  - 2. ANSI-C2, National Electrical Safety Code - NESC.
  - 3. International Building Code - IBC.
  - 4. International Fire Code - IFC.
  - 5. Underwriters Laboratory (UL) or approved equal.

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- B. Standards: Reference to the following standards infers that installation, equipment and material shall be within the limits for which it was designed, tested and approved, in conformance with the current publications and standards of the following organizations:
1. American National Standards Institute - ANSI.
  2. American Society for Testing and Materials - ASTM.
  3. American Society of Heating Refrigerating and Air Conditioning Engineers - ASHRAE.
  4. Institute of Electrical and Electronics Engineers - IEEE.
  5. Insulated Cable Engineers Association - ICEA.
  6. National Electrical Manufacturers' Association - NEMA.
  7. National Fire Protection Association - NFPA.

1.3 DEFINITIONS

- A. "Accessible" means arranged so that an appropriately dressed man, 6 feet-2 inches tall, weighing 250 pounds, may approach the area in question with the tools and products necessary for the work intended and may then position himself to properly and safely perform the task to be accomplished, without disassembly or damage to the surrounding installation.
- B. "Authority Having Jurisdiction" is the individual official, board, department, or agency established and authorized by the political subdivision created by law to administer and enforce the provisions of the Code as adopted or amended.
- C. "As Specified" denotes a product, system, or installation that:
1. Includes all of the salient characteristics identified in the Drawings and Specifications;
  2. Meets all of the requirements of the "Basis of Design"; and
  3. Is produced by a manufacturer listed as acceptable on the Drawings or in the Specifications.
- D. "Basis of Design" refers to products around which the design was prepared. Some or all of the particular characteristics of Basis of Design products may be critical to the fit or performance of the completed installation. Such characteristics are often subtle. Where substitutions are made to products that are the Basis of Design, the Contractor is alerted that nominally acceptable substitutions may produce undesirable side effects such as switchboards that no longer fit the space due to increased product dimensions. The Contractor is responsible for resolving all impacts of substitutions. Approval of a substitution request does not relieve the Contractor of complying with the design intent and all Codes.
- E. "Contracting Agency" is the Owner as defined in the General Conditions of the Contract.
- F. "Demolish" means to permanently remove a component, equipment, or system and its appurtenances with no intent for reuse and to properly dispose of it.
- G. "Furnish" means to purchase material as shown and specified, and cart the material to an approved location at the site or elsewhere as noted or agreed to be installed by supporting crafts.
- H. "Install" means to set in place and connect, ready for use and in complete and properly operating finished condition, material that has been furnished.

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- I. "Product" is a generic term that includes materials, equipment, fixtures and any physical item used on the project.
- J. "Provide" means furnish all products, labor, subcontracts, and appurtenances required and install to a complete and properly operating, finished condition.
- K. "Remove" means to remove a component, equipment, or system and it's appurtenances and either store it for re-installation, reuse, or turn it over to the Contracting Agency.
- L. "Rough-in and Connect" means provide an appropriate system connection such as conduit with junction boxes, wiring, switches, disconnects, etc., and wiring connections. Equipment furnished is received, uncrated, assembled, and set in place under the Division in which it is specified.
- M. "Serviceable" means arranged so that the component or product in question may be properly removed, and replaced without disassembly, destruction or damage to the surrounding installation. "Serviceable" components shall be "accessible".
- N. "Shop Drawings" are dimensioned working construction drawings drawn to scale to show an entire area of work in sufficient detail to demonstrate service and maintenance clearances and complete coordination of all trades.
- O. "Substitution" is a product, system or installation that is not by a listed manufacturer or does not conform to all salient characteristics identified in the Contract Documents, but which the Contractor warrants meets all specific requirements listed in the Contract Documents.
- P. "System Drawing" is a diagrammatic engineered drawing that shows the interconnection and relationship between products to demonstrate how the products interact to accomplish the function intended. Examples of system drawings include control and instrumentation diagrams, and wiring diagrams. Some drawings, such as dimensioned and complete Fire Suppression Drawings may be both System Drawings and Shop Drawings.

1.4 CONSTRUCTION PHASING REQUIREMENTS

- A. The facility will remain operational throughout the project construction. Project will require construction phasing to minimize impacts to facility operations. Contractor will be required to develop and coordinate construction phasing plans with Owner. Refer to Architectural and Division 1 for additional information.

1.5 PERFORMANCE REQUIREMENTS

- A. Provide labor, products and services required for the complete installation, checkout and startup of electrical systems shown and specified. Where the work of several crafts is involved, coordinate related work to provide each system in complete and in proper operating order.
- B. Lay out the work in advance and avoid conflict with other work in progress. Physical dimensions shall be determined from existing conditions. Verify locations for junction boxes; disconnect switches, stub-ups, etc., for connection to equipment furnished by others, or in other Divisions of this Work.

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- C. Refer to the “Suggested Coordination Schedule” in Section 200000 - Mechanical General Requirements.
- D. Cooperate with others involved in the project, with due regard to their work, to promote rapid completion of the entire project.
- E. Coordinate installation of panels, equipment, system components, and other products to provide proper service areas and access for items requiring periodic maintenance inspection or replacement.
- F. Reference to a specific manufacturer’s product (even as “Basis of Design”) does not necessarily establish acceptability of that product without regard to compliance with all other provisions of these specifications.
- G. Local Conditions: The Contractor shall thoroughly familiarize himself with the work as well as the local conditions under which the work is to be performed. Schedule work with regard to seasons, weather, climatic conditions and other local conditions which may affect the progress and quality of the work.
- H. Demolition: Coordinate related demolition in support of the project. Restore circuits and systems, which are to remain, but which are affected in any way by demolition Work. Conduct a site visit prior to bid to determine Scope. Refer to Part 3 of this Section for execution requirements.

1.6 SUBMITTALS

- A. Refer to Division 1 for general submittal, closeout submittal and product substitution requirements. In addition, prepare Divisions 26, 27 and 28 submittals in accordance with the following.
- B. Specification section drawings, calculations, and products shall be complete and submitted together in one package.
- C. General:
  - 1. The Contracting Agency’s obligation to review submittals and to return them in a timely manner is conditioned upon the prior review and approval of the submittals by the Contractor as required by the Construction Contract.
  - 2. Streamlining: in many instances, the products, reference standards, and other itemized specifications have been listed without verbiage. In these cases, it is implied that the Contractor shall provide the products and perform in accordance with the references listed.
  - 3. Submittal review is for general design and arrangement only and does not relieve the Contractor from any of the requirements of the Contract Documents.
  - 4. Submittals will not be checked for quantity.
  - 5. Submittals will not be exhaustively checked for dimension or fit, or for proper technical design of manufactured equipment. Provision of a complete and satisfactory working installation is the responsibility of the Contractor.

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6. Furnish suppliers with the applicable portions of the Contract Documents and review and verify that the suppliers' submittals clearly represent products which comply with the Contract Documents.

D. Electronic Submittals:

1. Submittals may be in electronic (PDF) format.
  - a. Electronic submittals shall follow the organization and formatting required for paper submittals.
    - 1). Provide electronic bookmarks within the PDF document in place of tabs and sub-tabs.
    - 2). If individual PDF files are provided for each product or shop drawing sheet, organize files into folders and name files and folders to correspond with applicable specification sections or drawing titles.
  - b. If submittal is a scanned document, run the optical character recognition OCR function to ensure the document is searchable and can be copied and pasted.
  - c. Electronic submittals may be transmitted via Email, disc or download from a project or construction Website.

E. Coordination:

1. Create and maintain a master submittal log for all items submitted in Divisions 26, 27 and 28.
2. Prior to submission for approval hold a meeting of all trades to review all shop drawings and submittals. All trades shall cross-check all shop drawings and submittals for conflicts, clearances, physical space allocation and routing, discrepancies, dimensional errors, omissions, contradictions, departures from the Contract requirements, correct electrical/mechanical services and connections, and provisions for commissioning.
3. Revise, correct, and appropriately annotate submittals prior to submission for approval.
4. A current copy of approved submittals and the submittal log shall be kept at the job site.

F. Product Submittals

1. General: This section describes in detail the preparation of electrical product submittals. Submittals not provided as described shall be rejected without review. This procedure is designed to accelerate and improve the accuracy of the technical review process, as well as, simplify the preparation of the Installation, Operation, and Maintenance Manuals (IO&Ms) during project closeout.
2. Submittal Organization:
  - a. Organize product submittal information in the same order as the products are specified to simplify the technical review process. Provide a separate tabbed divider for each Divisions 26, 27 and 28 specification section. Provide the typed section number on each tab.
  - b. Within each section, organize the product information in the same order as the products are specified in Part 2 of each applicable specification section. Provide sub-

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tabs within each section for each separate product article. Provide the typed product article number on each tab.

- c. Provide product submittal information for each product specified in 8-1/2" x 11" format. Fold-out 11" x 17" format is also acceptable.
- d. If a particular specified product is being omitted from the product submittal or will not be used for the project, provide a single sheet within the article tab identifying the product and annotated with a brief reason why the product is not being submitted, for example: "NOT USED," NO SUBMITTAL REQUIRED," "TO BE SUBMITTED BY (PROVIDE DATE)," etc. This will inform the reviewer that the product was not overlooked.
- e. Partial submittals from individual subcontractors may be provided which cover a particular sub-contractor's scope of work. In this case, arrange partial submittals by system classification such as: LIGHTING, POWER DISTRIBUTION, FIRE ALARM, ACCESS CONTROL SYSTEM, etc. Within each system classification, arrange product submittals by specification section, as described, such that each specification section can easily be reorganized into a master set of Divisions 26, 27 and 28 product submittals organized by specification section. This will greatly simplify the preparation of IO&M manuals as described below.
- f. Bind product submittal information in 3 inch wide, hard backed, loose leaf, 3 ring binders with clear front and spine insert pockets. Divide information into multiple volumes such that the pages in each binder rest naturally on one side of rings.
- g. Provide a master table of contents at the front of each volume which lists the Divisions 26, 27 and 28 specification sections and indicates which sections are located within each volume.
- h. Provide a table of contents within each section which lists the Part 2 products for that section in the same order as the applicable specification section.
- i. Provide identical cover and spine inserts for each product submittal volume.
- j. For multiple volumes, label each volume. Include the following typed information on the front cover and spine inserts of each volume:
  - 1). The Contracting Agency Name
  - 2). Project Name
  - 3). Contractor Name
  - 4). Subcontractor Name preparing the submittal.
  - 5). Date that the submittal or resubmittal was initiated.
  - 6). "Electrical Product Submittals", etc. as appropriate.
  - 7). "Volume 1 of X, Volume 2 of X," etc.

3. Product Information:

- a. Indicate manufacturer's name and address, and local supplier's name, address, phone number.
- b. Indicate each product as "Basis of Design", "As Specified" or as "Proposed Substitution."
- c. Identify Catalog designation and/or model number.
- d. Neatly annotate each salient characteristic and design options of the product to demonstrate compliance with the Contract Documents to include: Scheduled information, drawing information and specified information. Clearly indicate product deviations from the Contract Documents and mark out non-applicable items on generic "cut-sheets."

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- e. Include manufacturer provided dimensioned equipment drawings with mechanical and electrical rough-in connections.
  - f. Include operation characteristics, performance curves and rated capacities.
  - g. Include motor characteristics and wiring diagrams for the specific system.
  - h. Provide basic manufacturer's installation instructions.
4. Provide coordination data to check protective devices.
  5. Provide information required to verify compliance with the short circuit withstand and interrupting ratings, as shown on the Drawings or further stated in these Specifications.
  6. Provide certification that all data shown on the Drawings or further stated in these Specifications concerning available short-circuit currents has been confirmed with the serving Electric Utility.
  7. Product Substitutions:
    - a. Clearly indicate both in the section table of contents and on the individual product submittal information each proposed substitution, deviation or change from the product as described in the Contract Documents.
    - b. Submittal approval does not include substitutions, deviations or changes from the requirements of the Contract Documents unless they are specifically itemized and approved. The term "No Exceptions Taken" will not apply to substitutions, deviations or changes not clearly identified.
    - c. Provision of a satisfactory working installation of equal quality to the system as described in the Contract Documents shall be the responsibility of the Contractor.
    - d. Correct unapproved deviations from the Contract Documents discovered in the field as directed by the Contracting Agency at no additional cost to the Owner.
- G. System Drawings:
1. Submit System Drawings for dynamic elements/systems of the project which are performance specified to include but not limited to: Fire Alarm Systems, Lightning Protection Systems and stand-alone packaged equipment.
  2. Prepare system drawings on full sized sheets of the same size as the original construction drawings.
  3. Include with each system a sequence of operation narrative which describes each mode of system operation in sufficient detail to demonstrate compliance with the Contract Documents to the satisfaction of the Contracting Agency.
- H. Shop Drawings:
1. General:
    - a. The Contract Documents are not intended for nor are they suitable for use as shop drawings. Do not use Contract Drawings for direct fabrication or installation of products or equipment.
    - b. Divisions 26, 27 and 28 products and systems shall not be installed without shop drawings approved by the Contracting Agency.
    - c. Rework, changes or additional engineering support required as a result of the installation of products and systems prior to the approval of applicable shop drawings by the Contracting Agency shall be provided at the Contractor's expense.

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2. Preparation:

- a. Review each Divisions 26, 27 and 28 specification section and identify the project's shop drawing requirements.
- b. Prepare shop drawings on full sized sheets of the same size as the original construction drawings.
- c. Arrange shop drawings to scale, showing dimensions where accuracy of location is necessary for coordination or communication purposes.
- d. Incorporate the actual dimensions and configurations of the products and systems approved through the product submittal process into the shop drawings.
- e. Provide dimensioned maintenance clearance areas around each product as recommended by the manufacturer.
- f. Meet with and coordinate Divisions 26, 27 and 28 work with the interrelated work of other trades including Architectural, Civil, Structural, and Mechanical to identify and resolve potential conflicts.
- g. Clearly identify and provide recommendations to resolve major conflicts which may impact the design of the systems as shown. Resolve such conflicts during the shop drawing review process.
- h. In cases where one or more equipment items in a mechanical or electrical room or space differ in dimensions or configuration from Basis of Design equipment, the working drawing shall show the entire area. The drawing shall be dimensioned to indicate that required aisle ways and maintenance clearances are being maintained to at least the degree shown on the Contract Drawings.
- i. Provide shop drawings for all products, systems, system components, and special supports that are not a standard catalog product and which may be fabricated for the Contractor or by the Contractor. In addition provide shop drawings for:
  - 1). Electrical and telecommunications rooms and spaces, including all equipment. Demonstrate all required clearances and working spaces are provided.
  - 2). Routing and interdisciplinary coordination of groups of conduits numbering more than one and over two inch trade size.
  - 3). Cable Trays.
  - 4). Telecom equipment rack elevations.
  - 5). Where noted on the drawings.
  - 6). Where noted in other Divisions 26, 27 and 28 sections.

3. Shop Drawing Submittal:

- a. Submit dimensioned shop drawings as specified to demonstrate proper planning and sequencing of the applicable trades for the installation and arrangement of Divisions 26, 27 and 28 with respect to other interrelated work.
- b. Installation conflicts arising from the failure to properly coordinate the work of related trades shall be resolved at the Contractor's expense.

I. Record Drawings

1. General: As the Work progresses, neatly annotate a designated and otherwise unused, set of Divisions 26, 27 and 28 Contract Drawings to show the actual locations and routing of Divisions 26, 27 and 28 Work and the terminal connection points to related Work. As a minimum, include the following:



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- a. Annotate record drawings to incorporate each applicable addendum.
- b. Annotate record drawings as directed by each applicable Request for Information (RFI) and accepted Change Order Proposal.
- c. Modify record drawings to show actual equipment sizes and locations.
- d. Provide fully dimensioned locations for permanently concealed conduits (i.e. conduit cast in concrete or buried underground/underslab).
- e. Show routing of work in permanently concealed blind spaces within the building.
- f. Maintain drawings in an up-to-date fashion in conjunction with the actual progress of installation. Accurate progress mark-ups shall be available on-site for examination by the Contracting Agency or their representative at all times.

2. Preparation:

- a. Neatly annotate record drawings to provide clear interpretation to support electronic drafting by a third party.
- b. Tape electronic sketches from addendums and/or RFIs directly to the record drawings as overlays.
- c. Annotate the record drawings in colored pencil using the same symbols and abbreviations as indicated in the Divisions 26, 27 and 28 legends and schedules of the Contract Drawings.
  - 1). Red to add information.
  - 2). Green to delete information.
  - 3). Blue to provide additional clarifying information which is not to be drafted.
- d. After submittal to the Contracting Agency, provide additional clarification, information or rework as necessary to support the accurate interpretation and electronic drafting of the record drawings.

3. Submittals:

- a. Provide dimensioned underslab record drawings to the Contracting Agency prior to pouring the slab. For slabs poured in multiple sections, provide record drawings for the applicable slab sections to the Contracting Agency prior to each pour.
- b. Provide complete record drawings for concealed areas (i.e. above lay-in and hard ceilings and inside walls) to the Contracting Agency prior to concealment.
- c. Provide the remaining portion of the record drawings for exposed areas to the Contracting Agency prior to the final completion of the project.
- d. Prepare wiring diagrams for individual special systems as installed. Identify components and show wire and terminal numbers and connections. Include diagrams from the shop drawings and submittals, updated to show as-built condition.

J. Test Certificates:

1. Review the submittal requirements for Quality Assurance/Control Submittals for each specification section.
2. Submit copies of design data, test reports, certificates, manufacturer's instructions and field test reports as specified. This information may be included within the Operations and Maintenance (IO&M) Manuals as determined by the Contracting Agency.

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K. Operations and Maintenance (IO&M) Manuals:

1. Provide specific product IO&M information for each section as detailed within each Divisions 26, 27 and 28 section.
2. Begin the preparation of the electrical Operation and Maintenance Manuals with a complete and fully approved set of electrical product submittals organized, annotated and with the product information as indicated within the "Product Submittals" article for each specification section.
3. Next, augment each individual product submittal with the written installation, operations and maintenance information for each specific product. Obviously, this type of information is not applicable (or available) for bulk commodity or simplistic products such as conduit or equipment tags, etc.
4. Maintenance information shall include:
  - a. Preventive maintenance requirements for each product, including the recommended frequency of performance of each preventive maintenance task.
  - b. Instructions for troubleshooting, minor repair and adjustments required for preventive maintenance routines, limited to repairs and adjustments that may be performed without special tools or test equipment and that require no extensive special training or skills.
  - c. Information of a maintenance nature covering warranty items, etc., that have not been discussed in the manufacturers' literature.
  - d. Information data for spare and replacement parts for each product and system. Properly identify each part by part number and manufacturer.
  - e. Recommended spare parts list.
5. Organize the Operation and Maintenance Manual information by specification section (not by sub-contractor) with a tabbed divider separating each section. Provide the typed section number on each tab.
6. Within each section, organize the product information in the same order as the products are specified in Part 2 of each applicable section. Provide sub-tabs within each section for each product. Provide the typed product article number on each tab.
7. Bind the information in identical, 3 inch wide; hard backed loose leaf 3 ring binders with clear front and spine insert pockets. Divide information into multiple volumes so that the pages in each binder rest naturally on one side of rings.
8. Provide a master table of contents at the front of each volume which lists the Divisions 26, 27 and 28 specification sections and indicates which sections are located within each volume.
9. Provide a table of contents within each section which lists the Part 2 products for that section in the same order as the applicable specification section.
10. Provide identical cover and spine inserts for each IO&M manual volume.
11. For multiple volumes, label each volume.
12. Include the following typed information on the front cover and spine inserts of each volume:
  - a. The Contracting Agency Name.
  - b. Project Name.
  - c. "Electrical Operations and Maintenance Manual".
  - d. "Volume 1 of X, Volume 2 of X," etc.

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13. Submit copies of all Operation and Maintenance Manuals in electronic format (Adobe PDF).

1.7 QUALITY ASSURANCE

- A. Qualifications: Perform the Work using qualified workmen that are experienced and usually employed in the trade.
- B. Product Testing and Certification:
  1. Nationally Recognized Testing Laboratory (NRTL) Labeling: Electrical equipment and conductors shall be “Approved,” “Certified,” “Identified,” or “Listed” and “Labeled” to establish that the electrical equipment is safe, free of electrical shock and fire hazard, and suitable for the purpose for which it is intended to be used. The manufacturer shall have the specific authorization of one of the Occupational Safety and Health Administration (OSHA) approved Nationally Recognized Testing Laboratories (NRTLs) in accordance with the applicable national standards to label the equipment as suitable.
  2. Further details on the specific NRTLs, as well as the product standards that they are specifically recognized to evaluate equipment in accordance with, can be found on the OSHA Web site: <http://www.osha.gov/dts/otpca/nrtl/>
- C. Drawings and Specifications:
  1. The Drawings and specifications are complementary. Do not scale the Drawings. Locations of devices, fixtures, and equipment are approximate unless dimensioned.
  2. The Drawings are partly diagrammatic and do not show precise routing of conduits or exact location of all products, and may not show in minute detail all features of the installation; however, provide all systems complete and in proper operating order.
  3. Drawing symbols used for basic materials, equipment and methods are commonly used by the industry. Special items are identified by a supplementary list of graphical illustrations, or called for on the Drawings or in the specifications.
- D. Tests and Inspections:
  1. Schedule, obtain, and pay for permits and fees required by local authorities and by these specifications.
  2. Request for Tests: Notify the Contracting Agency a minimum of 72 hours in advance of tests. In the event the Contracting Agency does not witness the test, certify in writing that all specified tests have been made in accordance with the specifications.
  3. Deficiencies: Immediately correct deficiencies that are evidenced during the tests and repeat tests until system is approved. Do not cover or conceal electrical installations until satisfactory tests are made and approved.
  4. Operating Tests: Upon request from the Contracting Agency, place the entire electrical installation and/or any portion thereof, in operation to demonstrate satisfactory operation.
  5. The Contracting Agency may inspect and approve sample installation of systems and equipment prior to general installation of units.
  6. Test Witness: Arrange for the Contracting Agency to witness tests. The Contracting Agency may waive witnessing any specific test at its discretion.

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1.8 WARRANTY

- A. Warranty work shall be promptly coordinated and performed at the Contractor's sole expense. Workmanship, labor and materials (without limitation) in this Division shall be warranted for the longer of the following:
  - 1. As called for in the General Conditions of the Contract.
  - 2. For a minimum period of one year from the date of final acceptance.
  - 3. For the extended warranty period specified in a specific Section under this Division.
- B. Where a specific product carries a longer warranty as a standard offering of its manufacturer, extended warranty coverage beyond these requirements shall be retained by the Owner. The Owner will have recourse back to the manufacturer only in these cases, when the warranty as specified in A above has expired.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT FURNISHED IN DIVISIONS 26, 27 AND 28

- A. Materials furnished and installed in permanent construction shall be new, full-weight, standard in every way, and in first class condition.
- B. Materials shall conform to the standards of an organization acceptable to the Authority Having Jurisdiction and concerned with product evaluation that maintains periodic inspection of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner. Only materials designed for the purpose employed shall be used.
- C. Materials shall be identical with apparatus or equipment that has been in successful operation for at least two years. Materials of similar class or service shall be of one manufacturer.
- D. Capacities, sizes, and dimensions given are minimums unless otherwise indicated. Systems, materials and equipment proposed for use on this project shall be subject to review for adequacy and compliance with Contract Documents.

2.2 MATERIALS AND EQUIPMENT FURNISHED IN OTHER DIVISIONS

- A. Controls, including conduit, wiring, and control devices required for the operation of systems furnished in other Divisions shall be provided complete under the Division of the Specifications in which the equipment is specified, unless otherwise noted or specified.
- B. Work on the project that falls under the jurisdiction of the electrical trade shall be performed by Licensed Electricians in conformance with the electrical specifications.
- C. Provide complete power connections to equipment including but not limited to feeders, connections, disconnects and motor running overcurrent protection. Where starters are provided

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as part of packaged equipment, overcurrent heaters shall be provided under Divisions 26, 27 and 28.

PART 3 - EXECUTION

3.1 COORDINATION WITH ROOM NUMBERING

- A. Certain systems provided under this Division rely on identification systems that are based on room names or numbers. Systems labeled in this fashion include, but are not limited to, panelboards, circuit directories, communication and data systems identifiers, fire alarm systems, etc.
- B. The numbering scheme indicated in these Contract Documents is based on room numbers assigned during the design process. The Owner reserves the right to change the numbers prior to substantial completion, and the final names and numbers will not necessarily match those found in the Documents. Obtain from the Owner the final room numbers prior to commencing the numbering of Divisions 26, 27 and 28 systems. Tag and label all system circuits and devices in accordance with the final numbering scheme at no additional cost.

3.2 INSTALLATION

- A. Skilled craftsmen shall install materials and equipment. The norms for execution of the work shall be in conformity with NEC Chapter 3 and the National Electrical Contractors' Association "National Electrical Installation Standards", which herewith is made part of these specifications.
- B. Repair surfaces and furnish all required material and labor to maintain fireproof, airtight and waterproof characteristics of the construction.
- C. Installation of equipment shall be in accordance with manufacturers' instructions.

3.3 MULTIWIRE BRANCH CIRCUITS

- A. Multiwire branch circuits shall not be used on this project. Each branch circuit shall be provided with its own dedicated neutral conductor.

3.4 MOUNTING HEIGHTS

- A. Mounting height shall be to center of box above finished floor (AFF) as noted below unless otherwise shown or indicated. Other mounting heights are indicated on the Drawings by detail. Specific dimensions AFF are shown adjacent to the symbol. Where devices are shown on architectural elevations, the elevation height shall govern.

Lighting switches	44 inches
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Convenience outlets and similar devices	18 inches (see note below)
Convenience outlets in mechanical, boiler rooms and workrooms	44 inches
Motor controllers	60 inches to top
Panelboards	76 inches to top
Exterior WP convenience outlets	24 inches AFG
Telecommunications (Data/Telephone) outlets	18 inches (see note below)
Wall mounted audible and/or visual appliances such as bells, horns, strobes and similar signal devices	90 inches (or 6 inches below ceiling height for ceiling heights less than 96 inches)
Manual fire alarm box	44 inches
Security Card Reader	44 inches to center

- B. NOTE: In locations where baseboard-heating enclosures are to be installed, outlet-mounting height shall be raised to 6 inches above top of enclosure unless otherwise noted on drawings.

### 3.5 CUTTING & PATCHING

- A. Obtain written permission of the Contracting Agency before cutting or piercing structural members.
- B. Wall and floor penetrations shall be in accordance with Section 260529 - Hangers and Supports.
- C. Holes through existing concrete shall be core drilled. X-ray concrete before core drilling. Do not cut rebar without specific authorization from the Contracting Agency. Seal openings with UL Listed fire resistant resilient sealant.

### 3.6 VAPOR RETARDER/BARRIER PENETRATIONS

- A. Provide solid blocking installed flat at all vapor retarder penetrations. Provide flat blocking at the interior face of the exterior stud wall. Blocking shall be a minimum of 4 inches larger than the penetration. Locate the penetration at the centerline of the flat blocking. Secure vapor retarder to blocking.
- B. Seal the interior of raceways penetrating the vapor retarder inside the building. Between point of sealing inside of raceway (typically at junction box or conduit) and vapor retarder penetration, seal conduit joints (connectors and couplings) with vapor retarder tape, paint on sealer or approved means acceptable to Contracting Agency.
- C. To reduce thermal transfer and ensure sealing of raceway, PVC or equivalent conduit shall be used where penetrations of building envelope are made above ground where installation of PVC is allowed by NEC.

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- D. Penetrations of the building vapor retarder/barrier caused by the electrical installation shall be minimized, and where they are required, the opening in the vapor retarder/barrier shall be cut smaller than the penetrating object, so that the penetration will be a stretch fit. The penetration shall then be securely sealed with vapor barrier tape or an adhesive or caulk compatible with the surfaces being sealed.
- E. Boxes (electrical boxes, outlet boxes and telecommunication boxes, etc) penetrating walls with vapor retarder/barriers shall be sealed airtight using STI Series SSP Firestop Putty Pads. Mold putty pads around electrical junction boxes and conduits and behind vapor retarder/barrier to form an airtight seal in accordance with manufacturer's installation instructions.

3.7 FIRE RESISTIVE CONSTRUCTION

- A. Provide "tenting" or other protection acceptable to the Authority Having Jurisdiction for devices or fixtures installed in fire resistive construction (i.e., ceilings, walls, etc.) to maintain the fire resistive rating of the complete assembly.
- B. Where electrical raceways or other features penetrate fire rated building surfaces, they shall maintain the integrity of the building surface being penetrated. This shall be accomplished with either of the following methods:
  - 1. Sealing the penetration with an approved fire rated caulk or putty.
    - a. Fire rated caulk or putty: 3M Fire Barrier Caulk No. CP25, 3M Fire Barrier Moldable Putty, or as approved.
  - 2. A fire rated assembly enclosing the penetration.
    - a. Fire rated assembly: STI EZ Path, or as approved.
  - 3. Firestopping shall be applied according to the manufacturer's recommendations, and in a manner that is listed by a nationally recognized independent testing agency (such as UL) as preserving the fire time rating of the construction.

3.8 SOUND ISOLATION

- A. Where electrical raceways or other features penetrate walls that extend to structure, they shall maintain the integrity of the building surface being penetrated. Refer to the requirements of FIRESTOPPING as specified above. Note that this requirement exists regardless of whether the building surface being penetrated has a fire rating.
- B. Boxes (electrical boxes, outlet boxes and telecommunication boxes, etc) penetrating wall types that extend to structure or that contain batts shall be sealed airtight using STI Series SSP Firestop Putty Pads to reduce sound transmission. Mold putty pads around electrical junction boxes and conduits to form an airtight seal in accordance with manufacturer's installation instructions.

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3.9 PROTECTIVE FINISHES

- A. Take care not to scratch or deface factory finish of electrical apparatus and devices. Repaint all marred or scratched surfaces.
- B. Provide hot dip galvanized components for ferrous materials exposed to the weather.

3.10 SEPARATION OF SYSTEMS

- A. Conductors and equipment of different voltage levels, frequency, current characteristics (AC & DC) or functions (normal vs. emergency, etc.) shall not share the same raceways or enclosures unless specifically shown on the Drawings or approved by the Contracting Agency, or inherently necessary for correct system function (i.e., at transfer switches, transformers, etc.)

3.11 TESTING

- A. Prior to final test, switches, panelboards, devices and fixtures shall be in place.
- B. Test electrical systems. They shall be free from short circuits and unintentional grounds.
- C. Make changes necessary to balance the actual electrical loads on the complete system. Arrange for balanced conditions of circuits under connected load demands, as contemplated by the normal working conditions. Final load and balance test shall be demonstrated in the presence of the Contracting Agency.
- D. Feeder cables and branch circuit cables larger than #4 AWG shall be megger tested prior to final termination. If conductor fails test, replace wiring or correct defect and retest. Perform a 1,000 volt megohm meter test between the following circuit cables in each raceway:
  - 1. A phase and B phase conductors
  - 2. A phase and C phase conductors
  - 3. B phase and C phase conductors
  - 4. A phase and Grounded (Neutral) conductors
  - 5. B phase and Grounded (Neutral) conductors
  - 6. C phase and Grounded (Neutral) conductors
  - 7. A phase and Equipment Grounding conductors
  - 8. B phase and Equipment Grounding conductors
  - 9. C phase and Equipment Grounding conductors
  - 10. Grounded (Neutral) and Equipment Grounding conductors
- E. Feeder cables shall be megger tested prior to final termination. If conductor fails test, replace wiring or correct defect and retest. Perform a 1,000 volt megohm meter test on each circuit cable rated 600 volts between the conductor and ground. Submit logs of megger readings. The insulation resistance between conductors shall not be less than 100 Megohms.
- F. Furnish one (1) copy of certified test results to the Contracting Agency prior to final inspection.



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3.12 STORAGE AND HANDLING

- A. Items shall be delivered and stored in original containers, which shall indicate manufacturer's name, the brand, and the identifying number. Items subject to moisture and/or thermal damage shall be stored in a dry, heated place. Items shall be covered and protected against dirt, water, chemical, ultraviolet (UV) and/or mechanical damage.

3.13 PROTECTION OF MATERIAL AND EQUIPMENT

- A. The Contractor shall be responsible for materials and equipment to be installed under this Contract. The Contractor shall make good at his own cost any injury or damage which said materials or equipment may sustain from any source or cause whatsoever before final acceptance.
- B. Cover and protect electrical equipment during construction from dust, dirt, debris, overspray, or other construction contaminants.

3.14 CLEANING AND REPAIR

- A. Throughout the work, the Contractor shall keep the work area reasonably neat and orderly by frequent periodic cleanups.
- B. Prior to substantial completion, clean equipment and systems used during construction.
- C. Repair surfaces damaged or impacted by the work. Restore to original condition or better. Retexture surfaces to match surrounding surfaces. Repaint affected surfaces, with extent of paint to include adjacent surfaces to next wall or other clean break to avoid mismatched finish.
- D. As independent parts of the installation are completed, they may be tested and utilized during construction.

3.15 ACCESS DOORS

- A. Provide access doors required for access to equipment provided under Divisions 26, 27 and 28. Doors shall be rated for the surrounding construction. Use of access doors shall be minimized, and all locations and cosmetic features shall be submitted for approval in advance.
- B. Equipment likely to require examination, adjustment, servicing, or maintenance while energized (e.g. VAV controllers, electric duct heaters, etc.): Access doors provided for limited access working space shall comply with NEC 110.26(A)(4) and the following:
  - 1. Access doors shall have a minimum dimension of 22" x 30".
  - 2. Access doors shall be located so that working width and depth to front of enclosure is maximized.
- C. Doors shall be finished to match surrounding surfaces as approved by the Contracting Agency.

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3.16 DEMOLITION

- A. Examination Prior to Bid: Drawings involving existing conditions are based on building record drawings and/or limited field observation. Conduct a site inspection prior to submission of Bid to become thoroughly familiarized with the Scope of Work. Report discrepancies to Contracting Agency. Submission of bid certifies acceptance of existing conditions.
- B. Examination Prior to Start of Demolition: Conduct a thorough site inspection before disturbing existing installation. Verify field measurements and circuiting arrangements. Verify that abandoned wiring and equipment serve only abandoned facilities. Beginning of demolition certifies acceptance of existing conditions.
- C. Preparation:
  - 1. Disconnect electrical systems in walls, floors, ceilings, etc., scheduled for removal.
  - 2. Coordinate utility service outages with utility companies and Contracting Agency.
  - 3. 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.
  - 4. Existing Electrical Service: Maintain existing systems in service until new systems are complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from Owner at least 72 hours before partially or completely disabling system. Contractor shall not be entitled to any additional compensation due to inability of Owner to grant an outage at the desired time. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
  - 5. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Notify Owner and applicable Fire Department Authorities at least 72 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
- D. Demolition of Existing Electrical Work:
  - 1. Remove, relocate, and extend existing installations to accommodate new construction.
  - 2. Remove abandoned wiring to source of supply.
  - 3. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut concealed conduit flush with walls and floors, and patch surfaces.
  - 4. 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. In finished areas, blank covers shall be blank plates matching the device plates specified for new work, unless otherwise noted or specified.
  - 5. Disconnect and remove abandoned panelboards and distribution equipment.
  - 6. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
  - 7. Disconnect and remove abandoned light fixtures. Remove brackets, stems, hangers, and other accessories.
  - 8. Repair adjacent construction and finishes damaged during demolition and extension work.
  - 9. Maintain access to existing electrical installations that remain active. Modify installation or provide access panels as appropriate.

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10. Restore circuits and systems to remain that are affected in any way by demolition Work, such as loads downstream of demolished equipment, switched lighting circuits where selected fixtures are demolished, etc.
11. Salvage or disposal of removed items shall be as noted on the Drawings or as directed by the Contracting Agency. Items, which the Owner does not desire to retain, shall be disposed of at a legal disposal site.

E. Cleaning and Repair:

1. Clean and repair existing materials and equipment that remain or are to be reused or are affected by this work.
2. Panelboards: Clean exposed surfaces and interior of cabinet and retorque electrical connections. Provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.
3. Light Fixtures: Remove existing light fixtures for cleaning. Use mild detergent to clean exterior and interior surfaces; rinse with clean water and wipe dry

END OF SECTION 260000

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## PART 1 - GENERAL

### 1.1 SUMMARY

- A. This section includes specific requirements, products, and methods of execution relating to wire and cable, 600 volts or less, approved for use on this project.
- B. Related Sections
  - 1. 260533 - Raceways and Boxes for Electrical Systems
  - 2. 260553 - Identification for Electrical Systems

### 1.2 REFERENCES

- A. International Electrical Testing Association:
  - 1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- B. National Fire Protection Association:
  - 1. NFPA 70 - National Electrical Code.
  - 2. NFPA 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

### 1.3 SUBMITTALS

- A. Provide submittals for products in accordance with Section 260000 - Electrical General Requirements and Division 1.

### 1.4 QUALITY ASSURANCE

- A. Conductors shall be sized according to American Wire Gauge (AWG). Stranding, insulation, rating and geometrical dimensions shall conform to UL and ICEA specifications.

## PART 2 - PRODUCTS

### 2.1 INSULATION TYPES

- A. Branch circuit conductors shall be 600 volt insulated, and unless otherwise noted on the Drawings, shall have the following insulation types:

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1. Heated indoor spaces - THHN/THWN or XHHW.
  2. Indoor/outdoor between VSD and motor – XHHW.
  3. Outdoors, wet locations (such as slab-on-grade), or other cold locations (such as unheated attics) - XHHW.
- B. Feeder conductors shall be 600 volt insulated, and unless otherwise noted on the Drawings, shall have the following insulation types:
1. Heated indoor spaces - THHN/THWN or XHHW-2.
  2. Outdoors, wet locations (such as slab-on-grade), or other cold locations (such as unheated attics) - XHHW-2.
- C. Nylon-jacketed conductors such as Types THHN or THWN shall not be used in any location subject to ambient temperatures below 20° F.
- D. Special applications: Conductors in fluorescent fixture wiring channels shall have 90° C insulation rating, Types THHN, XHHW, or equal. Conductors in high temperature locations shall have one of the special insulation types suitable for the use and as permitted by the NEC.
- E. Conductors feeding Variable Frequency Drives (VFDs) and between VFDs and equipment supplied by the VFDs shall be Type XHHW-2.

2.2 MC CABLE

- A. Where concealed above ceiling, type MC (metal clad) cable is acceptable on this project for branch circuit wiring. Type MC cable shall not be used for branch circuit homeruns. Homerun shall be considered to originate within 10 feet of the last device or fixture connection or as approved by the Contracting Agency.
- B. MC cable shall not be installed concealed in walls.
- C. Type MC (metal clad) cables shall have integral code-sized grounding conductor.
- D. Type MC cable shall consist of a factory assembly of one or more conductors, each individually insulated and enclosed in a metallic sheath of interlocking tape or a smooth corrugated tube.
- E. Type MC cable shall be hospital grade. Non-hospital grade MC cable may be used only where expressly permitted by the Engineer of Record. Submit each request for use of non-hospital grade MC cable for review and approval.

2.3 TYPE FPLP/MC CABLE

- A. In existing non-accessible spaces, where required to be fished, Type FPLP/MC metal clad fire alarm/control cable is acceptable on this project. Cable shall be UL Listed as Type FPLP Metal Clad/Power limited fire-protective signaling cable - FPLP (105°C) / MC (90°C). Submit for approval, prior to installation, all intended applications. Cable installed without prior approval is subject to removal at the Contractor's expense at the discretion of the Contracting Agency.

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- B. Type FPLP/MC technical specifications:
  - 1. Armor: Galvanized steel (red striped).
  - 2. Conductors: Solid copper (number as required for application).
  - 3. Conductor insulation: TFN/THHN.
  - 4. Assembly covering: Polypropylene tape.
  - 5. Maximum temperature rating: FPLP 105°C (dry); MC 90°C (dry).
  - 6. Grounding: Bare grounding conductor.
  - 7. Maximum voltage rating: FPLP 300V; MC 600V.
  - 8. Minimum conductor size: 18 AWG.
  
- C. Fittings for use with Type FPLP/MC metal clad fire alarm/control cable shall be designed specifically for use with Type FPLP/MC and manufactured by the producer of the Type FPLP/MC cable.

#### 2.4 FLEXIBLE CORD

- A. Flexible cord shall be Type SO or ST, or for the larger sizes, Type G.

#### 2.5 MISCELLANEOUS

- A. Miscellaneous: Miscellaneous wire and cable for special purpose applications and not covered in the categories as indicated above or otherwise specified, shall be as shown on the plans and/or required by the intended use.

#### 2.6 MINIMUM SIZE

- A. Unless specified otherwise minimum wire sizes shall be as follows:
  - 1. #12 AWG for branch circuit wiring.
  - 2. #20 AWG for low voltage switching circuits if part of an approved cable assembly, #18 AWG otherwise.
  - 3. #14 AWG for control circuit wiring.
  - 4. #16 AWG for light fixture whips, refer to specification section 260533 - Raceway and Boxes for Electrical Systems, for maximum fixture whip lengths.
  
- B. On 20A circuits, with one-way conductor lengths measured from panel to farthest receptacle, or center of lighting string (as applicable):
  - 1. #10 AWG for 120V circuits of 75 feet to 120 feet.
  - 2. #8 AWG for 120V circuits of 120 feet to 200 feet.
  - 3. #10 AWG for 277V circuits of 130 feet to 215 feet.
  - 4. #8 AWG for 277V circuits of 215 feet to 330 feet.

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- C. Similar oversizing shall apply to circuits of other ratings and/or greater lengths, as necessary to comply with the voltage drop limitations in Part 3 of this Section.
- D. Cable or conductors for fire alarm systems and other special systems shall be as described in other sections of the specifications, noted on the drawing, or recommended by the equipment manufacturer, whichever is greater.

## 2.7 CONDUCTORS

- A. Conductors used on this project shall be copper, solid or stranded for wiring #10 and smaller, stranded for #8 and larger.
- B. Stranded control, communication, and alarm conductors shall have compression terminations where terminated on screw terminals.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Unless otherwise noted or specified, all conductors shall be run in raceways as specified in Section 260533 – Raceways and Boxes for Electrical Systems. Raceways shall be installed as a complete system, free from obstructions, and clean before conductors are installed.
- B. Provide conductors from outlet to outlet and splice branch circuit conductors only at outlet or junction boxes. Install all conductors in a single raceway at one time and leave sufficient cable at all fittings or boxes. Keep conductors within the manufacturer's allowable tension. Do not violate minimum bending radii. Lubricants for wire pulling, if used, shall conform to UL requirements for the insulation and raceway material.
- C. Do not install Type XHHW conductors in temperatures below -10° F, or the other types in temperatures below +20° F.
- D. Conductors that extend below grade shall be suitable for wet locations (type XHHW or XHHW-2). The use of THHN below grade is not acceptable.

### 3.2 CONDUCTOR SUPPORT

- A. Provide conductor supports as recommended by the NEC or cable manufacturer in vertical conduits.



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3.3 SPLICING

- A. No splicing or joints are permitted in branch circuits except at outlet or accessible junction boxes. Prior to splicing, conductors shall be stripped to the exposed length recommended by the splicing device manufacturer.
- B. Utilize compression type solderless connectors when making splices or taps in conductors No. 8 AWG or larger. Provide heat or cold shrink type insulating tubing on splices and tape outer surface continuously with Scotch #88 plastic tape to secure insulation strength equal to that of the conductors joined.
- C. Utilize pre-insulated connectors, hard-shell type only, Ideal Industries, Inc., "Wing-Nut" or "Twister Pro" or "In-Sure Push-in Connectors" for splices and taps in conductors No. 10 AWG and smaller in dry locations.
- D. Utilize Ideal "Twister DB Plus", water repellent, sealant filled, UL 486D Listed connector splices and taps in conductors No. 10 AWG and smaller in damp or wet locations.
- E. Utilize "Buchanan pre-insulated crimp connectors" on stranded conductors for fire alarm control and alarm circuits.
- F. Feeder conductors shall be installed with no splices unless otherwise noted on the Drawings. Splices in feeder conductors, where specifically allowed, shall be compression type butt splices.

3.4 CONDUCTOR TERMINATION

- A. Provide power and control conductors that terminate on equipment or terminal strips with solderless lugs or T & B "Sta-Kon" terminals.
- B. Prior to termination, conductors shall be stripped to the exposed length recommended by the termination device manufacturer.

3.5 CONDUCTOR PHASE COLOR CODING

- A. Service, feeder and branch circuit conductors throughout the project secondary electrical system shall be color coded as follows:

208/120 Volts	Phase	480/277 Volts
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray (see following)
Green	Ground	Green

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- B. Where color coded conductors are not commercially available, colored non-aging, plastic tape may be utilized where permitted by NEC.
- C. Where neutrals of different systems exist on the project, neutral conductor identification method shall satisfy the Authority Having Jurisdiction, as to compliance with NEC Article 200. Branch circuit neutral conductors shall have a color stripe matching the corresponding phase conductor where neutral is not shared.
- D. Phases in panelboards and similar equipment shall be connected Phase A, B, C from left to right, top to bottom, or front to back.

3.6 DERATING OF CONDUCTORS

- A. Derating of conductors shall be per National Electrical Code.

3.7 VOLTAGE DROP

- A. The maximum total voltage drop shall not exceed three (3) percent in branch circuits or feeders, for a total of five (5) percent to the farthest outlet based on steady state design load conditions. Wire sizes shown on the Drawings are for minimum ampacity. Wire and conduit sizes shall be increased to limit voltage drop based upon actual lengths required in the field. Base voltage-drop calculations on NEC Chapter 9, Table 9.
- B. Secondary transformer voltage taps may be used to offset voltage drop as long as no load voltage does not exceed 125 volts phase to neutral/ground at transformer secondary.

3.8 OPEN WIRING ABOVE LAY-IN CEILINGS PROHIBITED

- A. Wiring for all systems shall be installed in one of the raceway systems or cable tray systems listed for this project. Refer to the Drawings and the specific Section under which each system is specified.
- B. Wiring installed in cable trays in air-handling ceiling spaces shall be approved for the application and the specific system.
- C. Raceways and sleeves shall be sized in accordance with the cabling requirements for the special system involved.

3.9 TESTING

- A. Feeder and branch circuit cables larger than #4 AWG shall be megger tested prior to final termination in accordance with Section 260000 – Electrical General Requirements.

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3.10 FIELD QUALITY CONTROL

- A. Document each installation and operational step utilizing the approved PC/FC checklists in accordance with Section 019100 - Commissioning.

END OF SECTION 260519

SECTION 260519  
LOW VOLTAGE ELECTRICAL  
POWER CONDUCTORS AND  
CABLES

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PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes general requirements, products and methods of execution relating to the furnishing and installation of a complete grounding system as required for this project.

1.2 REFERENCES

- A. The publications listed below form a part of this specification. The publications are referred to in the text by basic designation only, latest edition.

NUMBER	TITLE
ANSI/IEEE C2	National Electrical Safety Code
ANSI/NFPA 70	National Electrical Code
ANSI/TIA/-606-C	Administration Standard for Commercial Telecommunications Infrastructure
ANSI/TIA-607-C	Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
IEEE C62.41	Recommended Practice on Surge Voltages in Low-Voltage Surge Protective Devices
IEEE C62.42	Guide for the Application of Gas Tube Arrester Low-Voltage Surge Protective Devices
IEEE Draft P1250 (D4)	Guide on Service to Equipment Sensitive to Momentary Voltage Disturbances
IEEE Std 1100	Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
IEEE Std 142	Recommended Practice for Grounding of Industrial and Commercial Power Systems
IEEE STD 81	Recommended Guide for Measuring Ground Resistance and Potential Gradients in the Earth
NFPA 70	National Electric Code (NEC) - Codebook and Handbook
REA PE-33	(1985) Shield Bonding Connectors
UL 1449 Edition 3	Surge Protective Devices (SPDs)
UL 467 Edition 6	Grounding and Bonding Equipment
UL 497 Edition 5	Protectors for Paired Conductors for Communication Circuits
UL 497A Edition 1	Secondary Protectors for Communication Circuits
UL 497B Edition 1	Protectors for Data Communication and Fire Alarm Circuits

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1.3 SUBMITTALS

- A. Provide submittals for products in accordance with Section 260000 - Electrical General Requirements and Division 1. Include copies of catalog cuts, data sheets and other descriptive information for all specified materials.

1.4 MINIMUM REQUIREMENTS

- A. The minimum requirements for the system shall conform to Article 250 of the NEC.

1.5 SPECIAL REQUIREMENTS

- A. Unless specified elsewhere, the ohmic values for grounds and grounding systems from system to earth shall be as follows:
  - 1. For grounding metal enclosures and frames for electrical and electronically operated equipment -- 5 ohms maximum.
  - 2. For grounding systems to which electrical utilization equipment and appliances are connected -- 5 ohms maximum.
  - 3. For grounding secondary distribution systems, neutrals, noncurrent carrying metal parts associated with distribution systems, and enclosures of electrical equipment not normally within reach of other than authorized and qualified electrical operating and maintenance personnel -- 10 ohms maximum.

PART 2 - PRODUCTS

2.1 CONNECTIONS

- A. Clamps, lugs, connectors, bonding bushings, and other such grounding and bonding items shall be:
  - 1. Labeled or listed for the purpose.
  - 2. Shall be made (both body and hardware) of hot dip galvanized steel, bronze, or other corrosion resistant alloy (except bushing throats shall be plastic).
  - 3. Shall be the products of O-Z/Gedney, T & B, Raco, or accepted equals.
  - 4. In outdoor, damp, or corrosive environments, metals for these items shall be copper (with or without tin-plating), bronze, or other corrosion resistant alloys only; O-Z/Gedney or accepted equal.

2.2 TELECOMMUNICATIONS GROUNDING AND BONDING SYSTEMS

- A. Bond telecommunication racks and/or cabinets, ladder racks, cable trays, conduits, and all other telecommunication room and equipment room metallic components to either a PBB or SBB with a green TEBC with a minimum specification of #6 AWG, 600-volt, insulated copper conductor.

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- B. Bond telecommunication equipment located within a telecommunication rack or cabinet to a local RBB with an UBC with a minimum specification of #6 AWG, 600-volt, insulated copper conductor. Each piece of equipment shall be connected back to the local RBB in a radial configuration, i.e., equipment ground connections shall not be "daisy chained".

### 2.3 IDENTIFICATION AND LABELING

- A. Grounding conductors shall be labeled in accordance with Specification Section 260553 and TIA/EIA-606-C.

## PART 3 - EXECUTION

### 3.1 EQUIPMENT GROUND

- A. The raceway system shall be bonded in conformity with NEC requirements to provide a continuous ground path. Where required by Code or Ordinance or where called for on the plans an additional grounding conductor shall be provided, sized in conformity with Table 250.122 of the NEC, unless larger size is noted.
- B. Provide separate grounding conductor securely bonded and effectively grounded to the enclosures at both ends of all non-metallic raceways and all flexible conduit.
- C. Provide an equipment grounding conductor sized in conformity with Table 250.122 of the NEC, unless larger size noted, for new feeder and branch circuit conduits. Where conductors are adjusted in size to compensate for voltage drop, equipment grounding conductors shall be adjusted proportionately according to circular mil area.

### 3.2 CONCEALED CONNECTIONS

- A. Permanent grounding connections, where permitted by the NEC to be concealed, shall not be so concealed until inspected and accepted by the Contracting Agency. Failure to comply with this requirement shall make the Contractor liable for all expenses incurred in the process of re-exposing the connections for inspection, and subsequent repair and patching of the concealing construction, including the work of other trades. The Contractor shall schedule inspection of such connections at least one work week in advance of concealment, and shall not be entitled to any additional compensation or time extension for delays caused by inability of the Contracting Agency's representative to be available at the desired time.

### 3.3 CORDS AND NONMETALLIC CABLES

- A. Unless specifically permitted otherwise, cords and nonmetallic cables shall be furnished with integral Code-sized grounding conductor. Securely bond metal components and effectively ground the entire electrical system.

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3.4 TELECOMMUNICATIONS GROUNDING AND BONDING SYSTEMS

- A. Alternating Current Equipment Ground (ACEG): When an electrical panelboard is located in the same room or space as the PBB or an SBB, that panelboard's ground bus shall be bonded to the PBB and/or SBB with an ACEG.
- B. Conductors
  - 1. Where insulated, the TBC and each TBB, BBC, TEBC, and UBC, shall be green, green with yellow stripe, or marked with a distinctive green color.
- C. Bonding and Connections:
  - 1. General:
    - a. Insulated wire splices shall be insulated with preformed wire covers.
- D. Identification and Marking:
  - 1. Show conductors on neatly marked record drawings. Submit to the Contracting Agency.
  - 2. Grounding conductors shall be marked per ANSI/TIA/EIA 606-C and as directed by the Contracting Agency. Mark each cable end using tie wrap style cable markers.

END OF SECTION 260526



PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes:

1. General hanger and support requirements for electrical equipment, conduit and cable trays not required to be vibration and/or seismically controlled.
2. Penetrations, sleeves and seals.

B. Products Installed But Not Supplied Under this Section:

1. Vibration Isolation and Seismic Control anchoring and support systems furnished under Section 200548 – Mechanical Vibration and Seismic Control.

C. Related Sections:

1. 019100 - Commissioning
2. 20 0548 - Mechanical Vibration and Seismic Control
3. 260000 - Electrical General Requirements
4. 260533 - Raceways and Boxes for Electrical Systems
5. 262416 - Panelboards
6. 262419 - Motor Control Centers
7. 262900 - Low Voltage Controllers
8. 265000 - Lighting Fixtures
9. 270536 - Cable Trays for Electrical Systems
10. 272010 - Telecom Distribution System
11. Division 09 - Painting

1.2 REFERENCES

- A. NFPA 70: National Electrical Code (NEC) latest legally enacted edition.

1.3 DESCRIPTION

- A. Provide general hanger and support requirements for electrical equipment, conduit and cable trays not required to be vibration and/or seismically controlled in accordance with the manufacture's written installation instructions and NFPA 70.
- B. Coordinate directly with Section 200548 – Mechanical Vibration and Seismic Control – Mechanical Vibration and Seismic Control to identify electrical equipment and systems which require vibration and/or seismic control bracing in addition to the requirements of this section.

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1.4 SUBMITTALS

- A. See Section 260000 - General Electrical Requirements for general submittal requirements
- B. Product Data:
  - 1. Provide manufacturers catalog data for each product specified. Indicate channel gauge and maximum load capacities of the selected products.
  - 2. Manufacturer's Installation Instructions: Include assembly instructions, recommended parts and special procedures as required.
- C. Shop Drawings:
  - 1. Provide a single shop drawing submittal which integrates the shop drawing requirements of this section along with the additional requirements of Section 20 0548 – Mechanical Vibration and Seismic Control – Mechanical Vibration and Seismic Control.
  - 2. Provide shop drawings to include the following:
    - a. Pre-engineered and field fabricated support system details for each installation location. To include but not limited to:
      - 1). Raceway and lighting fixture support.
      - 2). Conduit and control panel support.
      - 3). Cable tray and switch box support.
      - 4). Cable tray support (single and multi-tier).
      - 5). Trapeze hangers.
      - 6). Electrical equipment support.
    - b. Equipment locations and conduit and cable tray routing coordinated with mechanical equipment and systems. Indicate routing height above finished floor.
    - c. Indicate hanger type/attachment method and hanger spacing intervals.
- D. Project Record Information:
  - 1. Indicate installed locations of hangers and supports on project as-built shop drawings.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Acceptance at Site:
  - 1. Verify products are delivered in original factory packaging and are free from damage and corrosion.
  - 2. Replace equipment delivered to job site that does not comply with above requirements at no expense to the Owner.
- B. Storage and Protection:

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1. Store products in covered storage area, protected from the elements, outside the general construction area until installed.
2. Handle items to avoid damage.
3. Replace damaged items with same item in new condition.

1.6 WARRANTY

- A. Provide warranty in accordance with Section 260000 - General Electrical Requirements.

PART 2 - PRODUCTS

2.1 PRE-ENGINEERED SUPPORT SYSTEMS

A. Manufacturers:

1. Unistrut
2. Super-Strut
3. B-Line
4. K-Line
5. Erico.

B. Material:

1. Cold worked steel.
2. Type 304 stainless steel: Use for PVC, liquid-tight flex, or plastic-coated conduit installed on wood construction in outdoor, damp, corrosive or marine environments.

C. Finish:

1. Heated indoor areas: Pre-galvanized zinc coating.
2. Outdoor areas: Hot dipped galvanized finish. In addition, coat hot dipped galvanized finish channel field cuts with zinc rich paint provided by the support system manufacturer.
3. Painted areas: Paintable galvanizing or phosphatized and primed.
4. Surface metal raceways: U.L. Listed epoxy coating.

D. Channel:

1. Standard Size: 1-5/8 inch x 1-5/8 inch. Gauge thickness as required for attached load.
2. Standard Hole Pattern: Slotted. Provide solid channel in exposed public areas.

E. Nuts and Hardware:

1. Channel nuts: Hardened steel (ASTM-A675 and ASTM A36).
2. Bolts, screws and nuts: Hardened steel (ASTM-A307, ASTM A563 and SAE J429).
3. Finish: Electroplated zinc.

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- F. Fittings: Plate steel (ASTM A635). Epoxy or electroplated zinc coating.
- G. Electrical Accessories: Provide accessories from the support system manufacturer designed for the specific equipment to be supported to include but not limited to:
  - 1. Lighting fixture hangers.
  - 2. Outlet box adapters.
  - 3. Snap-in closures.
  - 4. Conduit connection plates.
  - 5. Junction box adapters.
  - 6. Strut joiners.
  - 7. "Caddy" fasteners are permitted for support of conduit to concealed metal studs and for conduit concealed above suspended acoustical ceilings.

2.2 SLEEVES, ACOUSTICAL SEALS AND FIRE-STOPPING

- A. See Part 3 - PENETRATIONS.
- B. Sleeves for pipes through fire rated and fire resistive floors and walls, and fire proofing: UL listed prefabricated fire rated sleeves and seals.

2.3 WALL/FLOOR PENETRATION WATER SEALS

- A. Mechanical seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the conduit and the wall opening.
- B. EPDM seals.
- C. 316 Stainless steel bolts and nuts.
- D. Hot-dipped galvanized or coated sleeve with full water stop flange with continuous weld on both sides.
- E. Manufacturer: Metraflex, Thunderline, Crouse-Hinds, or pre-approved equal.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Prior to installation, prepare detailed shop drawings of the planned installation of hanger and support products specified by this section. Coordinate the location, type and size of hangers and supports, housekeeping pads (thickness/perimeter overhang dimensions) and roof curbs with Architectural and Structural elements utilizing the shop drawing review process.

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- B. Submit shop drawings required by this section coordinated with the seismic design and associated shop drawings required by Section 200548 – Mechanical Vibration and Seismic Control – Mechanical Vibration and Seismic Control as a single submittal.
- C. Do not install hangers and supports without approved shop drawings.

3.2 GENERAL INSTALLATION

- A. Install hangers and supports in accordance with manufacturer's instructions, applicable Code requirements (NFPA 70) and approved shop drawings.
- B. See Section 260000 – Electrical General Requirements for electrical equipment wall mounting heights.

3.3 VIBRATION AND SEISMIC CONTROL PRODUCT INSTALLATION

- A. Install vibration isolators, seismic control and wind restraint systems in strict compliance with the manufacturer's written instructions and certified and approved application engineering installation drawings and details in accordance with Section 200548 – Mechanical Vibration and Seismic Control.

3.4 INSERT AND ATTACHMENT INSTALLATION

- A. Inserts
  1. Provide inserts or cast-in-place channels for placement in concrete formwork.
  2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
  3. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
  4. Use expansion type anchor bolts with pre-cast concrete including concrete masonry units within loading limits of the pre-cast material and anchor bolt manufacturer's recommendations.
  5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.
  6. Plastic screw inserts and caulked lead inserts are prohibited, except for mounting instructions and control diagrams.
- B. Attach electrical equipment to structure as follows:
  1. Hollow masonry: Toggle bolts.
  2. Solid masonry and concrete: Preset inserts or expansion bolts.
  3. Structural steel: Beam clamps which engage both sides of structural member or have retaining clips or other approved means for positive engagement.
  4. Metal surfaces: Machine screws, bolts or welding.
  5. Wood construction: Wood or sheet metal screws. Bugle head drywall screws or deck screws are not allowed.

6. Do not use powder actuated fasteners for anchorage in tension applications. Obtain written permission from the Owner prior to using any type of powder powered studs.
7. Attachment to plaster or gypsum board (sheet rock) not approved. Equipment shall be attached to or supported from structure.

### 3.5 RACEWAY INSTALLATION

- A. Support raceways using approved types of wall brackets, ceiling trapeze hangers or malleable iron straps utilizing attachment methods described above. "Perforated plumber's strap" is not permitted as a means of support.
- B. Support raceways independent of ceiling systems, piping and ductwork. Exceptions: Lighting fixtures and outlet boxes (i.e. ceiling speaker boxes) specifically designed for attachment to suspended ceiling systems
- C. Support EMT conduit (1-1/2 inch and smaller/dry locations) using hanger rods with spring steel fasteners.
- D. Support cable trays and multi-conduit runs independently from other support systems utilizing double hanger rods at each support point.

### 3.6 LIGHTING INSTALLATION

- A. General
  1. Attach safety hanger wires to lighting fixtures such that in event of a ceiling suspension system failure, no part of the fixture will drop more than 6 inches below normal ceiling height. Secure each end of each wire with a minimum of three tight wraps.
- B. Fixtures (greater than 20 pounds/non-suspended ceiling applications)
  1. Support lighting fixtures from structural members capable of supporting the total weight of the fixture and independent from electrical wiring system. Attach to steel members using approved beam clamps and rods.
- C. Fixtures (suspended ceiling system applications)
  1. Positively attach lighting fixtures to suspended ceiling grid for 100 percent of fixture weight acting in any direction using positive clamping devices that fully surround the supporting member (i.e. Caddy "IDS" or equal).
  2. Provide supplemental safety hanger wires as follows:
    - a. Fixtures (weighting less than 56 pounds): Provide two 12 gauge wires or equivalent chains connected from the diagonal corners of the light fixture housing to the structure above. These wires may be slack.
    - b. Fixtures (weighting greater than 56 pounds): Provide full direct support from the structure above. Attach wires from within 3 inches of each corner of the fixture.
    - c. Pendant-hung lighting fixtures

- 1). For each fixture, provide direct support from the structure above using a minimum of two 12 gauge wires, equivalent aircraft cable or an approved alternate support system without using the ceiling suspension system for direct support. Securely attach wire/cable to fixture, route through fixture stem and securely attached to structure.
- 2). Provide loop and hook or swivel hanger assemblies fitted with a restraining device to secure stem in the support position during earthquake motion.
- 3). Support fluorescent fixtures with flexible hanger device at the attachment point to the fixture channel to preclude breaking of the support. The motion of swivels or hinged joints shall not cause sharp bends in conductors or damage to insulation.

### 3.7 PENETRATIONS

- A. Coordinate electrical penetrations with architectural, structural and mechanical construction details prior to installation. Set sleeves in position in concrete formwork. Provide reinforcement around sleeves as required.
- B. Provide compatible materials, fasteners, adhesives, sealants, and other products required for proper installation.
- C. Penetrations through roof, exterior walls and floors shall be weather and water tight (see floor penetration seals).
- D. Firestopping: Provide UL rated firestopping assemblies for rated roof, wall and floor penetrations in accordance with Division 7.
- E. Conduit Sleeves
  1. Provide sleeves for conduit passing through floors, walls, ceilings, or roofs.
    - a. Fabricate sleeves in non-load bearing walls from 20 gauge galvanized sheet steel conforming to ASTM A 924/A 924M.
    - b. Fabricate sleeves in load bearing walls from standard weight galvanized steel pipe conforming to ASTM A 53/A 53M.
    - c. Provide 1/2 inch clearance between conduit and sleeve opening.
  2. Provide escutcheons for conduit passing through walls, floors and ceilings in finished areas, below counters and inside closets and casework subject to view when doors are open. Size escutcheons to cover sleeves. Secure escutcheons in position.
- F. Acoustical Seals
  1. Monolithic sound walls (i.e. poured concrete or masonry): Provide wall sleeve with approximately one-inch annular space around conduit. Pack annular space with backer rod or acoustical filler as specified in Division 7. Allow a 1 inch recess at each end of sleeve. Caulk sleeve flush with flexible sealant or fire-stopping material as specified in Division 7.

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2. Where acoustical wall is a two component type, such as a staggered or double stud partition, treat each component as a separate wall. Pack and seal each half of penetration sleeve as previously specified, except that only the exposed end of each sleeve portion shall be caulked with sealant or firestop. Provide adequate separation between each sleeve.

G. Wall Penetration Seals

1. Provide pre-engineered wall penetration water seal systems for exterior wall penetrations.
2. Select appropriate wall penetration sealing systems based on conduit material and nominal conduit size in accordance with the manufacturer's selection charts.
3. Install conduit and sealing system prior to waterproofing the wall. Grout void between water seal and outside face of foundation wall to provide continuous bearing surface for waterproofing fabric.

H. Floor Penetration Seals

1. Provide pre-engineered floor penetration water seal systems for conduit floor penetrations in rooms where a pipe leak/failure could result in water damage to adjacent spaces (i.e. mechanical rooms located above the ground floor or basement) and other areas as noted.
2. Extend conduit floor penetration sleeves 2 inches above finished floor.

3.8 ROOF FLASHING

- A. Provide EDPM pipe penetration and roof curb flashing in accordance with Division 7 as an integral part of the roofing system.

3.9 FIELD QUALITY CONTROL

- A. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.

END OF SECTION 260529



PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes specific requirements, products, and methods of execution relating to conduit, conduit fittings, surface raceways, multi-outlet assemblies, wireways, outlet boxes, pull boxes and junction boxes approved for use on this project. Type, size and installation methods shall be as shown on Drawings, required by Code and/or specified in this Section.
- B. Related Sections
  - 1. 260519 - Low Voltage Electrical Power Conductors and Cables
  - 2. 260526 - Grounding and Bonding for Electrical Systems
  - 3. 260529 - Hangers and Supports for Electrical Systems

1.2 REFERENCES

- A. American National Standards Institute/Underwriters Laboratory
  - 1. ANSI C80.1 – Electrical Rigid Steel Conduit
  - 2. ANSI C80.3 – Steel Electrical Metallic Tubing
  - 3. ANSI C80.5 – Electrical Rigid Aluminum Conduit
  - 4. ANSI C80.6 – Electrical Intermediate Metal Conduit
  - 5. ANSI/UL 1 – Flexible Metal Conduit
  - 6. ANSI/UL 6 – Electrical Rigid Metal Conduit – Steel
  - 7. UL 6A – Standard for Electrical Rigid Metal Conduit – Aluminum and Stainless Steel
  - 8. UL 360 – Standard for Liquid Tight Flexible Steel Conduit
  - 9. UL 514A – Metallic Outlet Boxes
  - 10. UL 514B – Conduit, Tubing and Cable Fittings
  - 11. UL 651 – Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
  - 12. UL 651A – Type EB and A Rigid PVC Conduit and HDPE Conduit
  - 13. ANSI/UL 651B – Standard for Continuous Length HDPE Conduit
  - 14. ANSI/UL 797 – Electrical Metallic Tubing – Steel
  - 15. ANSI/UL 1242 – Electrical Metal Intermediate Conduit – Steel
- B. National Electrical Manufacturers Association
  - 1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
  - 2. NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
  - 3. NEMA OS 1 – Sheet Steel Outlet Boxes, Device Boxes, Covers and Box Supports
  - 4. NEMA RN 1 – Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
  - 5. NEMA TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit
  - 6. NEMA TC 3 – Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing

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7. NEMA WD 6 - Wiring Device Configurations.

- C. NECA (National Electrical Contractors Association) Standard of Installation.

1.3 SUBMITTALS

- A. Provide submittals for products in accordance with Section 260000 - Electrical General Requirements and Division 1.
- B. Product Data: Provide dimensions, knockout sizes and locations, materials, fabrication details, surface raceway finishes (custom factory pre-painting, color as selected by architect), and accessories.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

1.4 QUALITY ASSURANCE

- A. Raceways and boxes shall be standard types and sizes as manufactured by a nationally recognized manufacturer of this type of materials and be in conformity with applicable standards and UL listings.
- B. Surface raceways shall be of the latest approved design as manufactured by a nationally recognized manufacturer and shall be listed by the Underwriters' Laboratory and bear the UL label.
- C. Pull and junction boxes 50 cubic inches and smaller shall conform to specifications for outlet boxes.
- D. Pull and junction boxes larger than 50 cubic inches shall conform to U.L. Standard 50, Cabinets and Boxes.
- E. Perform Work in accordance with NECA Standard of Installation.
- F. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Conduit types specifically approved for use on this project shall be of the following types only:
1. Galvanized rigid metal conduit - GRC or RMC.
  2. Intermediate metal conduit - IMC.

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3. Rigid copper-free aluminum conduit.
4. Electrical metallic tubing - EMT.
5. Polyvinyl chloride conduit - PVC: May be Schedule 40 or Schedule 80, except where Schedule 80 is specifically noted or specified.
6. Flexible metal (steel) conduit - FMC or flex: In short lengths as specifically permitted.
7. Liquid-tight flexible steel conduit - LFMC: In short lengths as specifically permitted.
8. Extreme temperature liquid-tight flexible steel conduit - AT: Shall have temperature rating of -67 ° F to +220 ° F, Liqueflex "ATLA", or as approved.
9. MC Cable, as specifically allowed in Section 260519 - Low Voltage Electrical Power Conductors and Cables
10. Types specifically identified on the Drawings or in the Specifications
11. Other products not specifically approved such as ENT, MC Cable, etc., are not allowed.
12. Manufactured wiring systems are not approved.

2.2 FIRE ALARM CONDUIT

- A. EMT conduit utilized for fire alarm system wiring shall be factory pre-painted with a bright red topcoat, Allied Fire Alarm Red or as approved. Other conduit types utilized for fire alarm system wiring shall be identified with red paint or red tape wrapped a minimum of 4 times around the conduit every 10 feet and at each fire alarm system junction box.

2.3 CONDUIT FITTINGS

- A. Fittings utilized with rigid steel, IMC, and aluminum shall be galvanized steel or iron or copper-free aluminum and shall be threaded. Conduit bushings shall be provided and shall be of the insulated types. Where grounding bushings are required, provide insulated grounding bushings with integral pressure type ground lugs, Thomas & Betts "Blackjack", or as approved.
- B. Couplings and connectors for EMT shall be made of steel or malleable iron. Die-cast products shall not be used. Connectors shall have insulated throats. Connectors and couplings shall be setscrew or compression type.
- C. Fittings for flexible metal conduit shall be steel or malleable iron only. Throats shall be insulated.
- D. Fittings for liquid-tight flexible conduit shall be steel or malleable iron, of a type incorporating a threaded grounding cone, nylon or plastic compression ring, and a tightening gland, providing a low resistance ground connection. Throats shall be insulated.

2.4 SURFACE METAL RACEWAY

- A. The Basis of Design is equipment from Wiremold, Hubbell or Mono-Systems, to set a standard for quality and style.
- B. Large multi-circuit raceways shall be aluminum channel 5 inches wide by 2 inches deep, with separation for low voltage channel, and fitted cover, suitable for use as surface metal raceway, Wiremold Series 5200 or as approved.

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- C. Small surface metal raceway for individual circuit runs shall be one piece surface metal raceway of the appropriate dimensions for the conductors, Wiremold Series 500/700, or as approved.
- D. Finish: Large raceways shall be aluminum. Small raceways shall be furnished with factory ivory color finish and field painted to match adjacent surfaces, unless otherwise noted on the Drawings.
- E. Large raceways shall have factory pre-punched base channel mounting fastener holes. Provide suitable backing for mounting attachment, hollow wall anchors shall not be used.
- F. Provide manufacturer's standard Fittings, Boxes, and Extension Rings:
  - 1. Wall box connectors shall be concealed entry type.
- G. Uses Permitted
  - 1. Surface metal raceway shall only be used where specifically shown on the Drawings.

2.5 CAST BOXES

- A. Cast boxes with threaded hubs, external mounting brackets or holes, and gasketed covers shall be used in the following locations:
  - 1. Exterior locations.
  - 2. Wet or damp locations.
  - 3. Mechanical rooms, pump stations, etc., where exposed to mechanical damage.
  - 4. Exposed interior locations below 48 inch above floor where subject to damage.
  - 5. Where shown on Drawings.

2.6 STEEL BOXES

- A. Galvanized pressed steel boxes may be used wherever they are permitted by code, except in areas indicated in the preceding paragraph.
- B. Flush mounted, pressed steel boxes shall be equipped with external mounting brackets for attachment to framing members with screws or nails.
- C. Ceiling boxes and wall boxes for bracket lights shall be not less than 4 inch in diameter by 1 ¼ inch deep and shall have 3/8 inch malleable iron fixture studs if required.
- D. Grounding Screw: All stamped steel boxes shall have a drilled and tapped hole in the back of the box for a grounding screw.
- E. Accessories: Box covers, extension rings, bases, hanger bars, etc., for use in connection with the installation, shall be approved for use in the various applications.

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2.7 TELECOMMUNICATION OUTLET BOXES

- A. Boxes for telecommunication outlets shall be a minimum of 4 inches square by 2 1/8 inches deep.
- B. Device rings for telecommunication outlets shall be single-gang, minimum 5/8 inches deep, to provide a minimum internal finished depth of 2 3/4 inches.

2.8 INDOOR PULL AND JUNCTION BOXES

- A. Indoor pull and junction boxes shall conform to Article 314 of the NEC and the following requirements:
  - 1. Sheet metal boxes are approved for use in all dry, interior, nonhazardous locations.
  - 2. Boxes installed in wet locations shall be NEMA 3R, unless otherwise noted.
  - 3. Furnish such boxes, whether shown or not, in order to conform to requirements for maximum pulling length and maximum number of bends allowed.
  - 4. Special boxes, as noted on the Drawings, shall be installed in areas of specific service and/or hazards.
- B. Junction box extension rings will not be accepted on new boxes. Appropriate size boxes shall be used for each application.

2.9 TELECOMMUNICATION SYSTEM PULL BOXES

- A. Telecommunication system Pull Boxes shall also conform to ANSI/EIA/TIA 569-A and the BICSI Telecommunications Distribution Methods (TDM) Manual.
- B. Dimensions:
  - 1. Pull boxes for straight through pulls shall have minimum interior dimensions in accordance with the following Table:

Maximum Trade Size Conduit	Size of Box			For Each Additional Conduit Increase Width
	Width (inches)	Length (inches)	Depth (inches)	
1 Inch	4	16	3	2 inches
1 1/4 Inch	6	20	3	3 inches
1 1/2 Inch	8	27	4	4 inches
2 Inch	8	36	4	5 inches
2 1/2 Inch	10	42	5	6 inches
3 Inch	12	48	5	6 inches
3 1/2 Inch	12	54	6	6 inches
4 Inch	15	60	8	8 inches

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## 2.10 TELECOMMUNICATION SYSTEM SPLICE BOXES

- A. Unless otherwise specified or noted on the Drawings, splice boxes shall not be used in interior horizontal pathway conduits or interior backbone pathway conduits.
- B. Where required in a building service entrance or campus backbone pathway system, splice boxes shall be provided in accordance with the requirements of ANSI/EIA/TIA-569-A - Commercial Building Standard for Telecommunications Pathways and Spaces and the Building Industry Consulting Service International (BICSI) Telecommunications Distribution Methods Manual.

## PART 3 - EXECUTION

### 3.1 CONDUIT USES PERMITTED

- A. Conduits shall be of the sizes shown on the Drawings or as required by the NEC, whichever is larger. Base sizes on using type XHHW for wire sizes #6 and smaller and type THHN/THWN wire for wire sizes #4 and larger. Unless otherwise noted, conduits installed in the following locations shall be of the types specifically identified only:
  - 1. Outdoors aboveground or damp locations - RMC, IMC or extreme temperature liquid-tight flexible steel conduit (where required).
  - 2. Dry indoor locations, concealed or exposed - RMC, rigid aluminum, EMT (where not susceptible to physical damage), flexible conduit where necessary, or IMC.
  - 3. Indoor locations, exposed, where susceptible to physical damage - RMC or IMC.
  - 4. Motor and equipment flexible connections - LFMC or FMC (when installed in plenum spaces).

### 3.2 RACEWAY INSTALLATION METHODS - GENERAL

- A. Concealed raceways: In occupied areas, conduit and raceways shall be concealed unless specifically noted otherwise. In service spaces (mechanical equipment rooms, electrical rooms, storage closets, etc.), approved raceways may be surface-mounted for connection to equipment in exposed surface mounted locations and in exterior locations as noted on the Drawings.
- B. Concealed raceways shall be routed as directly as possible with a minimum of bends. Concealed raceways above lay-in ceilings shall be installed a minimum of 12 inches above the ceiling grid.
- C. Exposed Raceways: Where allowed by this Specification or specifically noted on the Drawings, raceways may be mounted on the surface of walls, ceilings and other surfaces. Exposed raceways shall comply with the following:
  - 1. Exposed raceways shall be run parallel or perpendicular to building lines and bent symmetrically or made up with standard elbows or fittings.
  - 2. Surface-mounted conduit, junction boxes, pull boxes, outlet boxes, etc. installed in finished areas shall be painted to match the surrounding surfaces.
  - 3. Connectors and fittings for raceways and conduits installed on the surface in exterior locations shall be suitable for and Listed for use in a wet location.

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4. Conduits installed in exterior locations shall be painted to match the exterior finish of the building surface to which they are attached. This shall include conduits attached via racks and stand-off brackets, or attached directly to the surface.
- D. There shall not be more than the equivalent of four quarter bends (360 degrees total) between pull points. Pull boxes added to conduit runs as a result of this requirement shall be in accordance with this Section.
- E. Conduit and tubing shall be cut square and reamed smooth at the ends and all joints made tight. Conduit threads shall be lubricated with an approved thread lubricant.
- F. Raceway for power wiring shall not be installed in the floor slab beneath telecommunication rooms.
- G. Each conduit shall enter and be securely connected to a cabinet, junction box, pull box or outlet box by means of a locknut on the outside and a locknut/bushing on the inside, or by means of a liquid-tight, threaded, self-locking, cold-weld type wedge adapter. Connections shall be made wrench tight. Locknuts shall be the bonding type with sharp edges and shall be installed in a manner that will assure a locking installation. Locknuts and bushings or self-locking adapters will not be required where conduits are screwed into threaded connections. Conduit runs shall be protected from the entrance of foreign material prior to the installation of conductors.
- H. Conduit or tubing deformed or crushed in any way shall not be installed. Conduit shall be bent only with approved bender (hydraulic or hickey). Bending machines shall be used to make field bends in conduit of 1-1/4 inch size and larger. Torches shall not be used in making conduit bends.
- I. Raceways shall be spaced at least 6 inches from parallel runs of heating system pipes, flues, other high temperature piping systems, and other heat sources. This basic spacing shall be increased if necessary to ensure that raceways experience no significant temperature rise from external sources. Raceways shall not be embedded in any spray applied insulation, fireproofing, or other materials that would restrict heat dissipation.
- J. Raceways for Audio/Video systems shall be spaced a minimum of 24 inches from parallel runs of conduits and wiring of power, lighting, and Class 1 signaling. Maintain at least 48 inches of separation from dimmed lighting circuits. Where runs are run parallel for less than 50 feet the required spacing may be halved (12 inches, or 24 inches from dimmed lighting circuits). Where runs are adjacent for less than 6 feet, or where conduits cross at right angles, separations of 2 inches may be used.
- K. Pull wires shall be provided in spare and unused conduits. (Nylon "jet-line" or as approved.)
- L. Conduits stubbed up out of floor and terminating inside of an enclosure shall have insulating grounding bushings installed.
- M. Raceways penetrating vapor barriers or traversing from warm to cold areas shall be sealed on the inside with a non-hardening duct sealing compound to prevent the accumulation of moisture, and shall be taped airtight to the vapor barrier on the outside. Refer to Section 260000 for additional requirements and limitations regarding penetration of vapor barriers.

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- N. Raceways (particularly PVC) shall be provided with expansion joints where necessary to allow for thermal expansion and contraction. Set initial opening of expansion joints per manufacturer's instructions, to suit the ambient temperature at the time of installation.
- O. Provide flexible conduit connection at seismic joints to allow for displacement of conduit in all three axes. Provide appropriate lengths of flexible conduits at seismic joints and appropriate amounts of slack in conduit to allow movement of conduit/cablings in accordance with the design of the seismic joint. Slack shall be maintained in conduit after cabling is installed. Minimum lengths of flexible conduit and minimum amount of slack for various size conduits shall be as follows:
  - 1. 2 inch and greater: 4 foot length, 4-6 inches slack.
  - 2. 1-1/2 inch and smaller: 2 foot length, 3 inches slack.
- P. Flexible metal conduit with supplemental ground jumper shall be used for connection to vibrating equipment, or where installation conditions warrant its use with express permission. Flexible conduit shall not penetrate walls. Liquid-tight flexible conduit with supplemental ground jumper shall be used for motor and transformer connections (except utilize flexible metal conduit in plenum spaces). The ground jumper in flexible conduits shall be routed within the conduit.
- Q. Length of flexible conduit shall not exceed 36 inches, except for lighting fixture whips and where specifically noted. Fixture whips shall not exceed 72 inches. Flexible conduit shall not penetrate walls or vapor barrier retarder/barrier.
- R. Electrical raceways may penetrate roofing membranes only where absolutely necessary. Submit intended locations to Contracting Agency for approval prior to installation. Such penetrations shall be flashed and sealed as required for mechanical piping penetrations of roof. Where practical, conduits stubbed up to roof mounted equipment shall be routed within the equipment curb supporting the equipment.

3.3 RACEWAY INSTALLATION METHODS – TELECOMMUNICATIONS SYSTEMS

- A. Installation methods for telecommunication system conduits shall comply with Installation Methods – General, above, unless superseded by more stringent requirements of this section.
- B. Telecommunications conduits shall comply with the requirements of TIA/EIA-569-A and the Building Industry Consulting Service International (BICSI) Telecommunications Distribution Methods Manual. Note that some of these requirements are more stringent than the requirements of the National Electrical Code.
- C. There shall be no more than two 90-degree bends between pull points in telecommunications conduit. Pull boxes added to conduit runs as a result of this requirement shall be in accordance with this Section. If it is not practical to install a pull box in the run due to field conditions, the conduit size shall be increased to the next trade size for each additional 90-degree bend. Offsets shall be considered as equivalent to a 90-degree bend.
- D. Inside radius of conduit bends shall be at least 6 times the internal diameter of the conduit for sizes up to 2 inch trade size; 10 times the internal diameter of the conduit for sizes larger than 2



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inch trade size. Where bending machine shoes are not available with the required bending radius for a one-shot field bend, factory bent, large radius 90-degree elbows shall be provided.

- E. Conduits stubbed to cable trays shall be terminated within a maximum horizontal distance of 4 inches from the tray and in a vertical zone between 1 to 6 inches above tray. Conduits shall be supported from structure within a maximum horizontal distance of 12 inches from the tray. Conduits shall be provided with a grounding bushing and shall be bonded to the cable tray with a minimum 12 AWG copper conductor.
- F. Use of flexible conduit for telecommunications shall be kept to a minimum and shall be at the discretion of the Contracting Agency. Obtain prior written approval for the use of flexible conduit. Where required due to physical considerations, flexible metal conduit may be allowed in lengths not exceeding 4 feet. If used, flexible metal conduit shall be increased by one trade size for the application used (see Conduit Sizes).
- G. Conduits entering the telecommunications room or equipment room through the floor shall be terminated 4 inches above finished floor. Conduits entering the telecommunications room or equipment room from above shall be terminated 4 inches below the finished ceiling, but in no case shall the conduits terminate more than 12 inches above the cable pathway support or distribution frame.
- H. Conduit sleeves connecting vertically “stacked” telecommunications rooms shall be terminated 4 inches above finished floor. Conduits and cutout openings between floors shall be sealed with firestopping material that is reusable, to accommodate additions and deletions, moves and changes in the cabling system.
- I. Layout of conduits shall give consideration to nearby sources of electromagnetic energy such as electrical power wiring, large electric motors and generators, induction heaters, arc welders, variable frequency drives, etc. Maintain the greatest separation practicable between telecommunication raceways and sources of electromagnetic interference (EMI). A minimum of 5 inches of separation shall be maintained between telecommunication raceways and fluorescent lighting ballasts.
- J. Pull wires shall be provided in spare and unused conduits. (Nylon “jet-line” or as approved.)
- K. Maintain minimum separation from  $\leq 480V$  power wiring in accordance with the following table:

Condition	Minimum Separation Distance		
	< 2 kVA	2-5 kVA	> 5 kVA
Unshielded power lines or electrical equipment in proximity to open non-metal telecommunications pathways	5 inches	12 inches	24 inches
Unshielded power lines or electrical equipment in proximity to a grounded metal telecommunications conduit pathway	2.5 inches	6 inches	12 inches
Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to a grounded metal telecommunications conduit pathway	--	3 inches	6 inches

3.4 CONDUIT SIZES – GENERAL

- A. Minimum sizes for rigid steel, IMC, FRE, rigid aluminum and PVC-40 conduits shall be ¾ inch.
- B. Minimum size for EMT shall be ½ inch.
- C. Minimum size for flexible conduits shall be ½ inch , except fixture whips may be 3/8 inch as allowed by the NEC.

3.5 CONDUIT SIZES – TELECOMMUNICATIONS SYSTEMS

- A. Minimum size for conduit runs to outlets is 1 inch.
- B. Unless indicated otherwise, individual conduit homeruns shall serve no more than one telecommunications outlet.

3.6 STRUCTURAL COORDINATION

- A. Layout conduits in slabs to avoid compromising structural integrity. Obtain approval from Structural Engineer for maximum conduit sizes, quantities, arrangement, and placement in structural slabs.
- B. Structural members shall not be cut, drilled, or notched for raceways or other electrical features unless specifically accepted by the Contracting Agency.
- C. X-ray concrete prior to core drilling. Do not cut rebar without specific authorization from the Contracting Agency. Protect existing equipment and building finishes prior to performing core drills. Replace or repair equipment and/or building finishes damaged during core drilling operations as directed by the Contracting Agency.

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3.7 SURFACE RACEWAY INSTALLATION

- A. Install Products in accordance with manufacturer's instructions.
- B. Use flat-head screws, clips, and straps to fasten raceway channel to surfaces. Mount plumb and level.
- C. Provide outlets in locations shown or according to spacing specified on the Drawings. Where spacing is specified, the maximum distance from each end of the raceway to the first outlet shall not exceed one-half of the specified spacing distance. Mounting elevations shall be as noted on the Drawings or as shown on the Architectural Elevations. If a conflict exists, the elevation shown on the Architectural Elevations shall take precedence.
- D. Provide field paint touch-up with factory furnished paint to match factory pre-painted finish, for all chips, scraps, scratches, fittings and unpainted sections of the surface raceways and multi-outlet assemblies, after installation of all devices and covers are complete.
- E. Provide appropriate separate device finish plates for outlets and telecommunication jacks as specified in other Sections.
- F. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
- G. Close ends of wireway and unused conduit openings.
- H. Ground and bond raceways, multi-outlet assemblies and wireways under provisions of Section 260526 – Grounding and Bonding for Electrical Systems.

3.8 OUTLET BOX INSTALLATION

- A. Outlet boxes shall be securely fastened in position and supported independently of the conduit system.
- B. Outlet boxes located in suspended ceiling system shall be fastened to ceiling "t-bar" system with bar-hanger rods manufactured for the purpose, or from hanger rods with solid supports from structure above. "T-bar" hanger rods shall be clipped to cross-members supported by the main ceiling support members. Outlet boxes supported from the suspended ceiling system shall be provided with one safety wire attached to the box or box support clip, or two safety wires attached to the bar hanger.
- C. Boxes shall be installed true to the building lines and at equal heights in conformity with mounting heights specified in other sections of the specification.
- D. Provide the best suitable box for each outlet requirement. Extension rings shall not be used on new construction except where needed to bring an outlet box out to 1/8 inch of the finished wall or ceiling line.
- E. Boxes shall have only the holes necessary to accommodate the conduits at point of installation. All boxes shall have lugs or ears to secure covers.

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- F. Boxes shall be rigidly secured in position. Recessed boxes shall be so set that the front edge of the box shall be flush with the finished wall or ceiling line, or not more than 1/8 inch back of same. This requirement is more stringent than NEC requirements.
- G. Boxes shall be accessible.
- H. Provide boxes for each application that will not violate the fire rating of the wall, floor or ceiling assembly in which the box is installed.
- I. Do not place order for floor boxes without ensuring that the Contracting Agency has positively approved submittals for the specific cover types/styles colors necessary for all applications and locations.
- J. Recessed boxes shall not be placed back-to-back in adjacent rooms. They shall be offset at least 12 inches, or greater as required by codes and standards applicable to the specific construction.
- K. Boxes (electrical boxes, outlet boxes and telecommunication boxes, etc) penetrating fire rated walls, walls with vapor retarder/barriers, wall types that extend to structure or wall types that contain batts shall be sealed airtight with approved Firestop Putty Pads to reduce sound transmission, reduce air transmission and increase fire resistance. Mold putty pads around electrical junction boxes and conduits to form an airtight seal in accordance with manufacturer's installation instructions.

3.9 JUNCTION BOX AND PULL BOX INSTALLATION

- A. Junction and pull boxes shall be installed so that covers are readily accessible and adequate working clearance is maintained after completion of the installation.
- B. Select boxes properly sized per NEC for power and lighting applications.

3.10 TELECOMMUNICATIONS SYSTEM PULL BOXES

- A. Where a pull box is required in a 1 inch conduit run, outlet boxes as specified in this Section may be used. Where a pull box is required in a conduit run 1 1/4 inch or larger, or where required for multiple raceways, the box shall be sized in accordance with the Table in this Section.
- B. Pull boxes shall be located in straight-through sections of horizontal cabling pathways (conduits). Pull boxes shall not be used for angle pulls or to accomplish changes in direction of the pathway.
- C. Multiple raceways connecting to telecommunications system pull boxes shall penetrate box walls such that they are distributed evenly along the Box wall.

3.11 TELECOMMUNICATIONS SYSTEM JUNCTION BOXES

- A. Telecommunications system interior pathways shall not contain junction boxes.

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SECTION 260533  
RACEWAY AND BOXES FOR  
ELECTRICAL SYSTEMS

END OF SECTION 260533

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## PART 1 - GENERAL

### 1.1 SUMMARY

- A. Provide identification of on equipment, raceways, boxes and conductors.
- B. Section includes:
  - 1. Nameplates
  - 2. Labels
  - 3. Wire markers
  - 4. Conduit markers
  - 5. Miscellaneous Electrical Identification
- C. Related Sections: Divisions 26, 27 and 28 Sections.

### 1.2 SUBMITTALS

- A. Division 1 and Section 260000 – Electrical General Requirements.
- B. Product Data:
  - 1. Submit manufacturer's catalog literature for each product required.
  - 2. Submit electrical identification schedule including list of wording, symbols, letter size, color coding, tag number, location, and function.

## PART 2 - PRODUCTS

### 2.1 NAMEPLATES

- A. Electrical Distribution Equipment Labels and Nameplates
  - 1. Name equipment in accordance with Contract Documents.
  - 2. Nameplates shall be laminated plastic, 0.125 inch thick, with matte finish and square corners. Minimum lettering size as noted elsewhere in this section.
    - a. Label and Nameplate Colors:
      - 1). Normal Equipment: White letters on a black background.
      - 2). Emergency Equipment: White letters on a red background.
      - 3). Standby Equipment: Black letters on a yellow background.
    - b. Securely attach labels with threaded fasteners or pop-rivets. Adhesive attachment not acceptable.

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- c. Temporary markings not permitted on equipment. Repaint trims, housings, etc., where markings cannot be readily removed. Refinish defaced finishes.
3. Include item designation and branch circuit designation (panel and circuit number) on disconnects, starters, equipment and device nameplates, e.g., "FAN No. 4, Circuit LA-30").

2.2 WIRE AND CABLE MARKERS

- A. Wire and Cable Markers: Wrap on labels, cloth tape type wire markers or tubing type for all phase, neutral and ground conductors.

2.3 LABELS

- A. Adhesive film label with clear protective overlay: Machine printed, in black, by thermal transfer process or equivalent. Minimum lettering size as noted elsewhere in this section. Overlay shall provide a weatherproof and UV resistant seal for label.

2.4 UNDERGROUND ELECTRICAL LINE PLASTIC LINE MARKER

- A. Minimum 4 inch wide plastic tape with metallic core with suitable legend describing buried electrical lines.

PART 3 - EXECUTION

3.1 NAMEPLATE INSTALLATION

- A. Install nameplate parallel to equipment lines.
- B. Mechanically fasten nameplates using threaded fasteners or pop rivets.
- C. Mechanical fasteners shall have no sharp edges or points which can damage conductors or injure personnel.
- D. Temporary markings are not permitted on equipment. Repaint trims, housings, etc., where markings cannot be readily removed. Refinish defaced finishes.
- E. No labeling abbreviations are permitted without prior approval.

3.2 NAMEPLATE LOCATIONS

- A. Provide 1/4-inch minimum height letters on:



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1. Panelboards: Provide signage in accordance with NEC 408 indicating maximum available fault current and date of fault current calculation.
2. Disconnects, starters, VFDs and contactors:
  - a. Line 1: Load Served (Use nameplate designation for source).
  - b. Line 2: Panelboard and circuit number from which the device is fed.
  - c. Line 3: Voltage, Phase, fuse size or circuit breaker size.
3. Lighting control relays, dimmer controls and remote lighting control equipment.
4. Switches and receptacles where item controlled is not visible from the switch, or as noted on Drawings.
5. External Power Sources: Provide 1/4 inch white letters on red background on all starters or controllers that receive power from an external source that is not de-energized by operating the associated disconnecting means.
6. Designated electrical equipment.

3.3 RECEPTACLE AND LIGHT SWITCH DEVICE PLATES

- A. Provide 3/16 inch minimum height letters on receptacle and light switch device plates:
1. Engrave branch circuit designation (panel and circuit number) on receptacle and light switch device plates, e.g., "NHA-30"). Verify final panel designations with Contracting Agency prior to engraving nameplates.

3.4 TELECOMMUNICATION LABELING REQUIREMENTS.

- A. Provide machine printed labels for all telecommunication racks, cabinets, patch panels, cables, outlets, etc., in accordance with ANSI/TIA/EIA-606-B to match existing building standards. Provide labeling nomenclature in accordance with information on the Drawings or Owner's labeling conventions. Submit labeling samples for all required applications.
- B. Machine Printed Label Requirements:
1. PC Compatible.
  2. Can save and modify files.
  3. Fully integrated with AutoCAD.
  4. Editable Fonts and Sizes.
  5. Rotate Text and Objects.
  6. Vary Line Spacing.
  7. Ability to import graphical images.
  8. Capable for customization of layout.
  9. Re-positional labels.
- C. Labeling and color coding identification for this project shall conform to TIA/EIA-606-B.

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3.5 LABEL LOCATIONS

- A. Provide 3/16 inch minimum height letters on the following equipment:
1. Security System Device Labels:
    - a. Provide label on each security field device, denoting device address. Affix label to device faceplate for ceiling-mounted devices or wall mounted devices above 8'-0" AFF. Affix label inside back box for exterior devices.
  2. Fire Alarm Device Labels:
    - a. Provide label on exterior surface of each initiating device denoting the unique device address corresponding to the text annunciator description. For detectors, the label shall be affixed to the base and not to the detector itself. For pull stations, the label shall be affixed to the top of the device and not to the vandal proof cover.
    - b. Provide label on each remote test station indicating description and location of device being tested.
    - c. Provide label on telecom conductors at each end denoting FACP lines for use with the digital alarm communicator transmitter (DACT).

3.6 DISTRIBUTION/BRANCH CIRCUIT PANELBOARD CIRCUIT LABELING

- A. Distribution Panels and Branch Circuit Panelboard Directories: Provide neatly typed schedule (odd numbered circuits on left side or top, even on right side or bottom) under plastic jacket or protective cover to protect the schedule from damage or dirt. Securely mount on inside face of panelboard door. Define briefly, but accurately, nature of connected load (i.e., Lighting Room 201, Receptacles Janitor Room 155, Etc.) as approved. Sequentially numbered schedules shall not be used.
- B. Use final approved room numbers from finished construction (not necessarily as indicated on the drawings).
- C. Provide numbering for terminals on terminal strips in the terminal enclosure that identifies the origin, function and destination of each conductor.
- D. Install wire marker for each conductor inside panelboards (phase, neutral and ground conductors). Locate label within 6 inches of termination. Labels shall be visible with panel dead front installed.
- E. Provide updated circuit directory in existing panelboards that are modified. Install directory in panelboard in protective cover and submit electronically in the O&M Manual.

3.7 WIRE MARKER INSTALLATION

- A. Install wire marker for each conductor (phase, neutral and ground conductors) at panelboards, pull boxes, outlet and junction boxes, and each load connection. Locate label within 6 inches of termination in panelboards. Labels shall be visible with panel dead front installed.

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- B. Wire markers are not required on conductors in a pull or junction box that contains only an individual branch circuit, however, source panel and circuit number shall be noted on pull or junction box cover as noted elsewhere in this section.
- C. Fire Alarm Circuits: Provide cable markers showing Notification Appliance Circuit (NAC) or Signaling Line Circuit (SLC) loop identification number at fire alarm junction boxes and pullboxes.
- D. Security System Cables: Install wire marker for each cable at cabinets, pull boxes, junction boxes, and each load connection. Wire ID number shall be as shown on security system shop drawings.
- E. Power Circuits: Panelboard name and branch circuit or feeder number.
- F. Control Circuits: Control wire number as indicated on schematic and/or shop drawings.
- G. Color Code:
  - 1. Color code phases, neutral, and ground per NEC requirements and Section 260519 – Wire and Cable.
  - 2. Color code all low voltage system wiring in accordance with applicable Sections.

3.8 MISCELLANEOUS ELECTRICAL IDENTIFICATION

- A. Junction Boxes: Mark the circuit number(s) and panel source of wiring on all junction boxes with sheet steel covers. Mark with indelible black marker. On exposed junction boxes in finished areas mark on inside of cover.
- B. Conduits
  - 1. Mark all conduits entering or leaving panelboards with indelible black magic marker with the circuit numbers of the circuits contained inside.
  - 2. Fire Alarm System: Paint fire alarm conduits with a 6 inch band 10 feet on center with red paint where installed in concealed accessible location (or provide red conduit in accordance with Section 260519 – Low Voltage Electrical Power Conductors and Cables and Section 260533 – Raceways and Boxes for Electrical Systems. Where raceway is installed in exposed locations it shall be painted to match the adjacent surface.
  - 3. Empty Conduits: Provide tags with typed description of purpose, and location of opposite end, wired to each end of conduits.
- C. Junction Boxes
  - 1. Markings shall be made with indelible black marker.
  - 2. On exposed junction boxes in finished areas markings shall be on inside of cover.
  - 3. Mark the circuit numbers of wiring on all junction boxes with sheet steel covers.
  - 4. Mark all Special System junction boxes with sheet steel covers with appropriate system designation, e.g., "Intercom", "Clock", "Telecom", "Video Surveillance", etc. Fire Alarm System: Paint all fire alarm junction boxes inside and out with red paint where installed in

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concealed accessible location. Where installed in exposed locations paint boxes to match the adjacent surface.

- D. Provide a label at the fire alarm control panel that identifies the panelboard and circuit number that supplies the control panel. Provide a red label adjacent to the circuit breaker inside the panelboard that clearly identifies the circuit breaker that feeds the control panel in accordance with NFPA requirements.

3.9 CODE REQUIRED MARKINGS AND WARNINGS:

- A. Provide all placards, markings and identification systems required by Code and/or the Contract Documents, such as (but not limited to):
  - 1. Arc Flash.
  - 2. Conductor insulation color identification.
  - 3. Special conductor identification and legends.
  - 4. Multiple services placards.
  - 5. Emergency systems markings.
  - 6. Emergency source grounded circuit conductor connected to a grounding electrode at a location remote from the emergency source: Provide a sign at the grounding location identifying all emergency and normal sources connected at that location.
  - 7. Warning messages shall include an appropriate plain language imperative command, such as "DANGER HIGH VOLTAGE - KEEP OUT".
  - 8. Available Fault Current: Service equipment shall be legibly marked in the field with the maximum available fault current. The field marking(s) shall include the date the fault calculation was performed and shall be of sufficient durability to withstand the environment involved.

END OF SECTION 260553

## PART 1 - GENERAL

## 1.1 SUMMARY

- A. This section includes specific requirements, products, and methods of execution relating to intelligent lighting control devices approved for use on this project.
- B. Related Sections
  - 1. 260553 - Identification for Electrical Systems
  - 2. 262726 - Wiring Devices
  - 3. 265000 - Lighting Fixtures

## 1.2 SCOPE

- A. All lighting control devices shall be programmed and function in accordance with the Lighting Control Schedule as indicated on the Construction Documents.
- B. Control Devices under this section are shown diagrammatically on the drawings and additional Class 1 and/or Class 2 wiring may be required for a complete system. It shall be the responsibility of the contractor and system vendor to determine the quantity and type of cable/wiring required for the complete and proper operation of the system. System design is based upon intelligent controls and/or lighting fixtures interconnected with CAT5e cables or connected wirelessly.
- C. Provide material, labor and programming to provide a complete and properly working system that complies with the sequence of operations in the Lighting Control Schedule as well as applicable energy codes.

## 1.3 SUBMITTALS

- A. Provide Submittals for products in accordance with Section 260000 - Electrical General Requirements and Division 1.
- B. Shop Drawings/Submittals shall include but not limited to:
  - 1. Layouts of photocells/daylight sensors, occupancy sensors and standalone devices necessary for a complete working system.
  - 2. Wiring diagrams showing the connection of all system parts and necessary electrical provisions to accommodate the intent of the design.
  - 3. Installation sheets with complete product information.
  - 4. Manufacturer Start-up Instructions and requirements.
  - 5. Manufacturer's warranty certificate.
  - 6. Show layout of ALL sensors, integral or separate from fixtures, that will be visible to the building occupants.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. Cree SmartCast®

2.2 SYSTEM COMPONENTS & REQUIREMENTS

A. System shall have an architecture that is based upon the following:

1. Intelligent lighting control devices
2. Standalone lighting control zones

B. Intelligent lighting control devices shall consist of one or more basic lighting control components:

1. Occupancy sensors
2. Photocell/Daylight sensors
3. Relays
4. Power supplies
5. Low voltage or Line voltage wiring
6. Dimming outputs
7. Manual wall stations
8. Manual dimming stations

Combining one or more of these components into a single device enclosure is permissible to minimize overall device count of system (e.g. occupancy/photocell sensor).

C. Lighting control zones shall include one or more intelligent lighting control components and be capable of the following:

1. Stand-alone operation

D. Sensors shall be dual technology, a combination of a passive infrared (PIR) and ultrasonic or microphonic. Sensor unit requires infrared detection event to activate lights and will maintain occupied state dependent on continued passive infrared detection or, when dual technology is present, acoustic/ultrasonic detection of occupants.

E. Wall mounted sensors shall match standard switch and receptacle device color per Section 26 2726 – Wiring Devices.

F. Ceiling sensors shall be white unless otherwise noted.

G. Low Voltage Wall Stations shall be labeled in accordance with Section 260533 and the Construction Documents.

## 2.3 OCCUPANCY SENSORS

## A. Control Modules

1. Fixtures indicated with discrete ceiling control modules on the Lighting Fixture Schedule shall be limited to one control module to a group of fixtures within a lighting control zone.

## B. Wall Mounted Occupancy Sensor/Switch

1. Minimum 180-degree area coverage.
2. Sensor unit shall have several programmable modes of operation:
  - a. Occupancy Mode
  - b. Vacancy Mode
  - c. Automatic On with Exit Time
  - d. Override Off Mode
  - e. Disable Switch Mode

## C. Wall Mounted Occupancy Sensor

1. Minimum 180-degree area coverage.
2. Mount wall mounted sensor at 10 feet in rooms with ceilings higher than 10 feet.
3. In rooms with high ceilings, ceiling mounted occupancy sensor may be used.
4. Sensor shall have an optional integral photocell with three different modes of operations available:
  - a. Daylight Harvesting (0-10V Dimming to maintain the target light level)
  - b. ON/OFF Photocell Control (Lights switched OFF if ambient level surpasses the threshold and back ON if level drops).
  - c. Inhibit Only Photocell Control (Lighting is held OFF if sufficient ambient light level is present upon initial occupancy).

## D. Ceiling Mounted Occupancy Sensor

1. Minimum 360-degree area coverage.
2. Mount a minimum of 4 feet from air supply ducts.
3. Sensor shall have an optional integral photocell with three different modes of operations available:
  - a. Daylight Harvesting (0-10V Dimming to maintain the target light level)
  - b. ON/OFF Photocell Control (Lights switched OFF if ambient level surpasses the threshold and back ON if level drops).
  - c. Inhibit Only Photocell Control (Lighting is held OFF if sufficient ambient light level is present upon initial occupancy).

## 2.4 DAYLIGHT SENSORS

## A. Wall/Ceiling Mounted Daylight Sensor

1. Sensor shall have the following operational modes:

- a. Daylight Harvesting to dim
- b. Daylight Harvesting to Off
- c. Photocell Override (On/Off)
- d. Initial Inhibit Only (Hold Off)

## 2.5 PHOTOCELLS

### A. Outdoor Photocells

1. 120-277 VAC 50/60Hz
2. Stem and Swivel Mount
3. Photocell shall be weatherproof and suitable for outdoor environment (-40-degree Fahrenheit) or provided with weatherproof case.
4. Minimum of 2400V open type spark gap arrestor to protect against voltage surges.
5. Basis of design manufacturer: Intermatic.

## 2.6 LOW VOLTAGE WALL STATIONS

- A. Stations shall be capable of switching and/or dimming the lighting load with a momentary pulse length of 250msec.
- B. Stations shall be capable of multiway switching with all connected stations indicate the same state. For spaces with multiple wall stations, manual dimming control shall be available at all stations.
- C. Dimming Station shall have the following characteristics:
  1. Turn On/Turn Off lighting manually or automatic with occupancy sensor.
  2. Turn On lighting to last user level or can be programmed to a pre-set level (100%, 50%, or custom).
  3. Up/Down operation to manually adjust the intensity of the lights.
- D. Scene Controllers shall have two, three, four, or eight buttons for selecting programmable lighting control profiles or acting as on/off switches:

## 2.7 POWER PACKS

### A. Power (Relay) Packs shall have the following characteristics:

1. Plenum rated.
2. Communication will be delivered to each device via standard low-voltage network cabling with RJ-45 connectors.
3. Supply Voltage: 120 to 277 V(ac).
4. Relay Output: Class 1 relay rated for 16 A at 277 V(ac) and 1/2 HP at 120 V(ac).
5. Dimming Output: 0-10 VDC Dimming output.
6. Sink Current: 100 mA at 0-10 V(dc).
7. Mounting: Integral 1/2-inch chase nipple. Plastic clips into junction box are unacceptable.



## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Install equipment in accordance with the manufacturer's instructions in the locations indicated on the Drawings and coordinate ceiling-mounted devices with other constructions that is supported by and/or penetrates the ceiling, including luminaires, smoke detectors, HVAC equipment, and fire-suppression systems.
- B. Door swings shall be checked and, if necessary, switches shall be relocated to place them on the strike side of the door.
- C. Locate and aim sensors as required for complete and proper volumetric coverage within the range of coverage of controlled areas per the manufacturer's recommendations. Rooms shall have 90% minimum coverage to completely cover the controlled area. Coverage shall accommodate all occupancy at any location within the room. The locations and quantities of sensors shown on the Drawings are diagrammatic and indicate only the minimum quantity and placement of sensors that are to be provided. Provide additional sensors if required to properly and completely cover the respective room.
- D. All occupancy sensors shall be installed in accordance with manufacturer's recommendations. All units shall be set to "automatic on" mode and the maximum time delay before turning off light fixtures. Verify proper operation of all sensors. The sensing units' coverage area shall be restricted if required to avoid sensing people or extraneous influences in adjacent areas or corridors. This shall be done by covering a portion of the sensing lens with white paper tape in accordance with manufacturer's recommendations.
- E. Contractor is to provide a sufficient quantity and layout of occupancy sensors to properly meet coverage and intended sequence of operation. Locations shall be carefully selected to insure that coverage patterns are unobstructed.
- F. Mount occupancy and daylight sensors in finished spaces according to manufacturer instructions. In unfinished spaces or where ceiling-type sensors are installed where there is exposed structure, mount the sensors in surface mounted outlet boxes.
- G. Wiring shall be arranged as shown on the shop drawings. Low voltage cable shall be installed in raceways where concealed or J-hooks where installed in ceilings.
  - 1. CAT5e cables connect control devices in uninterrupted continuous runs without intermediate splices. Cables shall be free from shorts or ground and shall be tested.
  - 2. Cables shall be routed so as to maintain a separation of at least 610 mm (24 in) from all heat sources and from ballasts, transformers, dimmers and other sources of electromagnetic interference. Avoid exposed cables in occupied areas or in areas where they might be damaged as a result of normal use of the area. Where two (2) or more cables run in parallel, they shall be bundled with cable ties
  - 3. Cables run exposed in accessible ceiling spaces shall be supported by means of suitable cable support devices (J-hooks) from the building structure. They shall not lie upon the ceiling, nor shall they be supported from the ceiling frame, ceiling suspension wires, conduits, pipes, ductwork or lights. Supports shall be spaced no further apart than 4 feet on center.

4. Care shall be exercised during cable installation not to damage cable insulation. Damaged cables shall be removed and replaced. Type and spacing of supports shall ensure that cable will not kink or sag.
5. In each cable that terminates at a ceiling device, provide 305 mm (12 in) of slack cable, neatly coiled, to facilitate future modifications. Terminations shall be made in a neat and workmanlike manner.
6. Terminate the manufacturer's recommended cable type to the appropriate termination point (RJ45 jack, etc.).
7. Cabling for 0-10V dimming control shall be installed in raceway (1/2" EMT), except where installed above accessible ceiling. Raceway shall be installed orthogonal to room surfaces, and be concealed by structure wherever possible.
8. CAT5e control cable shall be run orthogonal to room surfaces, be routed along edges of rooms and concealed by structure wherever possible. Provide identification for control devices (Device ID #'s) per manufacturer instruction.

### 3.2 ADJUSTMENT, TESTING & DEMONSTRATION

- A. Notify the Contracting Agency at least two (2) weeks in advance of the date of each test, to allow witnessing of the tests if desired.
- B. Prior to the start of functional performance testing, complete all start-up and checkout procedures and verify that the equipment is completely ready to be tested. The contractor shall be present during functional performance testing.
- C. The contractor is to supply tools, instruments, gauges, testing equipment, protective devices and safety equipment for adjustment, testing and demonstration as needed.
- D. Prior to system testing, prepare a list of the devices to be tested, together with the associated location of each device and device identification (bar code number, ID, etc.). Include space to indicate test response for each device.
- E. During adjustment and testing, carefully record all settings and all test results, including expected test results, actual test results, and corrective actions taken. Records shall be submitted to the Contracting Agency and included in the Operating & Maintenance Manuals. Settings of devices from software is acceptable documentation
- F. Initial Set-up: Verify that wiring is correctly connected to each device. Adjust controls to function as specified under the sequence of operation. Settings shall comply with the sequence of operation.
- G. Verify sensor placement, aiming, calibration and settings to ensure trouble-free operation.
- H. For each room with day lighting controls calibration shall be performed on a day with sufficient daylight. Additional visits shall be scheduled as necessary if conditions are not correct for calibration. Follow manufacturer recommendations.
- I. Program sequences of operation that include time functions to operate at times selected by the Contracting Agency. Information must be available before technician is scheduled for start-up.

- J. Field Testing: Test all system features for proper function. Tests to be performed shall include, but not be limited to, the following:
1. Verify the sequence of operation for each device.
  2. Verify the setting and accuracy of each timing function in each device.
  3. Verify that each manual override control functions properly.
  4. Verify that occupancy sensors do not remain actuated due to normal conditions (e.g., air movement).
  5. Verify that occupancy sensors are actuated by hand motion within the entire area of coverage.
  6. Verify that occupancy sensors actuate when a person enters the area of coverage.
  7. Measure the illumination level in daylight zones equipped with daylight harvesting controls.
  8. Correct any deficiencies discovered as a result of the above testing, and completely retest the work affected by such corrections as part of the required installation and testing.

### 3.3 ON-SITE TRAINING

- A. After the system has been completed, tested and is operating properly, the manufacturer's representative shall demonstrate by actual usage, the proper operation of each system device and function in the presence of the Contracting Agency. Demonstration shall include repetition of selected field tests, as well as additional adjustment or testing required to demonstrate that the system performs in accordance with the operational description as specified herein and the Owner's operational requirements.
- B. The training shall be conducted after the Operating and Maintenance Manuals for the project are completed and available for use during the training session.
- C. Conduct two (2) hours minimum of training for the Owner's maintenance personnel in the operation and maintenance of the lighting controls and applicable software. Training time shall be extended as necessary to satisfy the Contracting Agency that all pertinent topics have been adequately covered.
- D. Maintain a training sign-in sheet, upon which participants in the training session, including the instructors, shall record their names. The training sign-in sheet shall be dated.
- E. On-site training shall follow a written training plan, prepared in advance. The training plan shall outline the topics to be covered, the publications to be used, and the training schedule.
- F. The training shall be conducted by technicians who are thoroughly familiar with the equipment and its features, and also with the Project. The training shall include instruction, field demonstration, and over-the-shoulder hands-on exercises. As a minimum, the training shall cover, but not be limited to, the following topics:
1. General overview of lighting controls, including purpose and principle of operation.
  2. Location of lighting control components.
  3. Interpretation of equipment output devices, such as indicators and status contacts.
  4. Control adjustments and settings.
  5. Operation of system controls, including over-ride switches.
  6. Recommended maintenance procedures and intervals.

7. Operation of system software.
- G. At the conclusion of the training session, obtain written sign-off from the Contracting Agency. Insert a copy of the sign-off form and the training sign-in sheet into the Operating and Maintenance Manuals.

3.4 FIELD QUALITY CONTROL

- A. Document each installation and operational step in accordance with approved shop drawings and manufacturer's requirements.
- B. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.

END OF SECTION 260923

## PART 1 - GENERAL

### 1.1 SUMMARY

- A. This section includes general provisions, products and methods of execution relating to line voltage wiring devices for use on this project.
- B. Related Sections
  - 1. 260533 - Raceway and Boxes for Electrical Systems

### 1.2 REFERENCES

- A. National Electrical Manufacturers Association:
  - 1. NEMA WD 1 - General Requirements for Wiring Devices.
  - 2. NEMA WD 6 - Wiring Devices-Dimensional Requirements.

### 1.3 SUBMITTALS

- A. Provide submittals for products in accordance with Section 260000 - Electrical General Requirements and Division 1.
- B. Do not place order for devices, plates, etc., without ensuring that the Contracting Agency has positively approved submittals for the specific colors necessary for all applications and locations. Note that the selection of one color for general use does not rule out the selection of other colors for special applications or for aesthetic reasons.

### 1.4 QUALITY ASSURANCE

- A. Manufacturers mentioned and catalog numbers specified are for establishment of type, configuration and quality. Other manufacturers and types may be submitted for approval.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Basis of Design is Hubbell commercial grade wiring devices to set a standard for quality. Equal devices manufactured by Arrow Hart (by Cooper Wiring Devices), Pass and Seymour, Leviton and Bryant are acceptable. Provide all similar devices of same manufacturer.

2.2 SWITCHES

- A. Provide UL listed 20 AMP switches with voltage rating for the load served. Switches shall include the following:
  - 1. Single Pole
  - 2. Three-way
  - 3. Four-way
  - 4. Key Operated
  - 5. Momentary Cont.
  - 6. Double Pole
  - 7. Pilot Switch
  
- B. Other switch types shall be provided as called for on the Drawings or as required by the application.

2.3 RECEPTACLES

- A. Provide grounding type receptacles as follows, or as required to match equipment furnished in this or other divisions.

15A-125V	NEMA #5-15R
15A-125V GFCI	NEMA #5-15R
15A-250V Single	NEMA #6-15R
Clock hanger 125V	NEMA #5-15R
20A-125V USB Charger Tamper Resistant	NEMA #5-20R
20A-125V	NEMA #5-20R
20A-125V GFCI	NEMA #5-20R
20A-125 SPD	NEMA #5-20R
20A-125V Tamper Resistant	NEMA #5-20R
20A-125V Tamper Resistant (hospital grade)	NEMA #5-20R
20A-250V Single	NEMA #6-20R
30A-250V Dryer	NEMA #14-30R
50A-250V Range	NEMA #14-50R

- B. Outlets requiring ratings and configurations different from those listed above shall be provided as shown on the plans and/or required by the equipment served.

2.4 DEVICE COLOR

- A. Device color shall be the following unless otherwise noted or as selected by the Architect:

1. white

B. Receptacles connected to standby panelboard shall be red.

## 2.5 DEVICE PLATES

A. Device plates shall be constructed of the following materials unless otherwise noted:

1. Satin finished Type 302 stainless steel

B. Indoor device plates for surface mounted boxes in utility spaces shall match the box and device type being used and shall be constructed of the following:

1. Stainless or galvanized steel

C. Weatherproof outlet plates shall be of the safety outlet enclosure type that can be closed to remain weatherproof while in use. The outlet cover/enclosure shall be clearly marked "Suitable for Wet Locations While In Use", "UL Listed", and "Extra-Duty". A gasket shall be provided between the enclosure and the mounting surface, and between the hinged cover and the mounting plate/base to ensure a proper seal. Enclosure shall be oversized depth, single-gang, vertical-mount, with non-locking latch, GFCI opening, cord openings, and cover.

D. Label receptacle and light switch plates in accordance with Section 260553 – Identification for Electrical Systems.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install wiring devices indicated complete with cover plates. Cover plates shall fit snugly against finished surfaces and line up true with adjacent building lines, and be symmetrical in location and appearance.

B. Switches shall be installed so their handles move in a vertical plane.

C. Door swings shall be checked and, if necessary, switches shall be relocated to place them on the strike side of the door.

D. Unless otherwise noted on the drawings, receptacles shall be installed in the vertical position with the grounding pin down unless wording on the face of the device requires other mounting.

E. Receptacles identified as Ground-Fault Circuit Interrupter (GFCI) type shall be provided as individual GFCI receptacles, unless otherwise noted.

F. NEMA 5 configuration receptacles located in shops or commercial kitchens whether on single or multiple receptacle circuits shall be rated at least 20 amps.

G. Receptacles in the following spaces shall be tamper-resistant in accordance with NEC Article 406:

1. Business offices, corridors, waiting rooms and the like in clinics, medical and dental offices, and outpatient facilities
- H. Receptacles located in patient care spaces shall be hospital grade in accordance with NEC Article 517.

END OF SECTION 26 2726



PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermal Magnetic Molded Case Circuit Breakers.
2. Electronic Trip Molded Case Circuit Breakers.
3. Fusible switches and fuses.

B. Related Sections:

1. 262416 - Panelboards

1.2 REFERENCESVCFV

A. The circuit breaker(s) referenced herein shall be designed and manufactured according to the latest revision of the following standards.

1. ANSI/NFPA 70 - National Electrical Code (NEC).
2. NEMA AB 1 - (National Electrical Manufacturers Association) Molded Case Circuit Breakers and Molded Case Switches.
3. UL 489 - (Underwriters Laboratories Inc.) Molded Case Circuit Breakers and Circuit Breaker Enclosures.
4. UL 943 - Standard for Ground Fault Circuit Interrupters.
5. UL 1053 – Ground Fault Sensing and Relaying Equipment.
6. CSA C22.2 No. 5 - (Canadian Standard Association) Molded Case Circuit Breakers, Molded Case Switches and Circuit Breaker Enclosures.
7. Federal Specification W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service.
8. Federal Specification W-C-865 - Fusible Switches.
9. IEC 60947 – Low Voltage Switchgear and Control Gear – Part 2: Circuit Breakers.
10. IEC 61000-4 Series – Electromagnetic Compatibility.

1.3 SYSTEM DESCRIPTION

A. Provide overcurrent protective devices as specified herein and as shown on schedules and/or drawings.

1.4 SUBMITTALS

A. Provide submittals for products in accordance with Section 260000 - Electrical General Requirements and Division 1.

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- B. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications. Submit product data for each type of overcurrent protective device, ground fault protector, accessory, and component indicated. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- C. Provide outline drawings with dimensions, and ratings for voltage, amperage and maximum interruption. Include instructions for circuit breaker mounting, trip unit functions and adjustments, trouble shooting, accessories and wiring diagrams.
- D. Coordination data to check protective devices: Manufacturer shall provide electronic and hard copy time/current characteristic trip curves (and  $I_p$  &  $I^2t$  let through curves for current limiting circuit breakers) for each type of circuit breaker.
- E. Provide information required to verify compliance with the short circuit withstand and interrupting ratings, as shown on the Drawings or further stated in these Specifications.
- F. Arc Flash Hazard Analysis Study: Provide an Arc Flash Hazard Analysis Study for the revised electrical distribution system provided under this project per the requirements set forth in NFPA 70E-Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA 70E, Annex D.

1.5 QUALITY ASSURANCE

- A. Devices shall be the latest approved design as manufactured by a nationally recognized manufacturer and in conformity with applicable standards and UL listings.
- B. Nationally Recognized Testing Laboratory (NRTL) Labeling: Electrical equipment and conductors installed in the State of Alaska must be "Approved," "Certified," "Identified," or "Listed" and "Labeled" to establish that the electrical equipment is safe, free of electrical shock and fire hazard, and suitable for the purpose for which it is intended to be used. The manufacturer shall have the specific authorization of one of the Occupational Safety and Health Administration (OSHA) approved Nationally Recognized Testing Laboratories (NRTLs) in accordance with the applicable national standards to label the equipment as suitable.
- C. The overcurrent protection device manufacturing facility shall be Registered by Underwriters Laboratories Inc. to the International Organization for Standardization ISO 9000 Series Standards for quality.

PART 2 - PRODUCTS

2.1 PRODUCT

- A. Match existing building standard electrical panelboards breaker types by Siemens.

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2.2 MOLDED CASE CIRCUIT BREAKERS

A. General Characteristics:

1. Circuit breakers shall be constructed using glass reinforced insulating material. Current carrying components shall be completely isolated from the handle, and the accessory mounting area.
2. Circuit breakers shall have an over center, trip free, toggle operating mechanism which shall provide quick make, quick break contact action. The circuit breaker shall have common tripping of all poles.
3. The circuit breaker handle shall reside in a tripped position between on and off to provide local trip indication. Circuit breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings.
4. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker.
5. MCCBs shall be able to receive a device for locking in the isolated position. MCCBs that serve as the main service disconnect shall be provided with a device for locking in the isolated position.
6. Electronic components shall withstand temperatures up to 221°F (105°C).
7. Lugs shall be UL listed to accept solid (not larger than #8 AWG) and/or stranded copper and aluminum conductors. Lugs shall be suitable for 75°C rated wire or 90 C rated wire, sized according to the 167°F (75°C) temperature rating in the NEC.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with reviewed product data, final shop drawings, manufacturer's written recommendations, and as indicated on the Drawings. Install circuit breakers in accordance with manufacturer's instructions, the National Electrical Code and applicable local codes.
- B. Size devices as shown and specified, or as required by the load being served.

3.2 ARC FLASH LABELING

- A. Provide arc flash labels for equipment that provides all of the following:
  1. Nominal system voltage
  2. Arc flash boundary
  3. At least one of the following:
    - a. Available incident energy level or arc flash PPE Category in NFPA 70E, Standard for Electrical Safety
    - b. Minimum arc rating of clothing
    - c. Site specific level of PPE

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3.3 FIELD QUALITY CONTROL

- A. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.

END OF SECTION 262800

## PART 1 - GENERAL

### 1.1 SUMMARY

- A. This section includes general requirements, products, and methods of execution relating to fusible and non-fusible disconnecting devices approved for use on this project.
- B. Related Sections:
  - 1. 260519 - Low Voltage Electrical Power Conductors and Cables
  - 2. 260526 - Grounding and Bonding for Electrical Systems
  - 3. 260529 - Hangars and Supports for Electrical Systems
  - 4. 260553 - Identification for Electrical Systems

### 1.2 SUBMITTALS

- A. Provide submittals for products in accordance with Section 260000 - Electrical General Requirements and Division 1.

### 1.3 QUALITY ASSURANCE

- A. Devices shall be of the latest approved design as manufactured by a nationally recognized manufacturer and in conformity with U.L. listings and the governing NEMA standards.
- B. Disconnects shall be of the same manufacturer as switchboards and panelboards.

## PART 2 - PRODUCTS

### 2.1 SAFETY SWITCHES

- A. Safety switches, fusible and non-fusible, shall conform to NEMA Standard KS1 for type HD (Heavy Duty) unless otherwise noted.
  - 1. Switch Interior: Switches shall have switch blades that are fully visible in the OFF position when the door is open. Switches shall be of dead front construction with permanently attached arc suppressers. Lugs shall be UL listed for copper and/or aluminum cables and be front removable.
  - 2. Switch Mechanism: Switches shall have a quick-make and quick-break operating handle and mechanism that shall be an integral part of the box, not the cover. Switches shall have a defeatable dual cover interlock to prevent unauthorized opening of the switch door in the ON position or closing of the switch mechanism with the door open. The switch shall be capable of being locked in the OFF position with three (3) padlocks.

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3. Enclosures: Switch enclosure shall be suitable for the environment in which the switch is mounted. NEMA 1 enclosure shall be code gauge, UL-98, sheet steel, treated with a rust inhibiting phosphate and finished in gray, baked enamel. NEMA 3R enclosure--same requirements as NEMA 1 except galvanized prior to painting.
4. Rating: Ampere, volt and horsepower ratings, as well as number of poles and presence of neutral bar shall be shown on the nameplate.

## 2.2 CIRCUIT BREAKERS

- A. Circuit breakers used as disconnects shall meet requirements specified in Section 262800 – Low Voltage Circuit Protective Devices. Enclosures for same shall meet the requirements as specified above.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Coordinate details pertaining to size of motor and/or equipment, location and requirements to enclosure, ratings, etc., so as to provide the most suitable unit for the intended purpose.
- B. Provide nameplates for disconnects. Coordinate names with mechanical equipment lists.
- C. Where the rating of a fused disconnect exceeds the ampacity of the conductors being protected, a permanent label noting maximum fuse size shall be installed in a conspicuous location within the switch.
- D. Where recommended or required by the equipment manufacturer, or required by underwriters' laboratories, disconnects shall be the fusible type, fused in accordance with the equipment nameplate information.
- E. Provide code required disconnects. For equipment under the jurisdiction of the IMC, provide a disconnect within sight of the equipment.

### 3.2 FIELD QUALITY CONTROL

- A. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.

END OF SECTION 262816

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes general requirements, products, and methods of execution relating to manual and magnetic motor starters provided in this and other Divisions. Overloads shall be furnished and installed in Divisions 26, 27 and 28.
- B. Related Sections:
  - 1. 260553 - Identification for Electrical Systems

1.2 REFERENCES

- A. National Electrical Manufacturers Association:
  - 1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
  - 2. NEMA FU 1 - Low Voltage Cartridge Fuses.
  - 3. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
  - 4. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices.
  - 5. NEMA ICS 6 - Industrial Control and Systems: Enclosures.
  - 6. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- B. International Electrical Testing Association:
  - 1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.3 SUBMITTALS

- A. Provide submittals for products in accordance with Section 260000 - Electrical General Requirements and Division 1.

1.4 QUALITY ASSURANCE

- A. Equipment shall be of the latest approved design as manufactured by a nationally recognized manufacturer and in conformity with the governing standards.

## PART 2 - PRODUCTS

## 2.1 BASIS OF DESIGN

- A. The Basis of Design is equipment from Square D by Schneider Electric to set a standard for quality. Equipment from alternative systems will be considered providing that sufficient documentation is provided to satisfy the CONTRACTING AGENCY that the equipment meets the requirements of the Specifications, and matches the Basis of Design on all points which are pertinent to the Project.

## 2.2 AC FRACTIONAL MANUAL STARTERS

- A. The manual starter shall consist of a manually operated toggle switch equipped with red pilot light and melting alloy type thermal overload relay.
- B. Thermal unit shall be one piece construction and interchangeable. Starter shall be inoperative if thermal unit is removed.

## 2.3 AC MANUAL STARTERS--LINE VOLTAGE TYPE

- A. Manual starters shall be constructed and tested in accordance with the latest published NEMA standards.
- B. The manual starters shall consist of a manually operated switch equipped with red pilot light and melting alloy type thermal overload relays in every phase conductor. Thermal units shall be one piece construction and the starter shall be inoperative if any thermal unit is removed.
- C. Starters shall be furnished in a NEMA 1 general purpose enclosure unless otherwise indicated on the plans or required by the conditions of the area in which they are installed.

## 2.4 AC MAGNETIC STARTERS--LINE VOLTAGE TYPE

- A. Motor starters shall be across-the-line magnetic type rated in accordance with NEMA standards, sizes and horsepower ratings.
- B. Starters shall be mounted in NEMA 1 general purpose enclosures unless otherwise indicated on plans or required by the conditions of the area in which they are installed.
- C. Starters shall be furnished with overload relays in every phase conductor and starters shall be inoperative if any overload unit is removed.
  - 1. Overload relays shall be the solid state type. Trip current rating shall be established by selection of overload relay and shall be adjustable (3 to 1 current range). The overload shall be self-powered, provide phase loss and phase unbalance protection, have a permanent tamper guard, and be ambient insensitive. Overload shall be standard trip (Class 20) and shall have a mechanical test function.



- D. Starters through NEMA size five (5) shall be equipped with double break silver alloy contacts. Contacts shall be replaceable without removing power wiring or removing starter from panel.
- E. Coils shall be of molded construction and shall be 120 VAC. Starters shall have a fused 120V control power transformer in enclosure, or alternatively on 120/208 or 120/240 volt systems, the power system neutral conductor may be utilized. In all cases, control power shall be disconnected by the starter disconnecting means, unless otherwise specifically approved.
- F. Starters shall be suitable for field addition of at least four (4) auxiliary electrical interlocks of any arrangement, normally open or normally closed.
- G. Starters shall have enclosure mounted red running pilot light and Hand-Off-Auto switch.

## 2.5 AC COMBINATION STARTERS WITH FUSIBLE DISCONNECT SWITCH OR CIRCUIT BREAKER

- A. Combination starters shall be manufactured in accordance with the latest published NEMA standards, sizes and horsepower ratings.
- B. Disconnect switch combination starters shall consist of a visible blade disconnect switch and a motor starter.
- C. Combination starters shall be mounted in NEMA 1 general purpose enclosures unless otherwise indicated on the plans or required by the conditions of the area in which they are installed.
- D. The disconnect handle used on combination starters shall always be in control of the disconnect device with the door opened or closed. The disconnect handle shall be clearly marked as to whether the disconnect device is "on" or "off".
- E. Magnetic starters provided under all Divisions of the Specifications shall be in accordance with this Section.

## PART 3 - EXECUTION

### 3.1 COORDINATION

- A. Coordinate details pertaining to the motor control equipment with the Division of these specifications where the equipment is specified.

### 3.2 CONTROL WIRING

- A. Control wiring and control devices shall be provided under the Specification Division in which the controlled equipment is specified. Coordinate all related work.

3.3 CONNECTIONS

- A. Provide liquid tight flexible conduit connections to motors and other equipment subject to vibration where LFMC is an acceptable wiring method. Provide flexible conduit connections to motors and other equipment subject to vibration that is located in spaces used for environmental air (e.g. fan rooms). Minimum length 12 inches.

3.4 NAMEPLATES

- A. Provide engraved nameplates for all starters in accordance with Section 260553 – Identification for Electrical Systems. Coordinate names with mechanical equipment lists.

3.5 REDUCED VOLTAGE STARTERS

- A. Reduced voltage starters shall be provided for all motors larger than:
  - 208 volts                      25 horsepower
  - 460 volts                      50 horsepower
  1. This requirement shall apply to starters furnished in this Division and other Divisions of the specifications.
  2. Motors controlled by Variable Frequency Drives (VFDs) are not subject to this requirement.

3.6 TWO SPEED STARTERS

- A. Provide two speed starters for all two speed motors. Starters shall comply with the requirements of the equipment and motor manufacturers. Refer to Mechanical Equipment Lists for equipment with two speed motors.
- B. This requirement shall apply to starters furnished in this Division and other Divisions of the specifications.

3.7 FIELD QUALITY CONTROL

- A. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.

END OF SECTION 262900

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes general requirements, products and methods of execution relating to lighting fixtures, LEDs, LED drivers and related products approved for use on this project.
- B. The Fixture Schedule is a general guide to type, quality and other characteristics. Fixtures of equal or better performance and quality may be substituted, subject to approval.

1.2 RELATED SECTIONS

- A. 262726 - Wiring Devices
- B. 260943 - Network Lighting Controls

1.3 QUALITY ASSURANCE

- A. The fixture shall be a standard catalog item as described on the Drawings and as made by a nationally recognized manufacturer.

1.4 SUBMITTALS

- A. Provide submittals for all products in accordance with Section 260000 and Division 1.
- B. Fixture mounting shall be clearly identified on submittal information and coordinated with architectural, features, assemblies, details and reflected ceiling plan.
- C. Fixtures and hardware color selection shall be clearly identified on submittal information and coordinated with architectural.

1.5 SHOP DRAWINGS

- A. Provide fabrication drawings that indicate fixture, type, kind, weight, lamp, LEDs, LED drivers, method of fitting and fastening parts together, location and number of sockets, and complete details of method of fitting suspension and fastening fixtures in place. Verify fixture dimensions with construction conditions prior to ordering fixtures.
- B. Provide wiring diagrams that indicate supply power and interconnections for lighting controls, equipment and light fixtures. Provide sufficient information to assemble and install equipment at the project site without further instructions.

1.6 WARRANTY

- A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
  - 1. Interior lighting fixtures: 36 months[Sub] from date of Substantial Completion.
  - 2. Controls mounted on or integral to lighting fixtures: 60 months[Sub] from date of Substantial Completion.
  - 3. LEDs and LED Drivers: 60 months[Sub] from date of Substantial Completion.
  - 4. Emergency Battery Drivers: 60 months[Sub] from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide fixtures in conformance with the Fixture Schedule, with all required flanges and supports. Lighting fixtures shall be provided complete with all suspension, trim, mounting, and operating accessories normally considered necessary for a complete, functional, and safe installation, whether specifically called for in the Contract Documents or not.

2.2 LIGHT EMITTING DIODE (LED) FIXTURES

- A. LED fixtures shall comply with Illuminating Engineering Society (IES) LM-79 guidelines.
- B. LEDs shall comply with Illuminating Engineering Society (IES) LM-80 guidelines.
- C. Fixture shall have an LM-79 photometric test report from a DOE CALiPER NVLAP accredited laboratory.
- D. Fixture shall utilize components (i.e. LEDs, driver, fixture housing, etc) included in LM-79 test.
- E. Fixture shall have lumen maintenance testing with minimum test duration of 10,000 hours.
- F. Manufacturer stated end of life shall be at 70% light output. Operating life shall be no less than 50,000 hours.
- G. Color temperature, and color rendering index (CRI) shall conform to the lighting fixture schedule shown on the Drawings.
- H. Fixture components shall be lead free, mercury free and RoHS compliant.

2.3 FULLY RECESSED FIXTURES

- A. Fixtures shall have thermal protection conforming to NEC and shall so be identified as thermally protected unless fixture is:

1. Identified for use and installed in poured concrete, or
2. Identified as suitable for installation in cavities where the thermal insulation will be in direct contact with the fixture.

2.4 EDISON BASE "A" LAMPS

- A. Edison Base "A" lamps installed in air handling units shall be LED A19 Series 75W Equivalent, 5000K, 120V.

2.5 DRIVER DISCONNECTING MEANS

- A. In indoor locations, LED Driver(s) shall have a disconnecting means either internal or external to each luminaire to disconnect simultaneously from the source of supply all conductors of the driver and LEDs/LED boards, including the grounded conductor in accordance with National Electrical Code (NEC) Article 410.

2.6 LED DRIVERS

- A. Characteristics:
  1. Input: 120-277V (UL) AC, 50-60Hz
  2. Efficiency: >81% at full load
  3. Power Factor: >0.9 at full load
  4. Total Harmonic Distortion (THD): <20% at full load
  5. 0-10V compatibility
  6. Flicker-free dimming down to 1%

2.7 EMERGENCY LIGHTING DRIVER – LED

- A. Provide emergency battery driver for LED fixtures with the following features:
  1. Shall be capable of operating at the minimum lumen output specified on the Lighting Fixture Schedule for a minimum of 90 minutes
  2. Universal input (120-277 VAC)
  3. Compatible with the LED fixture and driver intended for use with.
  4. High-temperature long-life, nickel cadmium battery. Electronic charger with 24 hour or less recharge time.
  5. Charge indicator lamp and test switch, with lamp visible, and test switch accessible, without opening fixture.
  6. UL listed.
  7. When used with dimmable drivers/fixtures circuitry/programming to restore light output to specified lumens in emergency mode shall be provided.

2.8 FIXTURE ACCESSORIES

- A. Lenses for recessed fixtures shall be 100 percent virgin acrylic with a minimum overall thickness of 0.125 inches, except where specifically noted.
- B. Canopies for pendant hung fixtures shall be of the ball joint type. Where more than one pendant is used per fixture, a ball joint fitting shall also be provided in the fixture end of each pendant.
- C. Furnish one tamperproof screwdriver of each type of tamperproof fixture as required by fixtures specified on this project.

PART 3 - EXECUTION

3.1 GENERAL

- A. Drivers shall be installed per manufacturer's recommendations.
- B. Fixtures with integral drivers shall have the driver installed and prewired at the factory.
- C. Internal fixture wiring shall be factory installed in multiple fixtures which share a common driver. All wiring harnesses shall include an integral copper grounding conductor.

3.2 INSTALLATION

- A. Install fixtures level, plumb and true. Align rows accurately in three dimensions.
- B. Support suspended acoustical ceiling fixtures according to the requirements of the IBC and Section 260529 – Hangers and Supports and Section 20 0548 – Mechanical Vibration and Seismic Control as well as any local amendments.
- C. Fixture pendants, canopies, blank sections, corners, tees and other such accessories shall be finished to match their respective fixture.
- D. Refer to applicable details on architectural drawings for specific mounting requirements for all fixtures with special mounting requirements such as cove-mounted fixtures and linear fixtures.
- E. For linear fixture systems, verify fixture dimensions and mounting type with other trades prior to installation.
- F. Utility Rooms: Surface ceiling mount fixtures in rooms/areas with ceilings. In areas without ceilings pendant fixtures down to bottom of structure or height indicated on the Lighting Fixture Schedule. In areas with mechanical equipment, ductwork and piping, pendant fixtures down to bottom of mechanical ductwork or piping as appropriate. Fixture pendants shall be rigid (threaded hangar rods) and shall be sway braced where pendants exceed 24 inches in length.
- G. Provide an unswitched circuit connection for the following (as applicable):

1. Exit signs
2. Emergency lighting units (ELUs)
3. Emergency fixtures
4. Emergency night lights
5. Fixtures with emergency battery LED drivers

- H. Wiring for fixtures connected to emergency circuits shall be kept entirely independent of all other wiring and equipment in accordance with NEC Article 700.
- I. Clean all fixtures and lenses prior to final acceptance.

### 3.3 FIRE-RESISTIVE CONSTRUCTION

- A. Refer to Section 260000 Electrical General Requirements.

### 3.4 FIELD QUALITY CONTROL

- A. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.

END OF SECTION 265000

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## PART 1 - GENERAL

## 1.1 DESCRIPTION AND GENERAL SPECIFICATIONS

- A. Provide the equipment, materials, and labor to install the systems shown on the Drawings and specified herein. This shall include (but not be limited to) provision of all trenching and backfill, raceways, sleeves, boxes, gutters, shelves, enclosures, shelf and enclosure supports, backboards, equipment racks, line and low voltage wire and cable, pull ropes (in unused conduits), terminal modules, panels, outlets, jacks, splices, connections, cable management, labeling, testing and all other material, equipment, and labor required to make the systems fully operational.
- B. The intent of this Specification is to place in working order a complete, fully tested and documented Category 6A system complying with the Codes and Standards referenced herein.

## 1.2 RELATED SECTIONS

- A. 260533 - Raceway and Boxes for Electrical Systems
- B. 260536 - Cable Trays for Electrical Systems
- C. 272020 - Telecom Optical Fiber Distribution

## 1.3 COORDINATION

- A. The necessity to coordinate this work with the Serving Utility, Owner and the Contracting Agency is emphasized.
- B. Coordinate work with other contractors and trades. The layout and installation of the systems shown on the Drawings and specified herein shall be coordinated such that all special requirements for telecommunications systems shall be provided and incorporated into the project. The systems to be coordinated shall include (but are not limited to) electrical raceway, grounding, fire rated assembly, lighting, power distribution, control and instrumentation, and labeling of cables, terminations, outlets, jacks, etc. Report all conflicts to the Contracting Agency.

## 1.4 CODES AND STANDARDS

- A. Where a Nationally Recognized Testing Laboratory (NRTL) listing or classification exists for a product and the product is suitable for the purpose specified and indicated, the product shall bear the appropriate marking indicating the listing or classification.
- B. Where a UL Standard is in effect, equipment shall:

1. Meet that Standard.
2. Bear the UL Label.

### 1.5 SUBMITTALS

- A. The following shall be submitted in accordance with Section 260000 - Electrical General Requirements and Division 1 in sufficient detail to show full compliance with the specification:
1. Manufacturer's Catalog Data shall be submitted for the following items. Data shall include a complete list of parts, special tools, and supplies.
    - a. Copper Cable.
    - b. Information Outlets.
    - c. Patch Panels.
    - d. Equipment Racks.
    - e. Terminal Modules.
    - f. Other accessories.
  2. Manufacturer's Installations Instructions.
  3. Labeling System: Coordinate with Contracting Agency for Owner's labeling conventions. Submit Project labeling system for approval.
  4. Contractor qualifications and experience as specified in this Section.
  5. Manufacturer's Warranty as specified elsewhere in this Section, including all warranty provisions and procedures for Owner to follow to obtain warranty service.
- B. One copy of approved submittals shall be kept at the job site.

### 1.6 SHOP DRAWINGS

- A. Work shall be laid out in advance. Shop drawings shall be submitted to the Contracting Agency for approval before work begins.
- B. Shop Drawings shall include dimensioned layout of Telecommunications Rooms, including backboards, patch panels, grounding terminal bus bars, ladder racking, equipment, etc. Layouts shall show lighting fixtures, HVAC equipment, etc., which affect room layouts.
- C. Shop Drawings shall include dimensioned layout of major pathways for backbone and horizontal cables, including large conduits (2 inch and larger) and sleeves.
- D. Work under this section has been indicated on the Drawings in locations that should allow installation without interfering with the work of other trades; however, exact finish locations cannot be indicated. Therefore, locations of all work and equipment shall be verified to avoid interferences, preserve headroom and keep openings and passageways clear. Review the plans for the work of the other trades and coordinate adjustment of this work, the work of the other trade or both to achieve the best installation for the Owner without additional claims or charges. Shop Drawings shall reflect coordination of work under this Section with the work of other trades.

## 1.7 REFERENCE CODES AND STANDARDS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only, latest edition. The reference codes and standards are minimum requirements.

B.

<b>Reference</b>	<b>Title/Revision</b>
ANSI/ICEA	Publication S-80-576
ANSI/IEEE C2	National Electrical Safety Code
ANSI/NFPA 70	National Electrical Code
ANSI/T1E1.7/92-004R	Electrical Protection Applied to Telecommunications Network Plant at Entrances to Customer Structures or Buildings
ANSI/TIA/EIA-568-C.0	Generic Telecommunications Cabling for Customer Premises
ANSI/TIA/EIA-568-C.1	Commercial Building Telecommunications Cabling Standard
ANSI/TIA/EIA-568-C.2	Balanced Twisted-Pair Telecommunication Cabling and Components Standard
ANSI/TIA/EIA-569-B	Commercial Building Standards for Telecommunications Pathways and Spaces
ANSI/TIA/EIA-606-A	Administration Standard for Commercial Telecommunications Infrastructure
ANSI/TIA/EIA-607-B	Commercial Building Grounding and Bonding Requirements for Telecommunications
BICSI	Telecommunications Distribution Methods Manual
CFR 47 Part 68	Connection of Terminal Equipment to the Telephone Network
FCC Part 15	Radio Frequency Devices
FCC Part 68	Connection of Terminal Equipment to the Telephone Network
IEEE	LAN Standards: 802.3; 802.4; 802.5; 802.6
UL 1283	Electromagnetic Interference Filters
UL 1449	Transient Voltage Surge Protection
UL 1459	Standard for Telephone Equipment
UL 1950	Standard for Information Technology Equipment, Including Electrical Business Equipment
UL 467	Grounding and Bonding Equipment
UL 497	Protectors for Paired Conductors for Communication Circuits
UL 497A	Secondary Protectors for Communication Circuits
UL 497B	Protectors for Data Communication and Fire Alarm Circuits
UL 910	Safety Test for Flame-Propagation and Smoke Density Values for Electrical and Optical- Fiber Cables

## 1.8 OPERATING CONDITIONS

- A. The electronic equipment designed for office environments and Telecommunications Rooms shall be rated for continuous operation under ambient environment conditions of 10 degrees C (50 degrees F), to 30 degrees C (85 degrees F) and 35 to 65 percent relative humidity, non-condensing.

## 1.9 QUALITY ASSURANCE

- A. Perform all Work in accordance with all regulatory rules and regulations as well as references in this specification.
- B. Perform all Testing in accordance with ANSI/TIA/EIA-568-C specifications and submit all printed reports.

## 1.10 QUALIFICATIONS

- A. The telecommunications work specified in this Section is acknowledged to require special skills mastered by education, experience, or both. Bidders for telecommunications work described in this Section shall be specialty telecommunications contractors, who may be a division of the Divisions 26, 27 and 28 Subcontractor.
- B. Contractor Certification:
  - 1. This subcontractor shall be a certified installer of the cabling system, pre-qualified by the Manufacturer for the purpose of offering the Extended System Warranty as required in this Section.

## 1.11 REGULATORY REQUIREMENTS

- A. All Work shall conform to the requirements of NFPA 70 and all local amendments.
- B. All Work shall conform to the requirements of all Federal, State and Local Electrical and Telecommunications Regulations.

## 1.12 SPECIAL WARRANTY

- A. The warranty shall extend from the date of Substantial Completion to the longer of twenty (20) years or the length of the Extended Warranty offered by the successful manufacturer.
- B. The warranty shall be extended to the Owner via the manufacturer through a single point of contact and shall be fully backed by the manufacturer.
- C. The Extended Product Warranty and System Assurance Warranty for this wiring system shall be provided consisting of the following:

1. Extended Product Warranty - The Extended Product Warranty shall ensure against product defects, that all approved cabling components exceed the specifications of ANSI/TIA/EIA 568-C and ISO/IEC IS 11801, exceed the attenuation and NEXT requirements of ISO/IEC IS 11801 for cabling links/channels, and that the installation will exceed the loss and bandwidth requirements of ISO/IEC IS 11801 for links/channels. The warranty shall apply to all passive Telecommunication Distribution System (TDS) components.
  2. System Assurance - The System Assurance shall cover the failure of the wiring system to support any existing application, as well as additional application(s) introduced in the future by recognized standards or user forums that use the ANSI/TIA/EIA 568-C or ISO/IEC IS 11801 component and link/channel specifications for cabling.
  3. All communications system components shall be rated for end-to-end system Category 6A, or greater performance levels on all pair combinations and warranted to support any existing or future applications which are designed to operate over a 500MHz horizontal channel (as defined in ANSI/TIA/EIA 568-C), to include support of the following applications. Performance shall be guaranteed under the Special Warranty at 100 meters (328 feet):
  4. Extended Product Warranty - The Extended Product Warranty and the System Assurance shall cover the replacement or repair of defective product(s) and labor for the replacement or repair of such defective product(s).
    - a. In the event this specialty subcontractor is unable to perform, goes out of business or ceases to exist, the manufacturer shall be responsible for identifying a new contractor to assume the warranty work.
    - b. Manufacturers shall bear full responsibility for the work of their certified installer, including all aspects of the design and installation.
    - c. In the event this specialty subcontractor fails to provide satisfactory warranty support, the manufacturer shall be responsible for taking all necessary remedial steps including finding a new contractor to provide warranty work.
  5. System Certification - Upon successful completion of the installation and subsequent inspection, the customer shall be provided with a numbered certificate, from the manufacturing company, registering the installation.
- D. Submit a summary of warranty highlighting major features. Clearly disclose all exceptions to the requirements of this document, and specifically indicate any and all provisions that could potentially void the warranty or reduce its benefit to the Owner.
- E. Warranty programs approved as meeting the specified warranty are listed below. Final approval is subject to review and approval of the warranty:
1. Commscope Uniprise Extended Warranty

#### 1.13 MANUFACTURERS' RECOMMENDATIONS

- A. All installation procedures shall be in accordance with the recommendations of the manufacturer of the material being installed.

## 1.14 TERMINOLOGY

- A. "TDS" shall refer to the Telecommunication Distribution System cabling and hardware infrastructure internal and external to a building or buildings used to transmit voice, video and data, etc.
- B. "Stations" shall refer to individual telephone or computers, or remote peripherals of those systems (e.g., printers, facsimile machines, modems, etc).
- C. "Outlets" shall refer to the group of receptacles or jacks at the location where the stations connect.
- D. "Jacks" or "Ports" shall refer to the individual receptacles where phones, computers, etc. connect.
- E. "Station Cables" shall refer to the horizontal cables connecting patch panels or terminal blocks in the Telecommunications Rooms to the stations.
- F. "Pathways" shall refer to conduits, sleeves, cable-trays, j-hooks, etc., which are employed to route backbone and stations cables between equipment rooms, telecommunications rooms, stations, outlets, etc.
- G. "Backbone Cables", "Riser Cables" or "Tie Cables" shall refer to copper cables 25-pair or more and optical fiber cables 6-strand or more, connecting main cross-connect facilities, intermediate cross-connect facilities and telecommunications rooms. These cables may include outside plant cables between buildings and riser cables between floors.
- H. "Equipment Rooms" (ER) or "Communication Equipment Rooms" (CER) shall refer to a special-purpose room that provides space and maintains a suitable operating environment for large communications and/or computer equipment. Main rooms may also be referred to as an MDF.
- I. "Telecommunications Rooms (TR)" shall refer to a floor-serving facility for housing telecommunications equipment, cable terminations and cross-connect wiring. This is the point at which station cables terminate. It may also be referred to as an IDF.
- J. "Terminal Blocks" shall refer to multiple punch down cable terminations.
- K. "Patch Panels" shall refer to rack or frame mounted multiple punch down cable terminations with RJ-45 style, 8P8C jacks on the face for "plug and play" cross connect capability.
- L. "Cable Management" shall refer to j-hooks, troughs, gutters etc., mounted in conjunction with telecommunications distribution equipment and terminal blocks, for the orderly routing of cables, patch cords, etc.
- M. "LEC" shall refer to the Local Exchange Carrier providing telephone service to the facility.

## 1.15 STORAGE AND HANDLING

- A. Care shall be exercised in handling materials during construction. Damaged materials shall be repaired or replaced as directed by the Contracting Agency.

## PART 2 - PRODUCTS

## 2.1 GENERAL

- A. All materials shall be as specified, first quality, manufacturer's current production.
- B. The Basis of Design for copper cabling, connecting hardware, and related hardware in this section is Commscope Uniprise cabling and Commscope Uniprise hardware with the CommScope Uniprise Warranty as standards for quality and performance and to match existing cabling system installed. All manufacturers other than those listed in this section will be rejected without review.
- C. The approved alternate cabling products manufacturers are:
  - 1. Superior Essex
  - 2. Berk-Tek
- D. The approved alternate connecting hardware products manufacturers are:
  - 1. Ortronics
  - 2. Leviton
- E. Products shall provide the standard of performance required under paragraph 1.1 and the Special Warranty above.

## 2.2 PATCH PANELS

- A. Patch Panels: Modular jack panels shall be in 24 or 48 port configurations as shown on the Drawings. Modular jack panels installations shall contain a retaining trough between every panel. Modular Jack Panels shall be wired for T568A configuration.
- B. The terminations shall have the following characteristics:
  - 1. Wire Size Supported:
    - a. Solid Wire Ranges: 22-26 AWG, Re-termination >200
    - b. Stranded (7 Strands) Wire Ranges: 22-26 AWG, Re-termination: >200
  - 2. Electrical Specifications:
    - a. Meet or exceed performance defined by ANSI/TIA/EIA-568-C.2, for Category 6A component, link and channel performance.
    - b. UL Listed.

- C. Designation labels for each jack shall be provided for front/rear labeling of each patch panel. All cables shall be terminated in numerical sequence and labeled as to outlet number and jack position (A, B, C, D). Provide color-coded inserts (“icons”) for all jacks at patch panels and at each outlet.
- D. Equipment:
  - 1. Category 6A: High Density Modular Patch Panels
  - 2. Comply with FCC Part 68.
  - 3. ISO 9001 Certified Manufacturer.

### 2.3 INFORMATION OUTLETS/JACKS

- A. Faceplate Requirements:
  - 1. Configure single gang outlet information outlets in single, duplex, triplex, quad-plex, or six-plex jack arrangement, as indicated on the Drawings.
  - 2. Provide outlet faceplates with either top or bottom labeling positions.
  - 3. Provided blank module inserts for all unused module locations.
  - 4. Equipment: Refer to Specification Section 262726-Wiring Devices for faceplate type/color.
- B. Jack Requirements:
  - 1. Jacks for Voice and Data:
    - a. Communications jacks shall consist of multi-position 8-pin modular (8P8C) jacks.
  - 2. Category 6A Jacks:
    - a. Jacks shall be manufactured by the same manufacturer as the modular patch panels.
    - b. All Jacks shall conform to ANSI/TIA/EIA 568-C Commercial Building Telecommunications Cabling Standard, Horizontal Cable Section and shall meet or exceed the following electrical and mechanical specifications:
      - 1). Electrical Specifications: Jacks shall meet or exceed performance specifications for the Channel as defined by ANSI/TIA/EIA-568-C.
      - 2). Temperature Range: -40° to 150°F (-40° to 66°C).
      - 3). Comply with FCC Part 68.
      - 4). ISO 9001 Certified Manufacturer.

### 2.4 PATCH CORDS

- A. Patch cords and equipment cords will be Owner furnished and Owner installed.

### 2.5 HORIZONTAL CABLES

- A. General:



1. Data cables shall be extended between the station location and its associated TR and shall consist of 4 pair, 23 gauge, UTP, and shall be terminated on the 8 pin modular jacks provided at each outlet. Cable jacket shall comply with Article 800 NEC for use as a plenum cable. The 4 pair UTP cable shall be UL Listed Type CMP (plenum).
2. Where conduit is run below slab-on-grade, the cable jacket shall be wet location rated.
3. Provide cables with four FEP insulated conductor pairs (4/0 configuration)
4. Category 6A UTP, 4 Pair .
5. All cables shall conform to the ANSI/TIA/EIA 568-C Commercial Building Telecommunications Cabling Standard, Horizontal Cable Section, and be part of the UL LAN Certification and Follow-up Program.
6. Cables shall meet or exceed Category 6A performance specifications for the Channel as defined by ANSI/TIA/EIA-568-C.2.
7. Environmental:
  - a. Storage temperature: 68° F to 122° F (20° C to 50° C).
  - b. Installation Temperature: 32° F to 122° F (0° C to 50° C).
  - c. Operating Temperature: 14° F to 140° F (-10° C to 60°.
8. UL or ETL Verified for Category 6A Electrical Performance.
9. UL Listed for Fire Safety.
10. ISO 9001 Certified Manufacturer.
11. Equipment: Category 6A, Uniprise Ultra 10, or as approved.

## 2.6 RISER CABLES

- A. Unshielded 24 AWG multi-pair copper cables shall be used as the vertical riser cables. The cable shall support voice, data, and building service applications. The bending radius and pulling strength requirements of all backbone cables shall be observed during handling and installation. The multi-pair copper cables shall be in non-plenum form and placed in conduit as required.
- B. The non-shielded non-plenum cable shall consist of 24-AWG solid-copper conductors insulated with color coded PVC, 25 pair cable shall be UL Verified to ANSI/TIA/EIA 568-C for Category 3, 25 to 100 pair shall be conformance tested to meet ANSI/TIA/EIA 568-C for Category 3 cables. The cable shall be available in 25, 50, 75 and 100 pair. The copper cable shall meet or exceed the following electrical specifications listed below:
  1. UL Listed for Fire Safety.
  2. ISO 9001 Certified Manufacturer.

## 2.7 LABELING

- A. Provide machine printed labels for all patch panels, cables, outlets, etc., in accordance with ANSI/TIA/EIA-606-B. Provide labeling nomenclature in accordance with information on the Drawings or Owner's labeling conventions. Submit labeling samples for all required applications.

- B. Labeling and color coding identification for this project shall conform to TIA/EIA-606-B for a Class 3 Administrative System.

### PART 3 - EXECUTION

#### 3.1 GENERAL

- A. Provide, connect and test all equipment and materials for the systems herein specified and shown on the Drawings. All wiring shall be neatly tied or laced in cabinets and terminated on terminal strips provided for the purpose. Each cable shall be identified by an approved marking system at each end.
- B. Outlet/Jacks shall be identified with machine printed labels. Hand lettered labels shall not be used.
- C. Provide labels and color-coded inserts for each jack at patch panels, in accordance with TIA/EIA-606-B.
- D. Provide full set of snap-in icons for workstation outlets for use by Owner to mark jacks for analog and digital telephones as two unique classes of data. Store icons in clear plastic bags in each MTR/TR.
- E. Coordinate installation of lighting, ventilation and all other systems in the communication rooms to avoid interferences.
- F. Test the systems and provide training as specified.
- G. Work under this section shall be closely coordinated with work under other sections of the project.

#### 3.2 COLOR CODE SYSTEM

- A. Cables for one floor may be run in the tray system of another floor where necessary or shown, and shall be clearly identified by their unique floor-specific color. One color shall be used for all horizontal cables originating on a floor. A different color shall be used for the floor above, and another unique color for the floor below.

#### 3.3 CODES AND PERMITS

- A. Apply and pay for all fees, permits, and obtain serving utility and governmental approvals.
- B. Coordinate all work with the serving utility.
- C. Raceway fill requirements for communications systems shall be in accordance with ANSI/TIA/EIA-569 and BICSI.

- D. NEC bending radius of all communications ducts, raceways, cable trays, etc., shall be increased to not less than the installed cable manufacturer's recommendations, and the applicable ANSI and BICSI Standards.
- E. Communications work shall be in complete accordance with the following:
  - 1. National Electrical Code (NEC), latest legally enacted edition.
  - 2. Regulations of the State Fire Marshal.
  - 3. National Fire Protection Association (NFPA) Codes.
  - 4. All state, county and local codes and ordinances.

### 3.4 DELIVERY AND STORAGE

- A. Materials and Equipment shall be stored with protection from mechanical damage, weather, humidity and temperature variation, dirt and dust, and other contaminants.
- B. Cables shall be tested immediately upon receipt and received or rejected and returned based upon testing or visual inspection.

### 3.5 LAYOUT

- A. All work shall be laid out in advance. Shop drawings shall be submitted to the Contracting Agency for approval before work begins. Maximum height for terminal blocks and patch panels shall be 6 feet-6 inches, minimum height shall be 1 feet-6 inches. Cables shall be racked and supported in a workmanlike fashion. All work shall be labeled according to ANSI/TIA/EIA 606-B, and color coded according to BICSI Standards. In the absence of details on the drawing governing the layout of terminations, the following guidelines shall apply.
  - 1. All horizontal cables from a common outlet shall terminate sequentially (in groups) on the same patch panel.
  - 2. Trunk or riser cables shall terminate on dedicated terminal blocks, separate from but adjacent to horizontal terminal blocks.
- B. Keep up to date "As-built" record drawings at each job site detailing the layout of all data racks and telephone, data and trunk terminations, including a typed listing of cables/rooms served by each terminal block and patch panel. Refer to Section 260000 - Electrical General Requirements for other Record Document requirements.
- C. Layout Shop Drawings shall be prepared using CAD. Final approved Shop Drawings shall be updated with precise "as-built" conditions and shall be submitted with the Operations and Maintenance Manuals. File format shall be AutoCAD "DWG" or "DXF."

### 3.6 CABLE INSTALLATION

- A. If cable dimensions shown are exceeded, all cable pathways and supports shall be resized to maintain the original fill ratios based on the dimensions shown.

- B. Follow cable manufacturer’s specification regarding handling methods, retaining/support methods, bending radius and maximum pulling tension limitations.
- C. Telecommunication cables shall not be installed in the same raceway as power cables.
- D. All cables shall be routed to minimize EMI and RFI interference. All cable shall be routed according to the following table. Spacings are minimum for all Category 3 and higher cable.

Minimum Separation of Telecommunications pathways from 480 volt or less power lines

Condition	<2 kVA	2-5 kVA	>5 kVA
Unshielded power lines or electrical equipment in proximity to telecommunications open or nonmetal pathways.	5 in	12 in	24 in
Unshielded power lines or electrical equipment in proximity to telecommunications grounded metal conduit pathways	2.5 in	6 in	12 in
Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to a telecommunications grounded metal conduit pathway	N/A	3 in	6 in
Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to telecommunications open or nonmetal pathways.	2.5 in	6 in	12 in
Mechanical ductwork, metal floors and other metallic planes to telecommunications open or nonmetal pathways.	2 in		
Mechanical ductwork, metal floors and other metallic planes to telecommunications open or grounded metal conduit pathways.	0 in		
Fluorescent or HID lighting fixtures	5 in	5 in	5 in

3.7 LUBRICANT

- A. Pulling lubricant, shall be used to minimize pulling tension and prevent sheath damage when pulling cables into ducts and conduits. Lubricant shall be applied to the cable sheath with a lubricator. When pulling has been completed, the exposed cable ends shall be wiped clean of lubricant.
- B. Lubricants shall be compatible with and intended for use with plastic-sheathed cables. Soap and grease type lubricants shall not be allowed.

## 3.8 DAMAGE AND DEFECTS

- A. Use a tension monitoring device to ensure that the maximum pulling tension that may be applied to the cable to be pulled into a conduit section is not exceeded.
- B. Cable shall be carefully inspected for sheath defects or other irregularities as it is paid out from the reel.
- C. Adequate care shall be exercised when handling and storing reels of cable to prevent damage to the cable. Cable with dents, flat spots, or other sheath distortions shall not be installed.

## 3.9 CABLE SUPPORTS

- A. Mount distribution rings (J-hooks) on appropriate mounting hardware suitable for the specific application. Mount securely to the building structure. Maximum support spacing shall be 4 feet on center.
- B. Coordinate the layout of cableways with all other trades. Report conflicts to Contracting Agency for resolution by the Contracting Agency.

## 3.10 TERMINATIONS

- A. Cables shall be marked with wire markers at both ends, and terminals on terminal blocks or patch panels shall bear the cable number. Trunk cables shall be neatly marked with "From-To" information.
- B. Wire twist shall be maintained to within 0.25 inch of the termination.

## 3.11 TERMINATION MODULES

- A. Protection modules shall conform to NEC 800-30 and be installed per manufacturer's recommendations.

## 3.12 COMPLETION AND TESTING

- A. Telecommunications System test reports shall be submitted to and approved by the Contracting Agency. The test reports shall certify that the Telecommunications Distribution System is complete, passes all test criteria, is fully operational, and that all work has been witnessed as specified.
- B. Incoming Inspection Tests:
  - 1. Inspect all materials for damage.
- C. Final Inspection Tests:

1. Testing of all copper wiring shall be performed prior to system acceptance. 100 percent of the horizontal and riser wiring pairs shall be tested. Link testing of all copper cabling shall be performed. Complete, end to end test results shall be submitted to the Contracting Agency.
  - a. Category 6A cable runs shall be tested for conformance to the specifications of EIA/TIA 568-C.2, Category 6A. Testing shall be done with a ANSI/TIA/EIA 568-C ETL verified Level II-E test set, with accuracy per Proposed TIA Level III standards.

3.13 OPERATING AND MAINTENANCE MANUALS

- A. Prepare manuals describing the servicing and maintenance requirements for the equipment being provided as required in this Section of these specifications.
- B. Refer to "Submittals" requirements of this Section for additional O&M requirements.

3.14 INSTRUCTION AND TRAINING

- A. Provide detailed instructions to the Owner on how to obtain warranty service under the Special Warranty.

END OF SECTION 272010

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes security access devices, control panel, and signal and control conduit and wiring.

1.2 RELATED SECTIONS

- A. 083100 - Access Doors and Panels
- B. 087000 - Finish Hardware
- C. 260533 - Pull and Outlet Boxes
- D. 260534 - Conduit and Fittings
- E. 262500 - Pull and Junction Boxes
- F. 262500 - Grounding

1.3 REFERENCES

- A. National Fire Protection Association:
  - 1. UL 294
  - 2. UL 1076
  - 3. ULC
  - 4. CE
  - 5. FCC - Part 15, Part 68
  - 6. NFPA 262 -Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

1.4 SYSTEM DESCRIPTION

- A. The existing access control system (ACS) is Lenel OnGuard system.

1.5 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Provide submittals in accordance with Division 1 and Specification Section 260000 - Electrical General Requirements.
- B. Shop Drawings:

1. Complete system wiring diagram showing each device and wiring connection including door hardware, power supplies, ADA door operators, magnetic door holders, electric strikes, wired electric locks, and wireless electric locks, etc.
  2. Sequence of operation.
  3. Include security access system block (architecture) diagram.
- C. Product Data: Submit manufacturer's product information and catalog data showing electrical characteristics and connection requirements.
1. Intelligent System Controllers (ISCs)
  2. Reader Interface Modules (RIMs)
  3. Door contacts
  4. Card readers
  5. Balanced magnetic switch (door contact)
  6. Security access system power supplies
  7. Wire and cable.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Project Record Documents: Record actual locations of security access equipment.
- B. Operation and Maintenance Data: Submit manufacturer's standard operating and maintenance instructions.
- C. Test Reports: Submit results for Field Quality Control testing and inspection.

#### 1.7 QUALIFICATIONS

- A. Manufacturer:
  1. Lenel.
  2. No Alternate Brands; No Substitutions.
- B. Installer: Certified Lenel security access system installer.

### PART 2 - PRODUCTS

#### 2.1 INTELLIGENT SYSTEM CONTROLLER (ISC)

- A. Manufacturers:
  1. Lenel Model 3300 as required.
  2. No Alternate Brands; No Substitutions.
- B. Description: Security Access Interface between RIMs and the Lenel OnGuard System.



2.2 READER INTERFACE MODULE (RIM)

- A. Manufacturers:
  - 1. Lenel Model 1300 or 1320.
  - 2. No Alternate Brands; No Substitutions.
- B. Description: The single and dual reader interface modules shall provide an interface between the ISC and card readers. The module must operate with any card reader that produces a standard Wiegand (Data 1 / Data 0 or Clock and Data) communication output. Up to sixteen (16) RIMs shall be connected to each port on the ISC. The RIM shall monitor on a per door basis, door position, exit push button, and two auxiliary alarm inputs, 12 volt DC, 2 Programmable inputs and outputs.
- C. 294. Supports 1A of 24VDC power for door strikes.

2.3 CARD READERS – MULTICLASS SE

- A. Acceptable Manufacturers are limited to the following:
  - 1. HID multiCLASS SE
  - 2. No Alternate Brands; No Substitutions.
- B. Product Description: Wiegand card reader in polycarbonate housing suitable for installation in interior locations.

2.4 BALANCED MAGNETIC SWITCH (DOOR CONTACT)

- A. Balanced magnetic type switches signals door position.
- B. Device shall consist of two units mounted adjacent to each other in door and
- C. frame.
- D. Switch unit: Door frame mounted containing magnetic switch.
- E. Magnet unit: Door mounted, containing permanent magnet.
- F. Acceptable Manufacturers are limited to the following:
  - 1. Sentrol 2767 High Security or approved equal.
  - 2. GRI 180-12-W, 195-12-W, 4405-A, or approved equal.

2.5 SECURITY ACCESS SYSTEM POWER SUPPLIES

- A. Manufacturer:
  - 1. Lenel Model LNL-AL400ULX

2. Altronix Trove with AL600ULXB and associated distribution boards.

- B. Provide each door with a dedicated electronic power supply with sufficient output capacity for the door control devices and alarms. This power supply shall be independent of the dedicated power supply for the Door Controller. If practical and at the Contractor's discretion, a multi-output power supply may be used for clustered portals with related functionality such as sally port combinations and vestibules. Multi-output power supplies shall have sufficient capacity to operate all the connected devices simultaneously while on line power or on battery power.
- C. Power supplies shall be housed in a lockable enclosure, keyed the same as the Security Control Panel Enclosures.
- D. Power supplies shall be regulated and field selectable for twelve or twenty-four volt dc operation.
- E. Power supplies shall be UL Listed for use with Access Control (UL294).
- F. Provide form "C" contacts for "AC Fail" supervision and "Low Battery" supervision.
- G. Provide power supplies with a self-contained battery backup capability with a minimum of eight hours duration at full load.

## 2.6 ELECTRIC STRIKE

- A. Furnished under 087000 - Finish Hardware.

## 2.7 ELECTRIC LOCK

- A. Furnished under Section 087000 - Finish Hardware.

## 2.8 EXIT HARDWARE

- A. Furnished under Section 087000 - Finish Hardware.

## 2.9 ADA DOOR OPERATORS

- A. Furnished under Division 087000 - Finish Hardware

## 2.10 WIRE AND CABLE

- A. Acceptable manufacturers are limited to the following:
  - 1. As indicated on the drawings and as recommended by the manufacturer.
- B. Product Description: Power limited cable, copper conductor; 300 volts insulation rated 105 degrees C.

- C. Cable located exposed in plenums: Power limited cable classified for fire and smoke characteristics, copper conductor, 300 volts insulation rated 105 degrees C, suitable for use in air handling ducts, hollow spaces used as ducts, and plenums.

### PART 3 - EXECUTION

#### 3.1 EXISTING WORK

- A. For existing doors modified under this Contract, provide appropriate conduit, wire, cable, security access, and electrical connections and extend to the new Lenel security access installations using materials and methods compatible with existing installations.
- B. For existing card readers replaced under this Contract, provide appropriate conduit, wire, cable, security access, and electrical connections and extend to the new Lenel security access installations using materials and methods compatible with existing installations.
- C. Disconnect and demolish existing card reader system, including RIMs, enclosures, abandoned conduits, etc., after replacement system has been installed and fully tested/commissioned.

#### 3.2 INSTALLATION

- A. Install conductors for circuit conductors and devices/security hardware in accordance with manufacturer's requirements and as noted on the drawings.
- B. Install wiring in conduit.
- C. Install conduit and wiring connections to door hardware devices.
- D. Install engraved plastic nameplates in accordance with Section 260000 - Electrical General Requirements.
- E. Ground and bond security access equipment and circuits in accordance with Section 262500 - Grounding.

#### 3.3 INTERFACE TO OTHER SYSTEMS

- A. Provide interface from fire alarm system to unlock emergency egress doors as required.

#### 3.4 FIELD QUALITY CONTROL

- A. Document each installation and operational step utilizing the approved PC/FC checklists in accordance with Section 019100 - Commissioning.

3.5 CONTRACTORS RESPONSIBILITIES

- A. Contractor shall provide all, but not limited to, the following for a complete and operating system.
  - 1. Perform basic hardware installation.
  - 2. Purchase additional reader and workstation terminal licenses to cover new facility three months before commissioning.
  - 3. Provide hardware training and demonstration of installation.
  - 4. Commission operations
  - 5. Provide basic programming as required to be able to conduct commissioning activities.

3.6 OWNERS RESPONSIBILITIES

- A. Owner will perform programming of time of day functions, notification, and assign specific users access levels.

3.7 DEMONSTRATION AND TRAINING

- A. 8 hours minimum of instruction each for two persons, to be conducted at project site with manufacturer's representative. At a minimum, review start-up procedures, programming, trouble shooting, repair, operation in normal and abnormal modes, operator codes and actions, report and history log access and generation, and custom functions. Contractor shall also record this training and as described in 3.5(B) below, and provide to Owner two (2) copies in digital format.
- B. Conduct a project walk-through demonstrating operation of each device.
- C. Utilize submitted Operation and Maintenance (O&M) manuals and test plan.

END OF SECTION 281300

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PART 1 - GENERAL

1.1 SUMMARY

- A. This specification covers the requirements for the materials, installation, programming and re-configuration of the existing Addressable Fire Alarm System.
- B. Furnish labor, equipment and materials to provide a complete addressable fire alarm system. System shall include initiating devices, notification appliances, control devices and monitoring as indicated on the drawings and as specified herein.

1.2 REFERENCES

- A. The equipment and installation shall comply with the current provisions of the following Codes and Standards:
  - 1. National Electric Code, Article 760.
  - 2. National Fire Protection Association Standards:
    - NFPA 72                      National Fire Alarm Code
    - NFPA 101                    Life Safety Code
  - 3. Local and State Building Codes.
  - 4. Local Authorities Having Jurisdiction.
  - 5. ULC, CSFM, BSA
  - 6. Underwriters Laboratories Inc.
- B. The system and all components shall be listed by Underwriters Laboratories Inc. for use in fire protective signaling system under the following standards as applicable:

UL 864/UOJZ, APOU	Control Units for Fire Protective Signaling Systems
UL 268	Smoke Detectors for Fire Protective Signaling Systems.
UL 268A	Smoke Detectors for Duct Applications.
UL 217	Smoke Detectors Single Station.
UL 521	Heat Detectors for Fire Protective Signaling Systems.
UL 228	Door Holders for Fire Protective Signaling Systems.
UL 464	Audible Signaling Appliances.
UL 1638	Visual Signaling Appliances.
UL 38	Manually Activated Signaling Boxes.
UL 346	Waterflow Indicators for Fire Protective Signaling Systems.
UL 1971	Standard for Signaling Devices for the Hearing Impaired.

UL 1481	Power Supplies for Fire Protective Signaling Systems.
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- C. Americans with Disabilities Act (ADA).
- D. International Standards Organization (ISO).
  - 1. ISO-9000.
  - 2. ISO-9001.

### 1.3 SUBMITTALS

- A. Provide submittals for products in accordance with Section 260000 - Electrical General Requirements and Division 1.

### 1.4 QUALITY ASSURANCE

- A. Installer Qualifications: A factory authorized installer is to perform the work of this section.

### 1.5 WARRANTY AND SERVICE

- A. Warrant all components, parts and assemblies against defects in materials and workmanship for a period of 12 months from date of final completion. Warranty service shall be provided by a trained specialist of the equipment manufacturer. The specialist shall be based in a fully-staffed branch office located within a reasonable distance from the job site.
- B. Service availability: The supplier shall have sufficient stock on hand and have a fully equipped service organization capable of guaranteeing response time within 2 hours of service calls, 24 hours a day, 7 days a week to service completed systems.

## PART 2 - PRODUCTS

### 2.1 GENERAL

- A. The existing building fire alarm system is the EST QuickStart.
- B. Equipment furnished for this project shall be new. Components and systems shall be designed for uninterrupted duty. Equipment, materials, accessories, devices, and other facilities covered by this specification or noted on contract drawings and installation specifications shall be the best suited for the intended use.
- C. Equipment provided shall be of a single manufacturer to insure absolute compatibility between the appliances and the control panel(s), and to insure that the application of the appliances are done in accordance with the single manufacturers' instructions.

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- D. If any equipment or device connected to the fire alarm system is provided by a different manufacturer, then that equipment shall be recognized as compatible by both manufacturers, and listed as such by Underwriters Laboratories.

2.2 ADDRESSABLE DETECTORS

A. General:

- 1. Each addressable detector shall include a sensor base containing a microprocessor control unit for scanning the sensor, analyzing the sensor output and communicating the sensor status to the FACP and a separate sensor containing the actual sensing instrumentation.

B. Sensor Bases

1. Standard Detector Mounting Base:

- a. Bases shall be listed for ceiling or wall mounting.
- b. Each sensor base shall contain a magnetically actuated test switch to provide for easy alarm testing at the sensor location.
- c. Each sensor base shall include a communication transmitter and receiver having a unique identification and capability for status reporting to the FACP. Device address shall be located in sensor base to eliminate false addressing when replacing sensors.

2. Detector Mounting Base with Unsupervised Wired Connection:

- a. Mounting bases with unsupervised wired connection shall have all the features of the standard sensor base and include a connection for a remote LED alarm indicator or unsupervised relay.

3. Supervised Relay Mounting Bases:

- a. Supervised relay mounting bases shall have all the features of the standard sensor base and include a two or four wire connection for supervised relay.
- b. In addition to supervised relay connection, supervised relay mounting bases shall have a wired connection for Remote LED Alarm Indicator or Unsupervised Relay.

4. In-Duct Mounting

- a. Where a smoke detector is required to be directly inserted into a low velocity duct, 4000 ft/min maximum air flow, 3 ft (0.91m) high x 3 ft (0.91m) wide maximum size, provide in-duct mounting base.
- b. Detector housing shall have visible LED indicator showing power and alarm status.

C. Sensors:

- 1. Fixed Temperature/Rate of Rise Heat Detector:

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- a. Fixed temperature/rate of rise heat detectors shall have a nominal fixed temperature alarm point rating of 135°F (57°C) and a rate-of-rise alarm point of 15°F (9°C) per minute. The heat detector shall be rated for ceiling installation at a minimum of 60 ft (18.3m) spacing on center.
- b. Simplex 4098-9714 Photoelectric Sensor.
2. Multi-sensor Detector:
  - a. Multi-sensor detectors shall include photoelectric and fixed temperature/rate of rise sensors within the same device. Sensing characteristics shall be the same as described for each standalone sensor detailed above.
- D. Duct Smoke Detector Housing:
  1. Provide smoke detector duct housing assemblies to accept a standard, relay or isolator detector mounting base and sensor. The housing shall protect the measuring chamber from damage and insects. The housing shall utilize an air exhaust tube and an air sampling inlet tube that extends into the duct air stream up to ten feet. Provide drilling templates and gaskets to facilitate locating and mounting the housing.
  2. Provide remote status/alarm LEDs and Remote Test Stations as shown on the plans or as required by the AHJ.

### 2.3 ADDRESSABLE MODULES

#### A. General:

1. Modules shall be capable of monitoring or controlling one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, valve tamper, non-addressable devices, and for control of AHU systems.
2. Addressable Modules shall be capable of mounting in a standard North American single gang box. Modules include cover plates to allow surface or flush mounting. Modules will receive their operating power from the signaling line circuit or a separate two wire pair running from an appropriate power supply, as required.
3. Modules shall have a diagnostic LED visible on the finished cover plate. The LED shall flash to confirm communication.
4. Modules shall be suitable for operation in the following environment:
  - a. Temperature: 32°F to 120°F (0°C to 49°C).
  - b. Humidity: 0-93% RH, non-condensing.

#### B. Provide module styles and quantities as necessary to meet the design requirements:

1. Individual Addressable Modules (IAM):
2. Zone Adaptor Modules (ZAM)



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2.4 ADDRESSABLE MANUAL FIRE ALARM STATION

- A. The manual fire alarm station shall have a diagnostic LED visible from the front of the station without removing the cover. The led shall flash to indicate communication and go solid to indicate that the station has been activated.
- B. Manual fire alarm stations shall be suitable for operation in the following environment:
  - 1. Temperature: 32°F to 120°F (0°C to 49°C).
  - 2. Humidity: 0-93% RH, non-condensing.

2.5 NOTIFICATION APPLIANCES

- A. General:
  - 1. Strobe appliances or combination appliances with strobes shall be capable of providing the “Equivalent Facilitation” which is allowed under the Americans with Disabilities Act Accessibilities Guidelines (ADA(AG)), and shall be UL 1971, and ULC S526 Listed.
- B. Strobes:
  - 1. Strobes shall have white housing and shall mount in a standard North American single gang box.
  - 2. Strobes shall provide synchronized flash outputs. It shall be possible to field select strobe output of 15cd, 30cd, 75cd, or 110cd.
- C. Horn/Strobes:
  - 1. Horn/strobes shall have white housing and shall mount in a standard North American single gang box.
  - 2. Strobes shall provide synchronized flash outputs. It shall be possible to field select strobe output of 15cd, 30cd, 75cd, or 110cd.
  - 3. Horn shall have an audible output of 84 dBA at 10 ft. when measured in reverberation room per UL-464.
  - 4. Horn audible output shall be in a synchronized temporal pattern.

2.6 ANCILLARY DEVICES

- A. Multi Voltage Control Relays:
  - 1. Provide remote control relays connected to supervised ancillary circuits for control of fans, dampers, door releases, etc. Relay contact ratings shall be SPDT or DPDT and rated for 10 amperes at 115 Vac. A single relay may be energized from a voltage source of 24 Vdc, 24 Vac, 115 Vac, or 230 Vac. A red LED shall indicate the relay is energized. A metal enclosure shall be provided.

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2.7 ELECTROMAGNETIC DOOR HOLDERS

- A. Provide electromagnetic door holders with the following features.
  - 1. Flush mounted wall units or floor units as required by door and application.
  - 2. Silent operation.
  - 3. Minimum 20 lbf (89 N) holding force.
  - 4. 120V 60Hz operation.
  - 5. Finish shall be chrome.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The entire system shall be installed in a workmanlike manner in accordance with approved manufacturer's manuals and wiring diagrams. Furnish all conduit, wiring, outlet boxes, junction boxes, cabinets and similar devices necessary for the complete installation. All wiring shall be of the type recommended by the NEC, approved by local authorities having jurisdiction for the purpose.
- B. All penetration of floor slabs and fire walls shall be fire stopped in accordance with all local fire codes.
- C. All wiring shall be in metal raceways shared by no other system. Raceways shall be installed in accordance with Section 260533 – Raceways and Boxes for Electrical Systems.
- D. Field devices shall be installed in accordance with Section 260533 – Raceways and Boxes for Electrical Systems. Paint boxes and covers red.
- E. Install Conductors in accordance with Section 260519 – Low Voltage Electrical Power Conductors and Cables. All wires shall be landed on device terminals, or terminal strips or blocks, and shall be labeled and numbered at their terminations. All wiring shall be installed in a neat and workmanlike manner. Bundles of wiring shall be secured with self-locking nylon cable ties, not tape.
- F. Coordinate exact mounting locations with the reflected ceiling plans. Coordinate exact mounting heights with architectural elevations.
  - 1. Where field conditions (such as conflicts with other features, obstructions that violate the placement rules of the applicable Fire Code, and the like) make it necessary to relocate detectors from the positions shown on the plans, such relocations shall be made in strict accordance with the applicable Fire Code, and shall be made at no additional cost to the Owner.
  - 2. As far as possible within the rules of the applicable Fire Code, the final placement of exposed detectors shall present a uniform appearance.
- G. Adjust each detector in accordance with manufacturer's recommendations for the specific location and circumstance.

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- H. Coordinate installation of duct-mounted detectors with Division 23. Duct detectors shall be located in accordance with NFPA 72 and manufacturer's recommendation to the greatest extent practical. Proposed duct detector locations shall be submitted for approval prior to installation of any equipment. Submit duct detector differential pressure measurements to verify proper operation of duct detectors.
- I. Control relays shall be located within 3 feet of the device or circuit controlled in accordance with NFPA 72.
- J. Fire/Smoke Dampers: Coordinate connections to fire/smoke dampers with Division 23. See Section 200000 - Mechanical General Requirements. See Division 23 drawings for locations.

3.2 FIRE ALARM SYSTEM SEQUENCE OF OPERATION

- A. The system shall identify any off normal condition and log each condition into the system database as an event.
  - 1. The system shall automatically display on the control panel Liquid Crystal Display the first event of the highest priority by type. The priorities and types shall be alarm, supervisory, trouble, and monitor.
  - 2. The system shall have a Queue operation, and shall not require event acknowledgment by the system operator. The system shall have a labeled color coded indicator for each type of event; alarm - red, supervisory - yellow, trouble - yellow, monitor - green. When an unseen event exists for a given type, the indicator shall flash. When all events of a given type have been displayed, the indicator shall change from flashing to steady.
  - 3. For each event, the display shall include the current time, the total number of events, the type of event, the time the event occurred.
  - 4. The user shall be able to review each event by simply selecting scrolling keys (up-down) for each event type.
  - 5. New alarm, supervisory, or trouble events shall sound an silenceable audible signal at the control panel.
- B. Operation of any alarm initiating device shall automatically:
  - 1. Update the control/display as described above.
  - 2. Sound all alarm signals throughout the building at the evacuation rate.
  - 3. Turn on all strobe lights throughout the building.
  - 4. Turn on a red alarm zone LED at the fire alarm control panel.
  - 5. Operate the alarm relay contacts to initiate the transmission of an alarm to a central station agency via leased telephone lines.
  - 6. Operate control relay contacts to shut down air supply fans. Shutdowns shall be hardwired from the Fire Alarm System (i.e., not implemented via building automation controls) and immediate acting, and shall not be overridden by Hand-Off-Auto switches or other controls.
  - 7. Operate control relay contacts to de-energize smoke/fire dampers to close dampers. Dampers shall typically be interlocked with their associated air handler unit so the dampers close whenever the air handler is de-energized.

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8. Separate Alarm and trouble conditions shall be transmitted to the Building Automation System (BAS) and Building Security System. Common alarm, common trouble and common sprinkler alarm conditions shall be monitored by the BCS and Security Systems. Provide separate sets of outputs for the BCS and Security Panels.

C. Activation of a sprinkler supervisory initiating device shall:

1. Update the control/display as described above.
2. Turn on a yellow zone LED at the fire alarm control panel.
3. Operate the supervisory relay contacts to initiate the transmission of a supervisory condition to a central station agency via telephone lines.

D. Fire alarm system wiring shall be electrically supervised to automatically detect and report trouble conditions to the fire alarm control panel. Any opens, grounds or disarrangement of system wiring and shorts across alarm bell/strobe wiring shall automatically:

1. Update the control/display as described above.
2. Operate the trouble relay contacts to initiate the transmission of a trouble alarm to a central station agency via telephone lines.

3.3 DOOR UNLOCKING DEVICES

- A. Any device or system intended to effect the locking/unlocking of emergency exits shall be connected to the building fire alarm system. These exits shall unlock upon receipt of any fire alarm signal.
- B. All emergency exits connected in accordance with the paragraph above shall unlock upon loss of the primary power to the fire alarm system. The secondary power supply shall not be utilized to maintain these doors in locked condition.

3.4 PROTECTION OF FIRE ALARM CONTROL UNITS

- A. Provide automatic smoke detection at the location of each fire alarm control unit(s) including fire alarm control panels, remote power supplies and remote battery supplies.

3.5 INTERCONNECTIONS TO OTHER SYSTEMS

- A. Provide input modules for monitoring of med gas storage room emergency shutdown buttons. Provide sufficient modules to give each shutdown button an individual address. Provide control modules to perform automatic shutdown of med gas storage rooms HVAC system upon activation of shutdown buttons and annunciation of non-fire alarm sounder/strobe at med gas storage rooms.

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3.6 REMOTE DETECTOR INDICATORS

- A. Provide remote LED indicators for all duct mounted smoke detectors where the detector is mounted where the LED alarm indicator is not easily visible. Provide a descriptive label in accordance with Section 260553 – Identification of Electrical Systems.

3.7 TESTING AND REPORTS

- A. Upon completion of the system installation, an Approved representative of the system manufacturer shall conduct a thorough test of the system and all related devices and components of the system, and submit a written report of the findings to the Contracting Agency. For devices, circuits, and equipment installed or modified as part of the project testing shall include, at the least, verification of the following:
  - 1. The functional operation of each resettable initiating device (manual fire alarm boxes, detectors, etc.) and circuits.
  - 2. The functional operation of each and every alarm device and circuit.
  - 3. The functional operation of each monitored device circuit.
  - 4. The functional operation of each control and output circuit.
  - 5. The supervision function of each Initiating, Indicating, Monitoring, Control and Supply Circuit.
  - 6. Central Station automatic signaling.
  - 7. Proper initiation and execution of mechanical systems control sequences.
  - 8. Verify that wire size, power supply, number of devices on a circuit, etc. are suitable to support 100% of devices being in alarm or operated simultaneously. Test shall include the following as a minimum:
    - a. Place all detectors and monitor modules in alarm. Each shall display its address and alarm condition. At least the first ten devices on each circuit shall also have their alarm LEDs lighted, where applicable.
    - b. Operate all control modules for the alarm or operated condition. Each module shall display its address and condition.
    - c. Reset all alarmed and operated devices. The panel shall display the address of any off-normal devices.
  - 9. Test a representative number of detectors for alarm verification by momentarily testing for alarm. The detectors shall not initiate an alarm. Then test by placing the detectors in alarm such that it remains in alarm for the selected verification time. The detector shall initiate an alarm.
  - 10. Test a representative number of detector for trouble by removing the detector from its base. The address and trouble condition for each shall be displayed. Insert a different type of detector into the base. The address and trouble condition shall be displayed. The detector shall return to normal only when the proper detector type is reinserted into the base.
  - 11. Print out the English-language descriptor, currently sensed value, prealarm threshold value, alarm threshold value and status of each sensor in the system. Also print out the

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English-language descriptor and status of each module in the system. The printout shall also include the date and time.

3.8 TRAINING

- A. After the system provided in this Section is completely installed and operational, and at a time chosen by the Owner, provide the Owner's system operators and maintenance personnel and representatives of the local Fire Department with a total of four (4) hours of instruction on the operation, maintenance, and troubleshooting of all equipment provided under this Section.
- B. Training sessions shall be presented by a fully qualified, trained representative of the equipment manufacturer, who is thoroughly knowledgeable on the specific installation. Separate sessions shall be given for operation personnel (i.e.: facility staff and Fire Department) and maintenance personnel, with the length and content of the sessions tailored to the respective groups.
- C. Provide an additional one (1) hour of follow-up instruction for review and clarification at a later time mutually agreed on with the Owner, if the Owner deems it necessary.

END OF SECTION 283100