

SECTION 23 8200
TERMINAL HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cabinet unit heaters.
 - 2. Fintube radiation.
- B. Related Sections:
 - 1. 20 0000 - Mechanical General Requirements
 - 2. 20 0529 - Mechanical Hangers and Supports
 - 3. 23 0593 - Testing, Adjusting and Balancing
 - 4. 23 2113 - Hydronic Piping and Specialties
 - 5. 25 9000 - Sequence of Operations

1.2 SYSTEM DESCRIPTION

- A. Design Requirements: Provide terminal heating and cooling units, piping, appurtenances, and controls to automatically maintain interior temperature setpoint for each area of the building.
- B. Performance Requirements: Provide performance and output shown or scheduled on drawings.

1.3 SUBMITTALS

- A. Refer to Section 20 0000 - Mechanical General Requirements for general submittal requirements.
- B. Product Data:
 - 1. Submit product literature for items specified in Part 2 and those products required by the performance standards of this section. Literature clearly annotated to indicate specified salient features and performance criteria.
 - 2. Include the following:
 - a. Performance characteristics as scheduled.
 - b. Enclosure style, material and grille arrangement.
 - c. Dimensional data.
- C. Samples:
 - 1. Provide color samples of fintube and cabinet unit heater enclosures.
 - 2. Colors to be selected by the Contracting Agency.
- D. Provide certificates, manufacturer's instructions, and manufacturer's field reports for Quality Assurance/Control Submittals:
 - 1. Provide a complete manufacturer's written installation, operation and maintenance manual for each type of installed equipment.

2. Clearly annotate the manual to indicate applicable information for the specific equipment model(s) installed.
3. Included with the manual one copy of the completed start-up and operation checklist. The checklist shall include:
 - a. Printed names and signatures of the installers.
 - b. Documentation from Manufacturer's representative and Contracting Agency that the equipment has been properly installed and is fully operational, thus validating the equipment warranty.

E. Closeout Submittals:

1. Project Record Documents: Record actual locations of components and locations of access doors in terminal unit cabinets required for access or valves.
2. Operation and Maintenance (IO&M) Manuals:
 - a. Refer to Section 20 0000 - Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
 - b. Provide copies of approved submittal information for inclusion within the project IO&M Manual. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, parts listings, and spare parts list.

1.4 **QUALITY ASSURANCE**

- A. Manufacturer qualifications: Company specializing in manufacturing the products specified in this section with a minimum of three years documented experience.
- B. Installers' qualifications: Minimum three years experience in the installation and start-up of packaged central air handling systems.
- C. Pre-Installation Meetings: Coordinate installation of terminal heating and cooling units with trades responsible for portions of this and any other related sections of the Project Manual prior to installation of any terminal heating and cooling unit components.
- D. Regulatory requirements: Products requiring electrical connection - Listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the Authority Having Jurisdiction.

1.5 **DELIVERY, STORAGE, AND HANDLING**

- A. Acceptance at Site:
 1. Verify that products are delivered in original factory packaging and are free from damage and corrosion.
 2. Remove damaged, or otherwise unacceptable, products from the project site when directed by the Contracting Agency.
- B. Storage and Protection:
 1. Outside the general construction zone, store products in covered storage area protected from the elements, 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.

- C. Extra Materials: Provide one set replacement filters for cabinet unit heaters.

1.6 **WARRANTY**

- A. See Section 20 0000 - Mechanical General Requirements, for general mechanical warranty requirements.
- B. Provide five (5)-year manufacturer's warranty for cabinet unit heaters.
- C. Submit necessary documentation to the Manufacturer's Representative to validate manufacturer's warranty.
- D. Provide to the Contracting Agency one copy of warranty documentation and confirmation receipt from the Manufacturer's Representative.

PART 2 - PRODUCTS

2.1 **FINTUBE RADIATION**

- A. Description: Radiation heating terminal units consisting of continuous finned tubing with or without metal enclosure.
- B. Heating Elements:
 - 1. Seamless copper tubing suitable for soldered fittings (as scheduled).
 - 2. Mechanically expanded, evenly spaced aluminum fins (as scheduled).
- C. Element Hangers: Elements shall be supported by sliding or rolling brackets designed to provide for unrestricted longitudinal movement and noiseless expansion. Hangers from the upper portion of the back panel which shall be of sufficient length to accommodate expansion and contraction of the element without distortion of the fins. Hangers shall be designed to support the element clear of all portions of the enclosure and shall not depend upon any frictional device for attachment. Hangers are not applicable to more than one element tier. Provide an approved expansion compensator for each 20 feet or greater of element including bare pipe connections.
- D. Enclosures: Configuration and dimensions as scheduled and to include:
 - 1. Minimum metal thickness: 14 gauge.
 - 2. Full back panel with vertical stiffeners and elements supports.
 - 3. Lower edge of enclosure braced to element supports and/or back panel.
 - 4. Concealed tongue and groove type stiffener joints between enclosure sections.
 - 5. Wall to wall enclosure or end covers as shown.
 - 6. Support cabinet rigidly to wall or on floor mounted brackets at three (3) feet on center maximum spacing.
- E. Finish: Factory applied baked enamel finish. Colors to be selected by Architect.
- F. Access Doors: For otherwise inaccessible valves, provide factory made permanently hinged access doors integral with cabinet.
- G. Rated heat output shall be determined in accordance with I-B-R procedures. Unless otherwise stated, the heat output requirements listed in the Schedule are standard catalog

ratings for hot water at a tube velocity of three feet per second. Corrections for velocity and glycol solutions have been included in calculations to determine element length and flow volume.

H. Capacity: As scheduled.

I. Manufacturers: Sterling, Modine, Rittling, Trane, Vulcan, Slant fin, JAGA.

2.2 **CABINET UNIT HEATERS**

A. Coils: Evenly spaced aluminum fins mechanically bonded to copper tubes designed for 100 psi and 220 degrees F.

B. Cabinet: 0.0598-inch steel with exposed corners and edges rounded, easily removed panels, glass fiber insulation, and integral air outlet and integral air outlet and inlet grilles.

C. Finish: Factory applied baked enamel finish. Colors to be selected by the Contracting Agency.

D. Fans: Centrifugal forward curved, double width wheels, statically and dynamically balanced, direct driven.

E. Filter: Easily removed, located to filter air before the coil. Permanent washable type or one (1)-inch thick glass fiber throwaway type.

F. Mixing Dampers: Where indicated, mixing sections with dampers. Refer to Section 25 9000 - Sequence of Operations.

G. Capacity: As scheduled.

H. Electrical Characteristics:

1. Horsepower, voltage, and phase as scheduled on the Drawings, 60 Hz.
2. Refer to Divisions 26.

I. Manufacturers: Modine, Sterling, Rittling.

PART 3 - EXECUTION

3.1 **PREPARATION**

A. Protection: Cover equipment and plug piping connections to protect components from construction dirt and debris.

B. Preparation: Prior to installation of terminal units, make sure wall construction is complete enough to correctly locate and mount units.

3.2 **INSTALLATION**

A. Install terminal equipment in accordance with manufacturer's instructions.

B. Install equipment exposed to finished areas after walls and ceilings are finished and painted.

C. Provide finished cabinet units with protective covers during balance of construction.

- D. Finned Tube Radiation: Locate on outside walls and run cover continuously wall-to-wall unless otherwise indicated. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window. Install end caps where units butt against walls.
- E. Cabinet Unit Heaters: Install as indicated. Coordinate to assure correct recess size for recessed units.
- F. Hydronic Units:
 - 1. Provide accessible ball type isolation valves on supply and return lines to each terminal unit to allow for unit drain down and repair.
 - 2. Provide low-point drain valve that allows for complete gravity drawing of terminal unit.
 - 3. Provide balancing valve as specified elsewhere.
 - 4. Provide high-point automatic air vent as specified elsewhere.
- G. Access Doors: Install such that a drain hose may be easily connected to each drain line hose bibb, allowing the applicable portion of the system to be completely drained.
- H. Install balancing valves and serviceable products for heating terminal units to be operable and adjustable without removal of the finish cover.
- I. Provide pressure and temperature test plugs on both sides of heat transfer elements to measure the drop across runs of heat transfer elements.
- J. In systems containing glycol, provide only products specifically designed and approved for continuous operation with the glycol solution specified.

3.3 **CONSTRUCTION**

- A. Interface with Other Work:
 - 1. Coordinate and sequence installation of terminal heating and cooling units with trades responsible for portions of this and other related sections of the Project Manual.
 - 2. Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.4 **REPAIR/RESTORATION**

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 **FIELD QUALITY CONTROL**

- A. Manufacturer's Field Services:
 - 1. Verify units are installed and operational in accordance with the manufacturer's written installation instructions.
 - 2. Both the Contractor and Manufacturer's Representatives shall sign start-up and operational checklist to confirm proper unit installation and operation.

3.6 ADJUSTING

- A. Adjust functional components for proper operation in accordance with manufacturer's recommendations, or as otherwise directed.
- B. Coordinate and work directly with the Testing, Adjusting and Balancing Agency to provide systems in proper operating order. Make corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.7 CLEANING

- A. After construction is completed (including painting), and prior to initial start-up, clean and wipe down exposed surfaces of units. Vacuum clean coils and inside of cabinets and enclosures.
- B. Touch up marred or scratched surfaces of factory finished cabinets and enclosures, using finish materials furnished by manufacturer.
- C. Clean permanent filters or install new disposable filters.

3.8 DEMONSTRATION AND START-UP

- A. Start-up and operate terminal heating and cooling units in accordance with the manufacturer's written installation and operation manual check list.
- B. Demonstrate proper system operation using the building automation system.
- C. Document start-up and operational checks using the checklist and submit in accordance with submittal requirements.

END OF SECTION 23 8200

SECTION 23 8318
SNOW MELTING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Radiant snow melting systems.
- B. Related Sections:
 - 1. 20 0000 - Mechanical General Requirements
 - 2. 20 0529 - Mechanical Hangers and Supports
 - 3. 20 0553 - Mechanical Identification
 - 4. 20 0700 - Mechanical Insulation
 - 5. 20 4100 - Mechanical Demolition
 - 6. 23 0593 - Testing, Adjusting and Balancing
 - 7. 23 2113 - Hydronic Piping and Specialties
 - 8. 23 2123 - Hydronic Pumps
 - 9. 25 9000 - Sequence of Operations

1.2 SYSTEM DESCRIPTION

- A. Design Requirements:
 - 1. Provide a complete automatic radiant snow melting system to serve the entry walkway and sidewalk areas as defined by the Contract Drawings.
 - 2. Drawings are partially diagrammatic and do not show all hardware, components, and features.
 - 3. Provide tubing, manifolds, fittings and hardware, valving, strainers, drains, vents, gauges, sensors, supports, and other appurtenances required for a complete and properly operating system. When possible, provide from the same manufacturer.
- B. CAUTION! Do not operate snow-melt system in an uncontrolled manner! Overheating the radiant tubing (140 degrees F. or greater) will cause damage to tubing, reducing heat transfer capability and therefore, system performance. Should this occur, replace tubing, sand and slab system at no additional cost to Owner.

1.3 SUBMITTALS

- A. Product Data:
 - 1. Refer to Section 20 0000 - Mechanical General Requirements for general submittal requirements.
 - 2. Provide manufacturers' product literature for each system product.
 - 3. Provide a complete copy of the technical design guide and installation instructions to be used. Clearly annotate this information to indicate installation method to be used.
- B. Shop Drawings:

1. Refer to Section 20 0000 - Mechanical General Requirements for general shop drawing requirements.
 2. Provide engineering design calculations that confirm Performance Requirements and Design Parameters as listed. Submit calculation using copies of forms provided with the approved design manual.
 3. Provide radiant snow-melt system shop drawings which indicate:
 - a. The intended boundaries of the snow-melt system.
 - b. Number/label each loop per manifold worksheet.
 - c. Each snow melt zone/circuit location and BTUH/SF thermal performance.
 - d. Location of in-slab precipitation sensor and conduit run.
 - e. Slab control joint and construction joint locations with typical tube routing detail where piping must cross joints.
 - f. Manifold, circulator pump, and expansion tank locations.
 - g. System piping diagram showing piping arrangement, circulation pump, control valves, isolation valves, balance and drain valves, test fittings and vents, temperature sensors and other appurtenances.
 4. Indicate mechanical and electrical service locations.
- C. Quality Assurance/Control Submittals:
1. Design Data and Test Reports: Provide copy of certified pressure test report.
 2. Certificates, Manufacturer's Instructions, and Manufacturer's Field Reports:
 - a. Provide copy of completed start-up and operation checklist.
 - b. Include printed names and signatures of the installers.
 - c. Include documentation from manufacturer's representative that the equipment has been properly installed and is fully operational, thus validating the equipment warranty.
- D. Closeout Submittals:
1. Project Record Documents:
 - a. Record actual locations of under slab system components, including tubing layout, precipitation sensor, and other items as applicable.
 - b. Indicate actual locations of control and construction joints.
 2. Operation and Maintenance (IO&M) Manuals:
 - a. Refer to Section 20 0000 - Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
 - b. Provide copies of approved submittal information for inclusion within the project IO&M Manual. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, parts listings, and spare parts list.
 3. Warranty:

- a. Submit necessary documentation to the Manufacturer's Representative to validate manufacturer's warranty.
- b. Provide one copy of warranty documentation and confirmation receipt from the Manufacturer's Representative to the Contracting Agency.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. **Manufacturer Qualifications:** Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
2. **Acceptable Installers:** Minimum three years experience in the installation and start-up of radiant snow melting systems.

B. Pre-Installation Meeting: Coordinate installation of radiant floor heating system components with trades responsible for portions of this and any other related sections of the Project Manual prior to installation.

C. Regulatory Requirements: Products Requiring Electrical Connection - Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Acceptance at Site:

1. Verify that products are delivered in original factory packaging and are free from damage and corrosion.
2. Remove damaged, or otherwise unacceptable, products from the project site when directed by the Contracting Agency.

B. Storage and Protection:

1. Store products in covered storage area protected from the elements, outside the general construction zone until installed.
2. Store PEX tubing in original factory packaging, out of direct sunlight, until ready for installation.
3. Handle items carefully to avoid breaking, chipping, denting, scratching, or other damage.
4. Replace damaged items with same item in new condition.

1.6 WARRANTY

A. See Section 20 0000 - Mechanical General Requirements, for general mechanical warranty requirements.

B. Submit necessary documentation to the Manufacturer's Representative to validate manufacturer's warranty, including the following:

1. **Manufacturer's Project Start-up and Site Inspection Report.**
2. **Documentation demonstrating compliance with the applicable Technical Information Manual.**
3. **Any other written documentation required by the approved manufacturer to validate the warranty.**

- C. Provide one complete copy of warranty documentation and confirmation receipt from the Manufacturer's Representative to the Contracting Agency.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Unless specified otherwise, provide products from the same manufacturer as part of a proven pre-engineered and cataloged system.
- B. Manufacturers:
 - 1. Uponor
 - 2. Wirsbo.
 - 3. Rehau.
 - 4. Mr. Pex (manufactured by LK Pex AB).
 - 5. Watts Radiant.

2.2 TUBING, FITTINGS AND FASTENERS

- A. Tubing:
 - 1. High density cross-linked polyethylene (PEX) tubing with co-extruded oxygen diffusion barrier, manufactured in accordance with ASTM F877 and DIN 4726. Tubing material shall be fully cross-linked to the specified standard prior to shipment from the manufacturer.
 - 2. Tubing: 5/8 inch I.D., 3/4 inch O.D.
 - 3. Maximum operating temperature: 180 degrees F.
 - 4. Maximum operating pressure: 100 PSIG.
- B. Tube Fittings:
 - 1. Brass compression sleeve and coupling, for locations which are inaccessible after installation.
 - 2. Brass compression union nut fittings, for locations which are accessible after installation.
- C. Tubing Anchors (For tubing secured to rebar or wire mesh):
 - 1. Molded plastic Star clips.
 - 2. Nylon cable ties.
- D. Tubing radius sleeve: Provide manufacturer's tubing radius sleeves where the tubing enters the concrete slab.

2.3 SNOWMELT SENSORS

- A. Sensor and sensor socket assembly suitable for casting in snow melt concrete slab.
- B. Sensor socket constructed of silicon brass with 3/4" conduit opening, top fitted to accept sensor assembly.
- C. Sensor:
 - 1. Capable of sensing presence of snow or ice, and to measure temperature of slab.

2. Brass body with O-ring seal to socket.
3. Thermistor sensors.
4. Manufacturer's jacketed cable.

D. Manufacturer: Tekmar Snow/Ice Sensor 90 and Sensor Socket 091, or equal.

2.4 **SENSORS**

A. Temperature sensors:

1. Provide air temperature sensors, slab temperature sensors, supply / return water temperature sensors and other sensors as indicated on the Drawings for a complete and operational system.
2. See Section 25 5000 - Building Automation System for monitoring requirements.

2.5 **MANIFOLD SUPPLY AND RETURN HEADERS**

- A. Premanufactured type 304 stainless steel manifold construction. Brass components. Mounting brackets.
- B. Quarter turn ball isolation valves.
- C. Flowmeter indicators, isolation and balancing valves for each loop.
- D. Air vents with isolation valves.
- E. Low point drain valves with 3/4-inch threaded hose connections and end caps.

2.6 **MANIFOLD ENCLOSURES**

- A. Provide pre-manufactured, recessed manifold enclosures of a size appropriate for the manifold.
 1. Painted steel cabinets.
 2. Header mounting rails.
 3. Access doors.
- B. Field fabricated enclosure assemblies are not acceptable.

2.7 **PUMPS**

A. See Section 23 2123 - HVAC Pumps.

2.8 **HEAT EXCHANGERS**

A. See Section 23 2113 - Hydronic Piping and Specialties.

2.9 **EXPANSION TANKS**

A. See Section 23 2113 - Hydronic Piping and Specialties.

2.10 **GLYCOL SOLUTION**

- A. Fifty percent Dowfrost HD inhibited propylene glycol solution, suitable for operating temperatures from minus 40 degrees F to 250 degrees F.

2.11 SNOWMELT CONTROLLER

- A. Provide a pre-packaged electronic control system specifically designed for snow melt systems to provide fully automatically control of the snow-melt system in accordance with the Sequence of Operation.
- B. Manufacturers:
 - 1. Tekmar 664 or equal
 - 2. Rehau.
 - 3. Wirsbo.
 - 4. Approved equal.

2.12 VALVES

- A. Refer to Section 23 2113 Hydronic Piping and Specialties

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protection: Cover equipment and plug piping connections to protect components from construction dirt and debris.
- B. Preparation:
 - 1. Verify that slab insulation, reinforcing steel or wire mesh and other structural items are complete and ready for tubing installation.
 - 2. Verify locations of slab control, construction and expansion joints.
 - 3. Verify locations of underground electrical trenches, structural elements and other items that may affect tubing installation.
 - 4. Verify that appropriate electrical connections are available, with the proper voltage and phase characteristics.
 - 5. Coordinate timing of work such that radiant tubing installation does not interfere with the work of other trades. Minimize construction activity in the area to prevent damage to tubing and other system components.

3.2 INSTALLATION

- A. Install snow-melt system in accordance with manufacturer's written instructions using specialty tools supplied by the manufacturer when required.
- B. Refer to civil drawings for slab construction details.
- C. Where tubing crosses slab expansion, control or construction joints, route piping under joints or provide a sleeve over tubing extending 10 inches minimum beyond the joint. Sleeve material as specified in the manufacturer's installation guide.
- D. Where tubing exits the slab, provide a sleeve over tubing extending 10 inches minimum into the floor and above the floor. Sleeve material as specified in the manufacturer's installation guide.

- E. Lay out supply piping, pumps, manifolds and other components in a neat and logical fashion. Verify that components are accessible for servicing, adjustment and removal.
- F. Sleeve tubing penetrations through slab floor and building foundation. Coordinate penetration sizes and locations with structural.
- G. Insulate tubing runs between floor penetrations and building exterior with one inch foam insulation compatible with tubing and designed for direct bury applications. See Section 20 0700 - Mechanical Insulation.

3.3 **CONSTRUCTION**

- A. Interface with Other Work:
 - 1. Coordinate and sequence installation of radiant snow-melt system components with trades responsible for portions of this and other related sections of the project.
 - 2. Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related work shall be completed at no additional expense to the Owner.

3.4 **SEQUENCE OF OPERATION**

- A. Control snowmelt system utilizing manufacturer's packaged control system.

3.5 **REPAIR/RESTORATION**

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Do not operate snow-melt system in an uncontrolled manner! Overheating the radiant tubing (140 degrees F. or greater) will cause damage to tubing, reducing heat transfer capability the therefore, system performance. Should this occur, replace tubing, sand and slab system at no additional cost to Owner.
- C. Substitute replacement parts from other manufacturers are not acceptable.

3.6 **FIELD QUALITY CONTROL**

- A. Flush and purge piping and manifold in accordance with manufacturer's installation guide. Verify that debris and air has been removed from floor circuits, manifold headers and supply piping.
- B. Pressure Testing:
 - 1. Prior to pouring the slab, perform a water pressure test as recommended by the manufacturer. An air testing is not acceptable. Pressurize with water for the length of time specified. If the maximum pressure drop is exceeded, repair leaks and re-test.
 - 2. Pressure gauges used for testing must show pressure increments of 1 PSIG and be located at or near the lowest point in the system.
 - 3. Comply with local codes during pressure testing. Where required, pressure tests should be witnessed by the Authority Having Jurisdiction.
 - 4. Maintain operating system pressure during slab installation.
 - 5. Complete the manufacturer's inspection and test reports showing acceptable performance and submit with warranty and IO&M documentation. Include the following:
 - a. Manufacturer's Project Start-up and Site Inspection Report.

- b. Documentation demonstrating compliance with the Technical Information Manual.
 - c. Other documentation as required.
- C. Manufacturer's Field Services:
 - 1. Verify system is installed and operational in accordance with the manufacturer's written installation instructions.
 - 2. Both the Contractor and Manufacturer's Representative(s) shall sign start-up and operational checklist to confirm proper system installation and operation.
- 3.7 **CLEANING**
 - A. Upon completion of installation and prior to initial start-up, vacuum clean and wipe down external system components and inside manifold cabinet.
- 3.8 **DEMONSTRATION & START-UP**
 - A. Start-up and operate radiant floor heating systems in accordance with the manufacturer's written installation and operation manual checklist. Allow sufficient slab curing time before startup.
 - B. During initial start up, bring slab up to temperature slowly in order to minimize the possibility of thermal shock.
 - C. Demonstrate proper system operation using the building automation system and packaged control system.
 - D. Document start-up and operational checks using the checklist and submit in accordance with submittal requirements.
- 3.9 **BALANCING**
 - A. Coordinate and work directly with the Balancing and Testing Agency to provide systems in proper operating order. Make corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

END OF SECTION 23 8318

SECTION 25 3000
BUILDING AUTOMATION SYSTEM FIELD DEVICES

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.

1.2 SYSTEM DESCRIPTION

- A. Extend existing BAS to incorporate new equipment. Existing BAS is by Long Building Technologies (formerly Control Contractors, Inc).

1.3 SUBMITTALS

- A. Submit in accordance with Section 25 5000 - Building Automation System and in accordance with Division 1.

1.4 CLOSEOUT SUBMITTALS

- A. Submit in accordance with Section 25 5000 - Building Automation System and in accordance with Division 1.

1.5 WARRANTY

- A. Refer to Section 25 5000 - Building Automation System.

PART 2 - PRODUCTS

2.1 TEMPERATURE SENSOR

- A. Digital room sensors:
 - 1. Temperature monitoring range: 45/104 degrees F.
 - 2. Network jack.
 - 3. Output signal: Changing resistance.
 - 4. Accuracy at Calibration point: Plus or minus 1 degrees F.
 - 5. Wall Mounted unit with finished cover:
 - a. Private offices and rooms:
 - 1). Digital display, setpoint adjustment capability. The setpoint adjustment shall be limited by the automation system to limit the amount of room adjustment (68-72 deg F).
- B. Liquid immersion temperature:
 - 1. Temperature monitoring range: Minus 40/240 degrees F.
 - 2. Output signal: Changing resistance.
 - 3. Accuracy at Calibration point: Plus or minus 0.5 degree F.

4. Provide immersion sensor assembly as specified. Immersion sensors shall include a separate thermowell for sensor installation. Annular space between well and sensor shall be filled with heat conductive compound.

C. 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.

D. 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.

E. Outside air temperature:

1. Temperature monitoring range: Minus 58/122 degrees F.
2. Output signal: 4-20 mA DC.
3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
4. Provide NEMA3R rated mounting assembly (rain tight).

2.2 WALL MOUNTED SENSOR GUARD

- A. Clear or opaque butyrate plastic guard, key lock, mounting plate.

- B. Provide on sensor in the Gathering room only.

2.3 LOW TEMPERATURE DETECTION THERMOSTAT

- A. Provide low temperature control thermostat, electric type manual reset, non-averaging 20 feet long sensing elements that switch whenever any 12 inch section or more of any portion senses a temperature as low as the thermostat setpoint as specified in sequences.

- B. Provide with automatic reset with control system reset.

- C. Provide with two sets of contacts, one for hardwired fan shutdown and one for remote monitoring.

2.4 HIGH AND LOW LIMIT THERMOSTATS

- A. Provide electric, high or low limit thermostats as required by sequence of operation.

- B. Freeze Protection Thermostats: Employ a 20 foot element. If any one foot section of the element is subjected to temperatures below 35 degrees F, the respective electric or pneumatic circuit opens, causing action to fans and dampers as required under the sequence of operations. Provide with automatic reset.

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 DIFFERENTIAL AIR STATIC PRESSURE SENSOR

- A. Provide integral pressure transducer and transmitter in enclosure suitable for wall or panel mounting. 4-20ma output signal proportional to the input pressure span.
- B. Transmitter range shall be selected so that the normal operating setpoint is midway between the upper and lower range of the transmitter. Transmitter range shall be bi-directional.
- C. The following sensor locations with static pressure ranges are:
 - 1. Fan Room static pressure: Plus or minus 0.1 inch W.C.
 - 2. Supply duct static pressure: Plus or minus 2.0 inch W.C.
 - 3. Filter bank static pressure drop: Plus or minus 1.5 inches W.C.
 - 4. Air flow station: Varies based on manufacturer recommendations.
- D. Temperature operating range: 32 to 122 degrees F.
- E. Each transmitter shall have field adjustable span and zero adjustments for field calibration. Accuracy plus or minus 0.5 percent of full scale. Linearity plus or minus 0.1 percent.

2.8 DIFFERENTIAL FLUID PRESSURE SENSOR

- A. Provide integral pressure transducer and transmitter with 4-20 mA output signal proportional to the input pressure span.
- B. Provide NEMA 1 aluminum enclosure.
- C. Transmitter range shall be selected so that the normal operating setpoint is midway between the upper and lower range of the transmitter. Transmitter range shall be unidirectional.
- D. The range for the sensor serving the hydronic heating system is 0-10 psig.
- E. Temperature operating range: Minus 40 to 175 degrees F.
- F. Each transmitter shall have field adjustable span and zero adjustments for field calibration. Accuracy plus or minus 1.0 percent of full scale.

2.9 FLUID PRESSURE SENSOR

- A. Provide integral pressure transducer and transmitter with 4-20 mA output signal proportional to the input pressure span.
- B. Provide watertight enclosure.

- C. Transmitter range shall be selected so that the normal operating setpoint is midway between the upper and lower range of the transmitter. Transmitter range shall be unidirectional.
- D. The range for the sensor serving the hydronic heating system is 0-50 psig.
- E. Temperature operating range: Minus 40 to 200 degrees F.
- F. Each transmitter shall have field adjustable span and zero adjustments for field calibration. Accuracy plus or minus 1.0 percent of full scale.

2.10 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.

2.11 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.

2.12 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.

2.13 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.

2.14 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.

2.15 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. of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
 - e. Dampers with 2 to 3 Inches w.g. 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 w.g. 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.

2.16 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.

2.17 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 four feet six 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. Fluid Temperature Sensor: The sensor shall have a separable well suitable for insertion in a pipeline or vessel. Cable connections shall be suitable for the highest temperature expected and low temperature sensors shall be sealed to exclude condensation of atmospheric moisture.
 - e. 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.
 - f. Mixed Air Temperature Sensors: The sensor shall be of the averaging type. Mount sensors with consideration for stratification of warm and cold air streams. Minimum binding radius for averaging sensors is four inches. Provide a minimum of one foot of averaging sensor element for each square foot of ductwork. Sensing element shall be installed such that it crosses completely through stratified airflow with complete passes. Partial passes are not allowed. If averaging sensor is not available provide one sensor for every four square feet of duct cross section area.
 - g. 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.
 - h. Low Temperature Detection Thermostats: Mount sensor element similar to Mixed Air Temperature Sensors.
3. Differential Fluid Pressure Sensor:
- a. Locate sensors as shown on the Drawings. Mount in accessible location.
 - b. Controls subcontractor to furnish differential pressure sensor snubbers. Installation of snubbers by plumbing subcontractor.
4. Fluid Pressure Sensor:
- a. Locate sensors as shown on the Drawings. Mount in accessible location.
 - b. Controls subcontractor to furnish fluid pressure sensor snubbers. Installation of snubbers by plumbing subcontractor.
5. 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.
6. 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 be 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.
7. 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 25 3000

SECTION 25 4000
VARIABLE SPEED DRIVES

PART 1 - GENERAL

1.1 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. All 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. 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.
- D. Related Sections:
 - 1. 20 0000 - Mechanical General Requirements
 - 2. 20 0513 - Common Motor Requirements
 - 3. 20 0529 - Hangers and Supports
 - 4. 20 0553 - Mechanical Identification
 - 5. 23 0593 - Testing, Adjusting and Balancing
 - 6. 23 2123 - Hydronic Pumps
 - 7. 25 5000 - Building Automation System
 - 8. 25 9000 - Sequence of Operations

1.2 REFERENCES

- A. Referenced Standards and Guidelines:
 - 1. Institute of Electrical and Electronic Engineers (IEEE)
 - a. IEEE 519-2014
 - 2. Underwriters Laboratories (as appropriate)
 - a. UL 508, 508A, 508C, UL 61800, 61800-5-1, 61800-5-2, UL 1995
 - 3. The Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA)
 - a. NEMA ICS 7-2014, Adjustable Speed Drives
 - 4. National Electric Code (NEC)
 - a. NEC 430.120, Adjustable-Speed Drive Systems
 - 5. CSA Group
 - a. CSA C22.2 No. 274
 - 6. International Building Code (IBC)
 - a. IBC 2018 Seismic – referencing ASCE 7-16 and ICC AC-156

1.3 QUALITY ASSURANCES

1. 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.
2. The base drive shall be CE and meet EN 61800-3 for the First Environment restricted distribution (Category C2).
3. The base drive shall be seismically certified per 2012 International Building Code (IBC) with a seismic importance factor of 1.0, and minimum 2.5 S_{DS} rating.
4. The base drive shall be SEMI-F47 certified. The drive must tolerate voltage sags to 50% for up to 0.2 seconds, sags to 70% for up to 0.5 seconds, and sags to 80% for up to one second.

1.4 SUBMITTALS

- A. Provide submittals for products in accordance with Section 20 0000 and Division 1.
- 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 harmonic mitigation and will not take the system out of compliance with IEEE 519.
 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 (2) 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.

1.5 WARRANTY

- A. 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 SPEED DRIVES

- A. The drive package as specified herein shall be enclosed in a NEMA Type 12 enclosure.
- B. The drive shall provide full rated output from a line of +10% to -15% of nominal voltage across an ambient temperature range of -15 to 40° C (5 to 104° 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% to reduce the harmonics to the power line. 5% 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% of its normal duty current rating for 1 minute every 10 minutes, 130% 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 4th 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 – A circuit breaker type disconnect shall be provided. The disconnect shall be door interlocked and padlockable. Drive input fusing shall be included on all packaged units that include a disconnecting means. All 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 Speed Drives (VSDs) and between VSDs and equipment supplied by the VSDs 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 START-UP

- A. 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 a copy provided to the Owner, and a copy kept on file by the manufacturer.

3.6 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.

3.7 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 25 4000

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SECTION 25 5000
BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. Changes to this specification have been agreed to between the City and the Contractor. See attached Long Proposal dated February 19, 2020 (2 pages).
- B. Section Includes: This section describes requirements, products, and methods of execution relating to the building automation controls system for the project.
- C. 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. 20 0000 - Mechanical General Requirements
 - 2. 23 0593 - Testing, Adjusting and Balancing
 - 3. 23 2123 - Hydronic Pumps
 - 4. 23 3400 - HVAC Fans
 - 5. 23 3600 - Air Terminal Units
 - 6. 23 5223 - Cast Iron Boilers and Accessories
 - 7. 23 8200 - Terminal Heating and Cooling Units
 - 8. 23 8318 - Snow Melting Equipment
 - 9. 25 3000 - Building Automation System Field Devices
 - 10. 25 9000 - Sequence of Operations
 - 11. 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. NFPA 70, National Electrical Code - NEC.
 - 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. Existing BAS is by Long Technologies (formerly Control Contractors, Inc). Long Technologies shall be the BAS subcontractor.
- B. Extend existing BAS to incorporate new equipment and sequences of operation.
- C. 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 work station 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.

D. 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.
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 25 9000 - Sequence of Operations.
9. Installation of control instrumentation and hardware specified in Section 25 3000 - 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. 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 work station.
 - 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.
12. 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.
13. A training program shall be provided to include: Data acquisition and report generation on the Operator's work station.
14. 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 20 0000 - 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.

1.6 CLOSEOUT SUBMITTALS

- A. 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.

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 State of Alaska and Contracting Agency.

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 SITE CONDITIONS

- ##### A. Existing Conditions: Field verify existing conditions.

1.10 WARRANTY

A. Manufacturer Warranty:

1. Provide in accordance with Section 20 0000 - 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. Long Building Technologies, no substitutes.

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 25 3000 - Building Automation System Field Devices, for requirements.
- B. Coordinate with Section 23 3600 - Air Terminal Units to have VAV controllers factory mounted on the VAV terminal unit.

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. Utilize the existing operator workstation.

2.8 NETWORKING COMMUNICATIONS

- A. The design of the BAS shall network an operator workstation(s) and stand-alone DDC Controllers. The network architecture shall consist of three levels; a Management Level Network (MLN) Ethernet network based on TCP/IP protocol, a high performance peer-to-peer building level network (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.
- B. 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.
- C. 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.
- D. Floor Level Network (FLN):
1. 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.

2.9 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.

2.10 UNINTERRUPTIBLE POWER SUPPLY

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

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 20 0529 - 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 54 inches AFF unless otherwise noted.

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.
 - c. Wells for hydronic temperature sensors.
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. Control and balancing dampers.
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.
 - f. Ethernet drop at or near designated BAS control panel(s).
 - g. Mounting and wiring of Variable Speed Drives (VSDs) furnished by the Mechanical Contractor per Divisions 20, 21, 22, 23, 25.
- C. System Integration. Products to receive integration under this section:
1. Variable Speed Drives:
 - a. Connect directly to the BAS through three twisted pair for Start/Stop, speed control and remote communications.
 - b. Factory-furnished with the appropriate communication hardware and software to allow communication.
 - c. Connections to VSD provided under this section.
 2. 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 25 9000 - 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 25 9000 - 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.
 4. Boiler Room: Indicate the following information for the heating pumps, boiler room ventilation equipment, and other boiler room equipment:
 - a. Put control points and adjustable set points on the screen.
 - b. Define action of dampers and valves (N/O or N/C).
 - c. Pump override commands.
 - d. Boiler override commands.
 - e. Reset schedules.
 - f. GPM flows.
 - g. Outside air temperature.
 - B. Graphical Electrical Displays: Create graphical displays of electrical equipment specified for connection to this system. Coordinate with Divisions 26, 27 and 28 and provide graphics on the PC-based workstations. At a minimum, these graphical displays shall include building floor plans utilized for Graphical Mechanical Displays.
 1. Building Lighting Control:
 - a. Status information.
 - b. Put control points and adjustable set points on the screen.
 - c. Lighting override commands.
 2. Site Lighting Control:
 - a. Status information.
 - b. Put control points and adjustable set points on the screen.
 - c. Lighting on/off override commands.
 - C. Use approved designations for room names, spaces, equipment tags, etc.
- 3.4 SITE QUALITY CONTROL**
- A. Programming BAS to provide system operation and monitoring in accordance with Section 25 9000 - Sequence of Operation and other referenced sections.
 - B. 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. Demonstrate the proper operation and control of systems controlled and monitored by the BAS.
2. 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 01 7900 - Demonstrations and Training.
2. In addition, provide forty (40) 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 25 5000

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PROPOSAL

Date: 2/19/2020
Proposal #: ACH19-01815 REV1
Expiration: 30 days from above date
Account Executive: Curtis Holeman
Contact Number: 907-242-6571

Unalaska Library Expansion Standalone HVAC Controls Proposal Unalaska, Alaska Addendums 1 thru 4 acknowledged

A. SCOPE OF WORK – HVAC CONTROLS

1. Provide and install HVAC controls per design progress drawings and specifications dated 9/26/18 and as described below.
2. **Note: New HVAC control system components shall be standalone Non DDC controls to help meet budget. DDC controls can be installed at a later date.**

B. Pricing

- **Base Bid for control system described below: \$59,963.00**

Not included are costs for:

- **Flight costs for 4 round trips from Anchorage to Unalaska**
- **Room costs for 30 Man-Days onsite**

C. INCLUSIONS:

- Demo existing controls as required
- Relocate thermostats as required
- Provide and install new VAV and baseboard controls as required. Controllers and thermostats shall be DDC but not networked together and tied into the existing DDC system. This can be done later and as budgets allow.
- Provide and install standalone damper actuator and interlock wiring for EF-1. EF-1 shall run continuously. DDC controls and monitoring can be added later as budgets allow.
- Provide control valve and provide and install standalone controls new controls for SCF-1. DDC controls and monitoring can be added later as budgets allow.
- Provide and install standalone TEKMAR snowmelt controls. DDC monitoring can be added later as budgets allow.
- Mount and wire factory controls for new boiler Blr-1 and boiler circ pumps. DDC control and monitoring is not included and can be added later as budgets allow.
- P-1a and b shall have integral speed control and shall be rotated manually. All other controls including DDC controls and monitoring can be added later as budgets allow.
- Provide and install standalone thermostat controls for new CUH-1. DDC controls can be added later as budgets allow.
- Engineered control drawings, product documentation, Startup/checkout for LONG Building Technologies provided equipment.
- 4 hours training for systems provided by LONG.
- 1-year warranty for parts and labor provided by LONG.
- Travel labor and food for 30 days onsite

D. EXCLUSIONS:

- **Flight costs for 4 round trips from Anchorage to Unalaska**
- **Room costs for 30 Days in Unalaska**
- Control dampers
- **Full DDC controls and connecting into existing BAS system for all new equipment. This can be added at a later date as budgets allow. See details in inclusions.**
- Installing valves, taps and wells.
- Providing VFD's and VFD startup. Integral to pumps.
- Startup and training on control systems not provided by LONG.
- Trenching and digging
- Starters, disconnects and power wiring
- Roof penetrations and core drilling.
- Cutting, patching and painting for access to equipment.
- All costs of sales tax, bonds and permits

Accepted for:	Submitted by: LONG Building Technologies
Accepted by:	Submitted by: Curtis Holeman
Title:	Title: Sr. Sales Engineer
Signature:	Signature: <i>Curtis Holeman</i>

SECTION 25 9000
SEQUENCE OF OPERATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Changes to this specification have been agreed to between the City and the Contractor. See attached Long Proposal dated February 19, 2020 (2 pages).
- B. Section Includes:
 - 1. 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.
- C. Related Sections:
 - 1. 20 0000 - Mechanical General Requirements
 - 2. 23 0593 - Testing, Adjusting and Balancing
 - 3. 23 2123 - Hydronic Pumps
 - 4. 23 3400 - HVAC Fans
 - 5. 23 3600 - Air Terminal Units
 - 6. 23 5223 - Cast Iron Boilers and Accessories
 - 7. 23 8200 - Terminal Heating and Cooling Units
 - 8. 23 8318 - Snow Melting Equipment
 - 9. 25 3000 - Building Automation System Field Devices
 - 10. 25 5000 - Building Automation System
 - 11. 28 3100 - Addressable Fire Alarm System

1.2 SUBMITTALS

- A. Refer to 20 0000 - Mechanical General Requirements.
- 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 20 0000 – 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.

1.3 QUALITY ASSURANCE

- A. Qualifications of Installers/Programmers: Minimum 3 years' experience in the installation and programming of direct digital control systems.
- B. Pre-Installation Meetings: Conduct coordination meetings, as necessary, to evaluate and coordinate the connection of the BAS to each piece of HVAC, electrical and plumbing equipment. Where the BAS is to be connected to packaged, stand-alone controllers, coordinate BAS remote control and monitoring capabilities with the specific features of the packaged controller to maximize remote operability and monitoring of each packaged controller through the BAS.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 FIRE ALARM PANEL MONITORING

- A. Monitor the building fire alarm panel alarm status output.

3.2 VENTILATION SYSTEM

- A. Main library AHU sequence of operation to remain.
- B. Typical Zone VAV Temperature Control with Reheat.
 - 1. Zone Sensors.
 - a. Zone Thermostat: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.
 - 2. Occupied Mode Operation.
 - a. Cooling Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone day setpoint temperature plus or minus one (1)-degree F. Reheat coil control valve remains shut.
 - b. Heating Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone day setpoint temperature plus or minus one (1)-degree F. Modulate VAV reheat coil control valve in parallel with control damper.
 - 3. Unoccupied Mode Operation.

- a. Heating Mode: When air handler is off, operate fan powered air terminal unit and modulate reheat coil valve to maintain zone night setpoint temperature plus zero (0), minus three (3) degrees F.
 - b. Cooling Mode: Ventilation system remains off regardless of zone temperature.
- C. Typical Zone VAV Temperature Control with Reheat (and auxiliary Fintube).
- 1. Zone Sensors.
 - a. Zone Thermostat: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.
 - 2. Occupied Mode Operation.
 - a. Cooling Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone day setpoint temperature plus or minus one (1)-degree F. Reheat coil and fintube control valves remain shut.
 - b. Heating Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone day setpoint temperature plus or minus one (1)-degree F. Modulate reheat coil valve in parallel with the control damper and open the two position fintube control valve.
 - 3. Unoccupied Mode Operation.
 - a. Heating Mode: When air handler is off, operate fan powered air terminal unit and modulate reheat coil valve and open two position fintube control valve to maintain zone night setpoint temperature plus zero (0), minus three (3) degrees F.
 - b. Cooling Mode: Ventilation system remains off regardless of zone temperature.

3.3 GENERAL EXHAUST FAN OPERATION (EF-1)

- A. Exhaust Fans EF-1, general building exhaust for public toilet rooms. Operate general exhaust fans as follows:
- 1. Open motor operated exhaust fan isolation damper and start exhaust fan when the ventilation system is in Occupied Mode.
 - 2. Stop exhaust fans and shut motor operated isolation damper during all other operating modes.
 - 3. Monitor exhaust fan motor and generate a fan specific "EF-X Trouble" alarm when exhaust fan fails to start during Occupied mode.

3.4 GATHERING ROOM VENTILATION SYSTEM (SCF-1)

- A. The small cabinet fan, SCF-1, provides ventilation and heating for the Gathering room.
- B. The system includes an outside air intake louver, mixing box with return and outside air dampers, a MERV8 filter section, a heating coil fan section along with a relief assembly equipped with a modulating relief damper.
- C. Zone Thermostat: Provide wall mounted thermostat with output signal to BAS system.
- D. Over ride switch: Provide a labeled, manual over ride switch to allow system operation outside of scheduled operating periods.
- E. Operate the system on a scheduled basis or for a three hour period when the over-ride switch is activated.
- F. Disabled Mode:
 - 1. When the SCF-1 is disabled, the outside air and relief dampers are closed, the heating coil valve is diverted from the heating coil and the SCF-1 fan is off.
- G. Enabled Mode:
- H. When the SCF-1 system is enabled to operate:

1. Modulate the mixing box dampers to provide a discharge air temperature to maintain the space temperature setpoint, initially set to 68 deg F.
 - a. Reset the discharge air temperature setpoint between 55 deg F and 80 deg F as required to maintain the space temperature setpoint.
 - b. When in Heating mode, modulate the mixing box dampers and the heating coil control valve in sequence to provide the discharge air temperature setpoint.
 2. Modulate the relief air damper open in sequence with the outside air mixing box damper.
- I. Low temperature shutdown:
1. Stop fan and close outside damper and relief damper if discharge supply temperature is less than 45 degrees F. (adjustable).
 2. Provide "SCF-1 Low Temperature" alarm to BAS.
 3. Provide BAS software reset to initiate the system restart sequence.
- J. Filter Monitoring:
1. Provide a differential pressure switch across filter bank.
 - a. Normal filter (2-inch Farr 30/30 GT) differential pressure range is 0.28 inches W.C. (clean) to 0.90 inches W.C. (dirty) at 500 feet per minute.
 - b. Generate a fan specific "SCF-1 High Filter Differential Pressure" alarm at 0.80 inch W.C.
- K. Fan Monitoring: Monitor supply fan motor with a current sensor and generate an independent fan specific "SCF-1 Failure" alarm if fan fails when it has been commanded "On" by the BAS.

3.5 HYDRONIC HEATING SYSTEM OPERATION

- A. Boiler firing is controlled by a package Boiler Controller to maintain supply temperature setpoint. Refer to Section 23 5223 Cast Iron Boilers and Accessories. Connect the BAS to the Boiler Controller. BAS system to enable and disable boiler operation via the Boiler Controller. Allow the secondary pump to operate for 10 minutes before enabling the boilers to operate via the Boiler Controller.
- B. The Boiler Controller controls boiler firing and dedicated boiler circulation pump, PMP-5 and PMP-5A, operation. Both boilers are permitted to fire if necessary.
- C. Secondary Loop Circulation Pumps, PMP-1 and PMP-1A: Secondary loop circulation pumps, PMP-1 and PMP-1A, are arranged in a lead/standby arrangement, with only one pump operating at a time.
 1. Rotate lead pump assignment to even runtime.
 2. Pumps are equipped with variable speed drives. Modulate the lead pump speed to maintain the differential pressure sensor setpoint, initially set at 5 psig.
 3. Monitor pump run status via a self-calibrating VSD motor current sensor. Generate a maintenance alarm if a pump fails to operate when commanded on.
- D. Monitor the boiler burner alarm contacts. Generate a maintenance alarm if a boiler burner is in an alarm condition.
- E. Monitor the glycol supply and return temperatures. Generate a maintenance alarm if the boiler supply temperature is less than or greater than the setpoint temperature by 10 deg F, adjustable for a period of 15 minutes or longer.

3.6 SNOWMELT SYSTEM

- A. Snowmelt system is controlled by packaged controller. Refer to Section 23 8318 Snow Melting Equipment.
- B. Monitor the snow melt supply (SMS) temperature.

- C. Monitor the pump run status via self-calibrating current sensors for pumps PMP-3 and PMP-4.
- D. Monitor the snow melt glycol pressure. Generate a maintenance alarm if the system pressure is less than 8 psig, adjustable.

3.7 HYDRONIC HEATING SYSTEM DEVICES

- A. Fintube: Provide a space temperature sensor. Open or close the fintube two position control valve to maintain space temperature setpoint of 68 deg F, adjustable.
- B. Cabinet Unit Heater: Provide a space temperature sensor.
 - 1. At 65 degrees F. (adjustable) and decreasing, start recirculating fan and open hydronic control valve.
 - 2. At 68 degrees F. (adjustable) and increasing, stop recirculating fan and shut hydronic control valve.

END OF SECTION 25 9000

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PROPOSAL

Date: 2/19/2020
Proposal #: ACH19-01815 REV1
Expiration: 30 days from above date
Account Executive: Curtis Holeman
Contact Number: 907-242-6571

Unalaska Library Expansion Standalone HVAC Controls Proposal Unalaska, Alaska Addendums 1 thru 4 acknowledged

A. SCOPE OF WORK – HVAC CONTROLS

1. Provide and install HVAC controls per design progress drawings and specifications dated 9/26/18 and as described below.
2. **Note: New HVAC control system components shall be standalone Non DDC controls to help meet budget. DDC controls can be installed at a later date.**

B. Pricing

- **Base Bid for control system described below: \$59,963.00**

Not included are costs for:

- **Flight costs for 4 round trips from Anchorage to Unalaska**
- **Room costs for 30 Man-Days onsite**

C. INCLUSIONS:

- Demo existing controls as required
- Relocate thermostats as required
- Provide and install new VAV and baseboard controls as required. Controllers and thermostats shall be DDC but not networked together and tied into the existing DDC system. This can be done later and as budgets allow.
- Provide and install standalone damper actuator and interlock wiring for EF-1. EF-1 shall run continuously. DDC controls and monitoring can be added later as budgets allow.
- Provide control valve and provide and install standalone controls new controls for SCF-1. DDC controls and monitoring can be added later as budgets allow.
- Provide and install standalone TEKMAR snowmelt controls. DDC monitoring can be added later as budgets allow.
- Mount and wire factory controls for new boiler Blr-1 and boiler circ pumps. DDC control and monitoring is not included and can be added later as budgets allow.
- P-1a and b shall have integral speed control and shall be rotated manually. All other controls including DDC controls and monitoring can be added later as budgets allow.
- Provide and install standalone thermostat controls for new CUH-1. DDC controls can be added later as budgets allow.
- Engineered control drawings, product documentation, Startup/checkout for LONG Building Technologies provided equipment.
- 4 hours training for systems provided by LONG.
- 1-year warranty for parts and labor provided by LONG.
- Travel labor and food for 30 days onsite

D. EXCLUSIONS:

- **Flight costs for 4 round trips from Anchorage to Unalaska**
- **Room costs for 30 Days in Unalaska**
- Control dampers
- **Full DDC controls and connecting into existing BAS system for all new equipment. This can be added at a later date as budgets allow. See details in inclusions.**
- Installing valves, taps and wells.
- Providing VFD's and VFD startup. Integral to pumps.
- Startup and training on control systems not provided by LONG.
- Trenching and digging
- Starters, disconnects and power wiring
- Roof penetrations and core drilling.
- Cutting, patching and painting for access to equipment.
- All costs of sales tax, bonds and permits

Accepted for:	Submitted by: LONG Building Technologies
Accepted by:	Submitted by: Curtis Holeman
Title:	Title: Sr. Sales Engineer
Signature:	Signature: <i>Curtis Holeman</i>

SECTION 26 0000
ELECTRICAL GENERAL REQUIREMENTS

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. 26 0000 - Electrical General Requirements
 - 2. 26 0519 - Low Voltage Electrical Power Conductors and Cables
 - 3. 26 0526 - Grounding and Bonding for Electrical Systems
 - 4. 26 0529 - Hangers and Supports for Electrical Systems
 - 5. 26 0533 - Raceway and Boxes for Electrical Systems
 - 6. 26 0553 - Identification for Electrical Systems
 - 7. 26 0943 - Network Lighting Controls (nLight)
 - 8. 26 2726 - Wiring Devices
 - 9. 26 2800 - Low Voltage Circuit Protective Devices
 - 10. 26 2816 - Enclosed Switches and Circuit Breakers
 - 11. 26 2900 - Low Voltage Controllers
 - 12. 26 2916 - Enclosed Contactors
 - 13. 26 5000 - Lighting Fixtures
 - 14. 27 2010 - Telecom Distribution System
 - 15. 28 3100 - 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.

- 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.

- 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 its 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 **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.
- C. Refer to the "Suggested Coordination Schedule" in Section 20 0000 - 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. Utility Coordination: Coordinate work with the serving utilities (electrical, telephone, cable television, etc.) and provide equipment and installation in accordance with the respective utility requirements. Meet with the serving utilities and coordinate the installation and location of the services. Provide a written statement of approval from each serving utility. Provide trenching from telephone and television stubout locations to property line in accordance with respective utility requirements.
- I. 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.

1.5 **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.
 - 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.
 - 7. Provide electronic submittal in addition to hard copy submittal. Engineer shall retain one hard copy submittal.
- 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-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.”
 - 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.
 - 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). Busways.
 - 4). Cable Trays.
 - 5). Floor ducts.
 - 6). Telecom equipment rack elevations.
 - 7). CCTV equipment rack elevations.
 - 8). Where noted on the drawings.
 - 9). 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:

- 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 his 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.

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.

13. Submit copies of all Operation and Maintenance Manuals in electronic format.

1.6 **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 24 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.
7. Certificate of Completion: Submit at time of request for final inspection, a complete letter in _____ the _____ following _____ format:
I, _____ (Name), of _____ (Firm), certify that the electrical work is complete in accordance with Contract Plans and Specifications, and authorized change orders (copies of which are attached hereto) and will be ready for final inspection as of _____ (Date). I further certify that the following Specifications requirements have been fulfilled:
 - a. Megger readings performed, ___ copies of logs attached.
 - b. Operating manuals completed and instruction of operating personnel performed, _____ (Date) _____ (Signed)
Owner's Representative
 - c. Record document drawings up-to-date, accurate, and ready to deliver to Contracting Agency.
 - d. Emergency systems tested and fully operational.
 - e. Fire Alarm System tested and fully operational.
 - f. Security System tested and fully operational.
 - g. Telecommunications System test reports have been submitted to and approved by the Contracting Agency. The test reports shall certify that the Telecommunications System is complete, passes all test criteria, is fully operational, and that all work has been witnessed as specified.
 - h. Generation System and controls tested and fully operational.
 - i. Intercom/Clock System tested and fully operational.
 - j. Ground-fault system performance test complete, copies of logs attached.
 - k. Other tests required by Specifications have been performed.
 - l. Specified Owner training complete.
 - m. Systems are fully operational. Project is ready for final inspection.

SIGNED: _____ DATE: _____
TITLE: _____

8. Operating Instructions: Prior to final acceptance, instruct an authorized representative of the Owner for eight hours on the proper operation and maintenance of electrical systems and equipment provided under this contract. This requirement is for several systems, and is in addition to special training specified in other sections. Make available a qualified technician for each component of the installation for this instruction. Give these operating instructions after the operation and maintenance manuals have been furnished to the Owner. Submit written certification, signed by the Contractor and an authorized representative of the Owner, that this has been completed.

1.7 **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 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	48 inches
Convenience outlets and similar devices	18 inches (see note below)
Convenience outlets in mechanical, boiler rooms and workrooms	48 inches
Motor controllers	60 inches to top
Panelboards	76 inches to top
Telephone panels	72 inches to top
Bracket lights	84 inches
Exterior WP convenience outlets	24 inches AFG
Clock hanger outlets and clocks	90 inches
Clock/speaker units	90 inches
Speakers	90 inches
Telecommunications (Data/Telephone) outlets	18 inches (see note below)
Range outlets	6 inches (or as required for access through drawer)
Dryer outlets	36 inches
Welder outlets	48 inches
Doorbell push buttons	48 inches
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	48 inches (or 48 inches to operable part where operable part of device is above centerline of device)
Fire alarm control panel	72 inches to top
Fire alarm graphic annunciator	72 inches to top
Fire alarm text annunciator	60 inches to center
Security Keypad	60 inches to center
Security Card Reader	48 inches to center
Nurse call annunciator	72 inches to top
Nurse call switches	48 inches
Intercom handsets and call-in switches	60 inches
Intercom administrative phone outlets	18 inches (see note below)

- 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 26 0529 - 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. 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.
- D. 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.

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.

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. Doors shall be finished to match surrounding surfaces as approved by the Contracting Agency.

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 24 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 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area. Provide fire watch for entire affected area for entire duration of outage. System outage shall not be considered terminated until the system has been tested and accepted in accordance with the testing requirements outlined in Section 28 3100 - Addressable Fire Alarm System.
- 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.
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.

END OF SECTION 26 0000

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SECTION 26 0519
LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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. 26 0533 - Raceways and Boxes for Electrical Systems
 - 2. 26 0553 - 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 26 0000 - 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:
 - 1. Heated indoor spaces - THHN/THWN or XHHW.
 - 2. 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, 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. Type MC (metal clad) cables shall have integral code-sized grounding conductor.
- C. 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.

2.3 FLEXIBLE CORD

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

2.4 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.

2.5 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 26 0533 - 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.
- 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.

2.6 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 26 0533 – 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.

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. Keep splices in underground junction boxes, handholes, and manholes to an absolute minimum. Use resin splicing kits manufactured by 3M Company to totally encapsulate the splice.
- G. 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

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 at transformer secondary.

3.8 RULES FOR OPEN WIRING ABOVE LAY-IN CEILINGS

- A. Where specifically allowed in other Sections of these specifications, open wiring not-in-conduit may be used for Class 2 special systems where installed in accessible ceiling spaces above lay-in ceilings.
- B. Open wiring installed in air-handling ceiling spaces shall be approved for the application and the specific system.

- C. Approved conduit sleeves shall be provided for all cables passing in or through walls, whether or not such sleeves are shown on the Drawings. Seal with UL Listed fire resistant resilient sealant.
- D. Wiring shall be in conduit where exposed or concealed within walls, under floors or above non-lay-in ceilings. The intent of this paragraph is to provide a complete raceway system for open wiring, using accessible ceiling spaces as a raceway.
- E. Groups of cables common to a specific system shall be neatly bundled and routed along the edges of corridors. Cross corridors at right angles.
- F. 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 26 0000 – Electrical General Requirements.

END OF SECTION 26 0519

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**SECTION 26 0526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

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/EIA 606-A	Administration Standard for Commercial Telecommunications Infrastructure
ANSI/TIA/EIA-607	Commercial Building Grounding and Bonding Requirements for Telecommunications
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

1.3 SUBMITTALS

- A. Provide submittals for products in accordance with Section 26 0000 - 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 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.

1.6 **TELECOMMUNICATIONS GROUNDING SYSTEM**

- A. Telecommunications ground systems shall be provided as shown on the Contract Drawings and as related herein.
1. Telecommunication Bonding Backbone (TBB) - A copper conductor extending from the telecommunications main grounding busbar (TMGB) to each telecommunications grounding busbar (TGB).
 2. Telecommunications Main Grounding Busbar (TMGB) - The TMGB serves as a dedicated extension of the building grounding electrode system for telecommunications infrastructure. The TMGB is generally located in the main telecommunications entrance room or as shown on the Drawings.
 3. Telecommunications Grounding Busbar (TGB) - A busbar placed in a convenient and accessible location in a Telecom Room (TR) that is connected back to the TMGB. All equipment served from the TR shall be connected to the local TGB.
 4. Site grounding system - connecting the TMGB in each structure to the low resistance earth grounding system.

PART 2 - PRODUCTS

2.1 **EQUIPMENT**

- A. Grounding conductors, ground rods, and equipment required for ground systems shall be listed for the purpose intended and approved by a Nationally Recognized Testing Laboratory (NRTL), and be in accordance with U.L. 467 and as follows:
1. Ground rods shall be 3/4 inch by 10 foot copper bonded steel. Erico Eritech or approved equal.
 2. Grounding conductors shall be copper. Unless specified otherwise, raceway for service grounding conductor shall be Schedule 40 PVC.
 3. Grounding conductor for telephone service entrance and telephone/data panels shall be #6 insulated copper, with 6 feet-0 inches slack cable at each panel. Comply with intersystem bonding requirements of NEC.
 4. Grounding conductor for television and radio distribution systems shall be #6 AWG insulated copper. Comply with intersystem bonding requirements of NEC.

2.2 CONNECTIONS

- A. Joints in grounding conductors and mats below grade shall be made with exothermic welding process or hydraulically crimped fittings listed for direct burial. Terminations above grade shall be made with solderless lugs, securely bolted in place
- B. 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.

2.3 TELECOMMUNICATIONS GROUNDING SYSTEMS

- A. Telecommunications Bonding Backbone (TBB):
 - 1. The TBB shall be a green #6 AWG minimum , 600 volt insulated copper conductor. The minimum size of each TBB shall be such that the total DC resistance back to the TMGB is less than 0.10Ω .
 - 2. Cable supports shall be strut with distribution rings.
- B. Grounding Busbars shall be Cadweld P/N B544A028, 1/4 inch by 4 inches by 16 inches copper with lug patterns for #8 through 1000 KCMIL conductors. Grounding busbars shall be electrolytic copper and mounted on fiberglass insulators rated at 2,700V.
 - 1. Provide one Grounding Busbar for each:
 - a. Telecommunications Main Grounding Busbar (TMGB).
 - b. Telecommunications Grounding Busbar (TGB).

2.4 TELECOMMUNICATIONS SYSTEM BONDING

- A. Bond telecommunication equipment chassis, ladder racks, cable trays, conduits, equipment frames, cabinets, and all other telecommunication room and equipment room metallic components to a local TGB with green #6 AWG, 600 volt, insulated copper conductor. Each piece of equipment shall be connected back to the local TGB in a radial configuration, i.e., equipment ground connections shall not be "daisy chained" and then connected to TGB.
- B. Bonding of grounding conductors shall be with the following methods as specified herein:
 - 1. Connections to grounding busses: Cool Amp Plating, field applied to both surfaces for bolted and compression connections.
 - a. Approved gas tight two hole copper grounding compression lugs T&B 54205 series 2 hole, crimp Cool Amp plated compression type for connection to grounding busses.
 - b. Fasteners shall be nickel plated steel nuts, bolts and lockwashers.
 - 2. Conductor splices and connection to ground rods:

- a. Cadweld exothermic welds. Bonds below grade shall be exothermic or hydraulically crimped fittings listed for direct burial.
- b. Burndy type "YG" extruded wrought copper prefilled with Pentrox heavy duty compression connectors with probe holes (Type YGA and YGS not acceptable).

2.5 IDENTIFICATION AND LABELING

- A. Grounding conductors shall be labeled in accordance with TIA/EIA-606-A.

PART 3 - EXECUTION

3.1 SERVICE GROUND

- A. Create an equipotential plane for the grounding system for this project at the service entrance equipment by connecting the following to the service entrance ground bus:
 - 1. The commercial system's grounded neutral conductor and, if installed, the standby generator frame.
 - 2. All metallic water services to the building.
 - 3. All grounds specified to be installed.
 - 4. The service entrance equipment and conduits entering and leaving the equipment.
 - 5. The metallic piping systems in the building.
 - 6. The metallic gas piping system upstream from the equipment shutoff valve.
 - 7. Concrete encased electrode, "Ufer ground," as further specified in this Part.
 - 8. Existing electrodes and bonds.
 - 9. Structural steel columns as noted elsewhere in this section.
 - 10. Other items or equipment called for on the Drawings.
- B. Current carrying capacity of the grounding and bonding conductors shall be in conformity with Table 250.66 of the NEC. Exception: The bonding conductor for metallic gas piping shall be sized in accordance with Table 250.122 based on the largest overcurrent device protecting feeder conductors exiting the main distribution switchboards.
- C. Measure resistance to earth of service grounds by the fall of potential method per IEEE STD 81 "Recommended Guide for Measuring Ground Resistance and Potential Gradients in the Earth". Record and submit test readings.

3.2 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 all 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.

- D. Refeeding existing feeder/branch circuits that do not have an existing equipment grounding conductor: Bond equipment grounding conductor of new feeder or branch circuit to junction box and new and existing conduits.

3.3 **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.

3.4 **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.

3.5 **ELEVATOR/ESCALATOR EQUIPMENT**

- A. Provide a Code sized ground conductor to the elevator/escalator equipment in accordance with "Safety Code For Elevators and Escalators", ANSI/ASME A17.1.

3.6 **TELECOMMUNICATIONS GROUNDING SYSTEM**

A. Service Ground:

1. Provide connection to the electric power service ground. The Main Grounding Conductor from the TMGB shall be as shown on the Drawings.
2. Measure resistance to earth of service ground as described in Part 3.
3. Coordinate all outages and ground well installations with the Contracting Agency.

B. Telecommunications Bonding Backbone (TBB):

1. Connect the TBB between each TGB and the TMGB in a star configuration to minimize ground loops.

C. Telecommunications Main Grounding Busbar (TMGB):

1. Equipment and metallic raceways located in the same room as the TMGB shall be bonded to the TMGB. Each piece of equipment shall be connected back to the TMGB in a radial configuration, i.e., equipment ground connections shall not be "daisy chained" and then connected to TGB.
2. TBB connections to the TMGB shall be made with listed 2 hole compression connectors or exothermic type welded connections. Each piece of equipment shall be connected back to the local TGB in a radial configuration, i.e., equipment ground connections shall not be "daisy chained" and then connected to TGB.
3. Where a panelboard for telecommunications is located in the same room as the TMGB, the panelboards Alternating Current Equipment Ground (ACEG) bus or the enclosure shall be bonded to the TMGB.
4. Connect the TMGB to the service entrance ground bus with a bolted lug connection.

D. Telecommunications Grounding Busbar (TGB):

1. Equipment and metallic raceways located in the same room as the TGB shall be bonded to the TGB.
 2. TBB connections to the TGB shall be made with listed 2 hole compression connectors or exothermic type welded connections.
 3. Where a panelboard for telecommunications is located in the same room as the TGB, the panelboards Alternating Current Equipment Ground (ACEG) bus or the enclosure shall be bonded to the TGB.
- E. Bonding and Connections:
1. General:
 - a. Cadweld exothermic welds. Bonds concealed or below grade shall be exothermic or hydraulically crimped fittings listed for direct burial.
 - b. Compression connections shall be made using a hydraulic 4 way compression die.
 - c. Compression connections shall be exposed unless UL Listed for direct burial.
 - d. Insulated wire splices shall be insulated with preformed wire covers.
 2. To Building Steel:
 - a. Cadweld connections to building steel.
- F. 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-A and as directed by the Contracting Agency. Mark each cable end using tie wrap style cable markers.

END OF SECTION 26 0526

SECTION 26 0529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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 20 0548 - Mechanical Vibration and Seismic Control.
- C. Related Sections:
 - 1. 20 0548 - Mechanical Vibration and Seismic Control
 - 2. 26 0000 - Electrical General Requirements
 - 3. 26 0533 - Raceways and Boxes for Electrical Systems
 - 4. 26 2200 - Low Voltage Transformers
 - 5. 26 2900 - Low Voltage Controllers
 - 6. 26 5000 - Lighting Fixtures
 - 7. 27 2010 - Telecom Distribution System
 - 8. Division 3 - Cast-In-Place-Concrete
 - 9. Division 9 - 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 20 0548 – 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.

1.4 SUBMITTALS

- A. See Section 26 0000 - 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. Housekeeping pads (coordinated with approved electrical equipment footprints and anchor point locations).
 - b. 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.
 - c. Equipment locations and conduit and cable tray routing coordinated with mechanical equipment and systems. Indicate routing height above finished floor.
 - d. 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:

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 26 0000 - 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.

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. Fluorescent 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.
- B. Submit shop drawings required by this section coordinated with the seismic design and associated shop drawings required by Section 20 0548 – 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 26 0000 – 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 20 0548 – 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.
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 FIELD QUALITY CONTROL

- A. Document each installation and operational step in accordance with approved shop drawings and manufacturers requirements.

END OF SECTION 26 0529

SECTION 26 0533
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

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. 26 0519 - Low Voltage Electrical Power Conductors and Cables
 - 2. 26 0526 - Grounding and Bonding for Electrical Systems
 - 3. 26 0529 - 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
7. NEMA WD 6 - Wiring Device Configurations.

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

1.3 **SUBMITTALS**

- A. Provide submittals for all products in accordance with Section 26 0000 - 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.
 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, Liguatite "ATLA", or as approved.
9. MC Cable, as specifically allowed in Section 26 0519 - 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.

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 PVC 40 shall be polyvinyl chloride, installed using PVC solvent to form a watertight joint, except elbows (including bends exceeding 15°) shall be metallic. These metallic elbows and bends shall be of the type specified in this section for the environment in which they are to be installed.
- D. Fittings for flexible metal conduit shall be steel or malleable iron only. All throats shall be insulated.
- E. 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. All 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 sheet metal channel 4 3/4 inches wide, 3-9/16 inches deep with metal divider to separate power and communications wiring compartments and fitted cover, suitable for use as surface metal raceway, Wiremold Series 4000, or as approved.
- 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 factory pre-painted a custom color as selected by the Architect. 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. Concealed conduit shall be used in all other locations.

2.5 **WIREWAY**

- A. Unless otherwise noted on the Drawings, surface wireway in exposed or concealed locations shall be sheet metal channel suitable for use as a wiring trough, with hinged or screw cover, sized in accordance with the NFPA 70. Wireway shall be Square D Class 5100, 5120, 5140, as appropriate for the environment, or as approved.
- B. Wireway shall be of the NEMA Type (general purpose, oil-tight, dust-tight, rain-tight, etc.) appropriate for the environment where installed.
- C. Wireway shall be furnished without factory pre-punched concentric or eccentric conduit knockouts. Knockouts shall be field punched as required for the conduits installed
- D. Finish shall be ANSI-49 gray epoxy paint finish applied by cathodic electrodeposition over a corrosion resistant phosphate preparation.

2.6 **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. Floor boxes installed in concrete.
 4. Exposed interior locations below 48 inch above floor where subject to damage.
 5. Where shown on Drawings.

2.7 **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.

2.8 **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.

2.9 **FLOOR BOXES**

- A. Unless specified otherwise, floor boxes shall be the flush type with flip-open brass covers to present a flush and protected appearance when not in use. Furnish finish hardware consistent with the floor finish (carpet, wood, concrete, etc.)

- B. All floor boxes shall be UL listed for scrub water exclusion per UL514A.

2.10 **ACCESS FLOOR MODULES**

- A. Access Floor Modules (AFMs) shall provide a fully flush appearance whether in use or not. Boxes in use shall have a hinged slot for the egress of cables from outlets to user equipment.
- B. AFMs shall consist of a floor insert with high capacity power, data and communications compartments.
- C. Box tops shall be Polymide, and shall include carpet/tile floor flange, hinged plate and retractable exit. Color selection shall include charcoal gray, dark brown and medium beige, minimum (color selection by the Contracting Agency through the submittal process).
- D. AFMs shall be equipped with all wiring devices and data/communications outlets as shown on the Drawings. Provide all accessories.
- E. AFMs shall be UL listed for scrub water exclusion per UL514A.
- F. AFMs shall be Steel City AFM-6 Access Floor Module capable of up to four duplex receptacles with data and communications.
- G. Materials
 1. Main box shall be made of 14 gage cold rolled steel, .070 inch minimum thickness, conforming to ASTM A366.
 2. Device panels shall be made of 16 gage cold rolled steel, .056 inch minimum thickness, conforming to ASTM A366.
 3. Hinged outer cover shall be reinforced with a 5/32" steel plate.
 4. Steel components to have an electrogalvanized zinc finish conforming to ASTM A386. Sheet metal steel fabrications shall be made of U.L. approved component G-90-U material.
 5. Nonmetallic cover components shall be nylon, U.L. recognized component QMFZ2.
- H. General Design
 1. Shall provide concealed service access to power and communications outlets in a raised floor installation.
 2. Shall deliver power and telephone/data cable without interference from electric power delivery.
 3. The following sizes shall be provided:
 - a. AFM-6: 7 15/16" x 10" x 4" deep. Provides a minimum interior capacity of 225 cubic inches. Accepts up to 6 duplex receptacles.
 4. Shall accept floor covering material as required.

5. Shall be self-leveling when installed.
6. Cover, when closed, shall protect exiting cables and cords from abuse and abrasion by retractable cable exits. Cover shall install flush with floor and be 180° reversible.
7. Carpet edge shall be protected from fraying by a carpet trim ring of a matching color.
8. AFMs shall accept conduit sizes as required on the plans.
9. Shall be listed by Underwriters' Laboratories

2.11 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.

2.12 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

2.13 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.

2.14 UNDERGROUND PULL AND JUNCTION BOXES

- A. Boxes set in ground shall be either precast concrete or cast iron. Covers shall be galvanized steel or cast iron, and shall be bonded to the grounding system with a stranded grounding conductor secured with a grounding lug. Provide sufficient slack to allow removal of the cover and normal working access.
- B. Underground concrete pull boxes installed in traffic areas shall be constructed to withstand AASHTO HS-20 wheel loading.

2.15 OUTDOOR ABOVE-GROUND PULL AND JUNCTION BOXES

- A. Boxes exposed to rain or installed in wet locations shall be NEMA 3R unless otherwise noted.
- B. Outdoor pull and junction boxes and conduit bodies for use with galvanized conduits shall be made of galvanized ferrous metal or cast aluminum, with integral threaded hubs or Myers-type weathertight hubs of matching composition and finish.
- C. Outdoor pull and junction boxes for use with PVC or plastic-coated conduits shall be made of fiberglass, with matching gasketed covers secured with captive monel or stainless steel screws; Hoffman A-JFG series or accepted equal. Each metallic conduit entry (including liquidtight flex) shall be provided with a bronze bond bushing and NEC-sized copper bonding jumper inside the enclosure.
- D. Furnish such boxes, whether shown or not, in order to conform to requirements for maximum pulling length and maximum number of bends allowed.

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. Underground or encased in concrete - rigid steel, PVC-40 or IMC.
 2. Outdoors aboveground or damp locations - RMC, IMC or extreme temperature liquid-tight flexible steel conduit (where required).
 3. Dry indoor locations, concealed or exposed - RMC, rigid aluminum, EMT (where not susceptible to physical damage), flexible conduit where necessary, or IMC.
 4. Indoor locations, exposed, where susceptible to physical damage - RMC or IMC.
 5. 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.
 - 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 26 0000 for additional requirements and limitations regarding penetration of vapor barriers.
- 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/cabing in accordance with the design of the seismic joint. Slack shall be maintained in conduit after cabing 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.

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 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.
- D. Maximum size for EMT shall be 3 inch, except telecom backbone conduits may be 4 inch where shown on the Drawings.

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 three 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. Underfloor raceways for slab-on-grade construction shall be embedded in the fill under the slab, not in the slab itself. Where raceways are required or permitted to be embedded in concrete, the thickness of concrete on all sides of each raceway shall not be less than 2 inches.
- D. 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.

3.7 EXISTING CONDUIT

- A. Accurately measure the physical length of all existing underground conduits by the use of True Tape or an approved equivalent prior to the purchase or installation of any cable, wire, or innerduct. Costs incurred as a result of not obtaining accurate lengths of underground conduits prior to the purchase or installation of cable, wire, or innerduct; such as the need to replace cable, wire or innerduct, or provide an additional manhole or pull point, shall be the responsibility of the Contractor.

3.8 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 26 0526 – Grounding and Bonding for Electrical Systems.

3.9 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.
- 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.

3.10 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.

3.11 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.

END OF SECTION 26 0533

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SECTION 26 0553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide identification of on all 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 26 0000 – 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.
 - 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.

2.5 POWER ONE-LINE DIAGRAM

- A. Laminated, approved print of the "As-Built" power distribution system. Install in accordance with Part 3.

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 BRANCH AND DISTRIBUTION PANELBOARD NAMEPLATES

- A. Nameplate shall contain the following information (minimum 1/2 inch height letters):
 - 1. Line 1: Panel Name as noted on drawings and schedules.
 - 2. Line 2: Voltage and Phase.
 - 3. Line 3: Shall indicate if panelboard is "NORMAL" (black background), or "STANDBY" (yellow background) or "EMERGENCY" (red background).
 - 4. Line 4: Source from which panel is fed, "FED FROM: PANEL NH-031".
- B. Install a 2 inch x 4 inch nameplate on each branch panelboard where a building contains distribution systems of different voltages (minimum 1/8 inch height letters):

THIS BUILDING CONTAINS TWO WIRING SYSTEMS:				
	<u>Phase A</u>	<u>Phase B</u>	<u>Phase C</u>	<u>Neutral</u>
480Y/277V	Brown	Orange	Yellow	Gray
208Y/120V	Black	Red	Blue	White

3.3 NAMEPLATE LOCATIONS

- A. Provide 1 inch minimum height letters on following equipment:
 - 1. Service disconnect(s) (red background).
 - a. Enclosures containing multiple service disconnects for utility power must clearly identify each switch as a service disconnect along with the load served.
 - b. Where the building has multiple electrical services at different locations, provide signage at each service that indicates the total number and location of all electrical service disconnects that control the electrical service to the building.

- c. Where an on-site emergency power source is provided, a sign shall be placed at the service entrance(s) indicating the type and location of on-site emergency power sources.
- B. Provide 1/2 inch minimum height letters on following equipment:
1. Service equipment Fault Current: Provide signage in accordance with NEC indicating maximum available fault current and date of fault current calculation.
 2. Secondary feeder breakers in distribution equipment. Designation as required by load served.
 3. Special equipment housed in cabinets, as designated on plans, on outside of door.
 4. Equipment housed in equipment cabinets, as designated on plans, on inside of cabinet door.
 5. Switchboards, motor control centers, transformers, as designated on plans, on outside of door or equipment.
 6. Emergency system equipment, boxes and enclosures, as designated on plans, on outside of equipment, boxes and enclosures.
 7. Control or low voltage system panels such as Fire Alarm, Security, Video Surveillance, etc., with the following information:
 - a. Line 1: Unique panel name as shown on the shop drawings.
 - b. Line 2: System description such as Fire Alarm, Security, etc.
 - c. Line 3: Panelboard and circuit number from which the panel is fed if applicable.
- C. Provide 1/4 inch minimum height letters on:
1. 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.
 2. Lighting control relays, dimmer controls and remote lighting control equipment.
 3. Switches and receptacles where item controlled is not visible from the switch, or as noted on Drawings.
 4. 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.
 5. Designated electrical equipment.
- 3.4 **RECEPTACLE AND LIGHT SWITCH DEVICE PLATES**
- A. Provide 3/16 inch minimum height letters on receptacle and light switch device plates:
1. Provide clear adhesive label (black letter on clear background) indicating branch circuit designation (panel and circuit number) on receptacle and light switch device plates, e.g., "NPA-30"). Labels shall be printed not hand written.

3.5 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. 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. Basis of Design:
 - 1. Brady Electrical/Datacomm Worldwide (latest version of LabelMark).
 - 2. Cable Management Software International (latest version of docIT).
 - 3. Approved alternate.
- D. Labeling and color coding identification for this project shall conform to TIA/EIA-606-B for a Class 2 Administrative System.

3.6 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).

3.7 **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. Dedicated branch circuit(s) feeding fire alarm control unit(s) shall be identified as "FIRE ALARM CIRCUIT" in accordance with NFPA 72. The circuit disconnecting means shall be identified with red marking.
- F. 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.

3.8 **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.
- 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 26 0519 – Wire and Cable.
 - 2. Color code all low voltage system wiring in accordance with applicable Sections.

3.9 TRANSFORMERS

- A. Nameplate shall contain the following information:
 - 1. Line 1: Transformer Name as noted on drawings and schedules.
 - 2. Line 2: KVA Rating/Primary/Secondary Voltage.
 - 3. Line 3: Source from which transformer is fed, "FED FROM: PANEL NHA"
 - 4. Line 4: Destination of transformer feed, "FEEDS: PANEL NPA.
- B. When the transformer disconnect is located in a remote location, the disconnecting means shall be labeled to reference the transformer location in accordance with NEC Article 450.

3.10 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 26 0519 – Low Voltage Electrical Power Conductors and Cables and Section 26 0533 – 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 concealed accessible location. Where installed in exposed locations paint boxes to match the adjacent surface.
- D. One-Line Diagram: Mount behind protective cover (1/8-inch minimum thickness clear Plexiglas) in accessible location at main switchboard.
- E. Exterior underground power, control, signal and communications lines.
 - 1. Install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches provide additional markers.
 - 2. Install markers for both direct buried and conduit encased conductors.
 - 3. Label each underground conductor with its circuit number or identification tag.

- F. 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.

3.11 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. Series Rated Systems.
 - 3. Conductor insulation color identification.
 - 4. Special conductor identification and legends.
 - 5. Multiple services placards.
 - 6. Emergency systems markings.
 - 7. 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.
 - 8. Warning messages shall include an appropriate plain language imperative command, such as "DANGER HIGH VOLTAGE - KEEP OUT".
 - 9. 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.

3.12 CLEARANCE STRIPING

- A. For electrical equipment located in areas with uncarpeted floors, the clearances dictated by NEC Article 110 shall be indicated by two inches wide colored striping on the floor.
- B. Striping shall be of a bright color (typically red or yellow) that contrasts with the floor color, and shall be applied by the most durable process that is commercially available for the particular floor finish. Examples are: epoxy paint on concrete floors, and colored tile segments in composition tile floors. Striping color and method shall be subject to approval by the Contracting Agency.
- C. On the floor immediately inside the striping, stencil in two inch block letters the statement: "ELECTRICAL CLEARANCE – NO STORAGE." For floor types where painted stenciling is not feasible or sufficiently durable, this message shall instead be posted on the wall below the equipment as an engraved nameplate of the type specified in this Section, with 1/2-inch lettering. Note the specific clearance requirements on the engraved nameplate.

END OF SECTION 26 0553

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SECTION 26 0943
NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes specific requirements, products, and methods of execution relating to lighting controls, approved for use on this project.
- B. Related Sections
 - 1. 26 0553 - Identification for Electrical Systems
 - 2. 26 2726 - Wiring Devices
 - 3. 26 5000 - Lighting Fixtures

1.2 SUMMARY

- A. Provide a Code Compliant Networked Lighting Control System as indicated on plans and outlined in this section.
- 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 CAT5 cables.
- C. Provide material, labor and programming to provide a complete and properly working system that complies with listed sequences of operation.
- D. Proper product adjustment, testing, and training shall take place in compliance with this document as well as applicable energy codes and listed sequences of operation.

1.3 SUBMITTALS

- A. Provide Submittals for products in accordance with Section 26 0000 - Electrical General Requirements and Division 1.
- B. Shop Drawings/Submittals shall include but not limited to:
 - 1. Layouts of photocells, occupancy sensors and networked 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis of controls design Manufacturer: nLight, Acuity Brands, One Lithonia Way, Conyers GA 30012, www.acuitycontrols.com

2.2 SYSTEM REQUIREMENTS

- A. System shall have an architecture that is based upon three main concepts; 1) intelligent lighting control devices 2) standalone lighting control zones 3) network backbone for remote or time based operation.
- B. Intelligent lighting control devices shall consist of one or more basic lighting control components; occupancy sensors, photocell sensors, relays, dimming outputs, manual switch stations, and manual dimming stations. Combining one or more of these components into a single device enclosure should be permissible so as to minimize overall device count of system.
- C. Intelligent lighting control devices shall communicate digitally, require <7 mA of current to function (Graphic wall stations excluded), and possess RJ-45 style connectors.
- D. Lighting control zones shall consist of one or more intelligent lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher level network backbone.
- E. Devices within a lighting control zone shall be connected with CAT-5e low voltage cabling in any order.
- F. Lighting control zone shall be capable of automatically configuring itself for default operation without any start-up labor required.
- G. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or the management software becoming unavailable.
- H. Power for devices within a lighting control zone shall come from either resident devices already present for switching (relay device) or dimming purposes, controls enabled luminaires, or from the network backbone. Standalone “bus power supplies” shall not be required in all cases.
- I. All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in remotely located devices such as panels) to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.
- J. System shall have one or more primary wall mounted network control “gateway” devices that are capable of accessing and controlling connected system devices and linking into an Ethernet LAN.
- K. System shall use “bridge” devices that route communication and distribute power for up to 8 directly connected lighting zones together for purposes of decreasing system wiring requirements.
- L. System shall be capable of wirelessly connecting a lighting zone to a WiFi (802.11n) wireless data network for purposes of eliminating the “bridge” devices and all cabling that connects zones to bridge devices.
- M. WiFi enabled devices shall be able to detect when WiFi network is down and revert to a user directed default state.
- N. WiFi-enabled devices shall be capable of current monitoring

- O. WiFi-enabled devices shall utilize WPA2 AES encryption
- P. WiFi-enabled devices shall be able to connect to 802.11b/g/n WiFi networks
- Q. WiFi-enabled devices shall have two local RJ-45 port for communicating with non WiFi-enabled system devices
- R. System shall have a web-based software management program that enables remote system control, status monitoring, and creation of lighting control schedules and profiles.
- S. Individual lighting zones shall be capable of being segmented into several “local” channels of occupancy, photocell, and switch functionality for more advanced configurations and sequences of operation.
- T. Devices located in different lighting zones shall be able to communicate occupancy, photocell (non-dimming), and switch information via either the wired or WiFi backbone.
- U. System shall be capable of operating a lighting control zone according to several sequences of operation. System shall be able to change a spaces sequence of operation according to a time schedule so as to enable customized time-of-day, day-of-week, utilization of a space. Note: Operating modes should be utilized only in manners consistent with local energy codes.
 - 1. Auto-On / Auto-Off (via occupancy sensors)
 - a. Zones with occupancy sensors automatically turn lights on when occupant is detected.
 - b. Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
 - c. Pressing a switch will turn lights off. The lights will remain off regardless of occupancy until switch is pressed again, restoring the sensor to Automatic On functionality.
 - 2. Manual-On / Auto-Off (also called Semi-Automatic)
 - a. Pushing a switch will turn lights on.
 - b. Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
 - 3. Manual-On to Auto-On/Auto-Off
 - a. Pushing a switch will turn lights on.
 - b. After initial lights on, zones with occupancy and/or photocell sensors turn lights on/off according to occupancy/vacancy and/or daylight conditions.
 - c. Sequence can be reset via scheduled (ex. daily each morning) events.
 - 4. Auto-to-Override On
 - a. Zones with occupancy sensors automatically turn lights on when occupant is detected.
 - b. Zone lighting then goes into an override on state for a set amount of time, or until the next time event returns the lighting to an auto-off style of control.
 - c. Sequence can be reset via scheduled (ex. daily each morning) events.
 - 5. Manual-to-Override On

- a. Pushing a switch will turn lights on.
 - b. Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.
 - c. Sequence can be reset via scheduled (ex. daily each morning) events.
6. Auto On / Predictive Off
- a. Zones with occupancy sensors automatically turn lights on when occupant is detected.
 - b. Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
 - c. Pressing the switch will turn the lights off and a short “exit timer” begins. After the timer expires, sensor scans the room to detect whether occupant is still present. If no occupancy is detected, zone returns to auto-on. If occupancy is detected, lights must be turned on via the switch.
7. Multi-Level Operation (multiple lighting levels per manual button press)
- a. Operating mode designed specifically for bi-level applications.
 - b. Enables the user to cycle through up to four potential on/off/dim low/dim high lighting states using only a single button.
 - c. Eliminates user confusion as to which of two buttons controls which load.
 - d. Three different transition sequences are available in order to comply with energy codes or user preference).
 - e. Mode available as a setting on all devices that have single manual on/off switch (ex. nPODM, nPODM-DX, nWSX LV).
 - f. In addition to achieving bi-level lighting control by switching loads with relays, the ability to command dimming outputs to “step” in a sequence that achieves bi-level operation is present.
 - g. Depending on the sequence selected, every button push steps through relay/dimming states according to table below:

MLO Mode		State of load after each pushbutton press			
		1st Press	2nd Press	3rd Press	4th Press
2-State (Alternating)	Load A	On	Off	Off	-
	Load B	Off	On	Off	-
2-State (Both On, A First)	Load A	On	On	Off	-
	Load B	Off	On	Off	-
2-State (Both On, B First)	Load A	Off	On	Off	-
	Load B	On	On	Off	-
3-State	Load A	On	Off	On	Off
	Load B	Off	On	On	Off
A and B On ¹	Load A	On	Off	-	-
	Load B	On	Off	-	-
A On Only ¹	Load A	On	Off	-	-
	Load B	Off	Off	-	-
A and B On & Dim High ¹	Load A	High	Off	-	-
	Load B	High	Off	-	-
Dim Low /High	Load A	Low	High	Off	-
Dim Low / High	Load A	High	Low	Off	-

NOTE 1: Modes for use only when Auto-On state of Load A & B is different than first MLO state

V. A taskbar style desktop application shall be available for personal lighting control.

W. An application that runs on “smart” handheld devices (such as an Apple® iPhone®) shall be available for personal lighting control.

2.3 INDIVIDUAL DEVICE SPECIFICATIONS

A. Device Plates and Device Colors

1. Device color for wall mounted devices shall match device color for wiring devices. Refer to Section 26 27 26 – Wiring Devices.
2. Device color for ceiling mounted devices shall be white.
3. Device plate type and color shall match device plate type and color for wiring devices. Refer to Section 26 27 26 – Wiring Devices.

B. Control module (gateway)

1. Control module shall be a device that facilitates communication and time-based control of downstream network devices and linking into an Ethernet network.
2. Devices shall have a user interface that is capable of wall mounting, powered by low voltage, and have a touch screen.
3. Control device shall have three RJ-45 ports for connection to the graphic touch screen, other backbone devices bridges) or directly to lighting control devices (up to 128 per port).

4. Device shall automatically detect all devices downstream of it.
5. Device shall have a standard and astronomical internal time clock.
6. Device shall have one RJ-45 10/100 BaseT Ethernet connection.
7. Device shall have a USB port
8. Each control gateway device shall be capable of linking 1500 devices to the management software, with reduced memory version capable of support up to 400 devices.
9. Device shall be capable of using a dedicated static or DHCP assigned IP address.
10. Network Control Gateway device shall be the following nLight model Series:

nGWY2

C. Networked system occupancy sensors

1. Occupancy sensors shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
2. Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted.
3. For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional "dual" technology shall be used.
4. Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.
5. All sensing technologies shall be acoustically passive, meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.
6. Sensors shall be available with zero or one integrated dry contact switching relays, capable of switching 1 amp at 24 VAC/VDC (resistive only).
7. Sensors shall be available with one or two occupancy "poles", each of which provides a programmable time delay.
8. Sensors shall be available in multiple lens options which are customized for specific applications.
9. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
10. All sensors shall have two RJ-45 ports or capable of utilizing a splitter.
11. All sensors shall have the ability to detect when it is not receiving valid communication (via CAT-5 connections) and blink its LED in a pattern to visually indicate of a potential wiring issue
12. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.

13. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.
14. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.
15. Wall switch sensors shall recess into single-gang switch box and fit a standard GFI opening.
16. Wall switch sensors must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.
17. Wall switch sensors shall have optional features for photocell/daylight override, and low temperature/high humidity operation.
18. Wall switch sensors shall be available in four standard colors (Ivory, White, Light Almond, Gray)
19. Wall switch sensors shall be available with optional raise/lower dimming adjustment controls.
20. Wall switch sensors shall be the following nLight model numbers, with device color and optional features as specified:
 - nWSX** (PIR, 1 Relay)
 - nWSX PDT** (Dual Tech, 1 Relay)
 - nWSX LV** (PIR, No Relay)
 - nWSX PDT LV** (Dual Tech, No Relay)
 - nWSX LV NL** (PIR w/ Night Light, No Relay)
 - nWSX PDT LV NL** (Dual Tech w/ Night Light, No Relay)
 - nWSX LV DX** (PIR, No Relay, Raise/Lower Dim Ctrl)
 - nWSX PDT LV DX** (Dual Tech, No Relay, Raise/Lower Dim Ctrl)
21. Network system shall have sensors that can be embedded into luminaire such that only the lens shows on luminaire face.
22. Embedded sensors shall be capable of both PIR and Dual Technology occupancy detection
23. Embedded sensors shall have an optional photocell
24. Embedded sensors shall be the following nLight model number:
 - nES 7** (PIR, No Relay)
 - nES 7 ADCX** (PIR w/ Photocell, No Relay)
 - nES PDT 7** (Dual Technology, No Relay)
 - nES PDT 7 ADCX** (Dual Technology w/ Photocell, No Relay)
25. Network system shall also have ceiling, fixture, recessed, & corner mounted sensors available.
26. Sensors shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.
27. Sensors shall be the following nLight model numbers, with device options as specified:

D. Networked system daylight (photocell and/or dimming) sensors

Model # Series	Occupancy Poles	# of Relays	Lens Type	Detection Technology
nCM(B) 9	1	-	Standard	PIR
nCM(B) 9 2P	2	-	Standard	PIR
nCM 9 RJB	1	-	Standard	PIR
nCM 9 2P RJB	2	-	Standard	PIR
nCM(B) PDT 9	1	-	Standard	Dual
nCM(B) PDT 9 2P	2	-	Standard	Dual
nCM PDT 9 RJB	1	-	Standard	Dual
nCM PDT 9 2P RJB	2	-	Standard	Dual
nCM(B) 10	1	-	Extended	PIR
nCM(B) 10 2P	2	-	Extended	PIR
nCM 10 RJB	1	-	Extended	PIR
nCM 10 2P RJB	2	-	Extended	PIR
nCM(B) PDT 10	1	-	Extended	Dual
nCM(B) PDT 10 2P	2	-	Extended	Dual
nCM PDT 10 RJB	1	-	Extended	Dual
nCM PDT 10 2P RJB	2	-	Extended	Dual
nRM 9	1	-	Standard	PIR
nRM PDT 9	1	-	Standard	Dual
nRM 10	1	-	Extended	PIR
nRM PDT 10	1	-	Extended	Dual
nRM 6	1	-	High Bay	PIR
nRM 50	1	-	Aisle Way	PIR
nWV 16	1	-	Wide View	PIR
nWV PDT 16	1	-	Wide View	Dual
nHW13	1	-	Hallway	PIR
nCM(B) 6	1	-	High Bay	PIR
nCM 6 RJB	1	-	High Bay	PIR

1. Photocell shall provide for an on/off set-point, and a deadband to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
2. Photocell and dimming sensor's set-point and deadband shall be automatically calibrated through the sensor's microprocessor by initiating an "Automatic Set-point Programming" procedure. Min and max dim settings as well as set-point may be manually entered.
3. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
4. Photocell and dimming sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements. (Note: This function should be performed prior to any dimming of the lamps including the "auto set-point" setting.)
5. Combination units that have all features of on/off photocell and dimming sensors shall also be available.
6. A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The second zone shall be capable of being controlled as an "offset" from the primary zone.
7. Sensor shall be the following nLight model numbers, with device options as specified:
 - nCM(B) PC (RJB)** (on/off)
 - nCM(B) PC DZ (RJB)** (on/off control, dual zone)
 - nCM(B) ADCX (RJB)** (remote automatic dimming control photocell)
 - nCM(B) ADCX DZ (RJB)** (remote automatic dimming control photocell, dual zone)
 - nRM PC** (on/off)
 - nRM PC DZ** (on/off, dual zone)
 - nRM ADCX** (remote automatic dimming control photocell)
 - nRM ADCX DZ** (remote automatic dimming control photocell, dual zone)
8. Network system shall have dimming photocells that can be embedded into luminaire such that only the lens shows on luminaire face.
9. Embedded sensors shall be the following nLight model number:
 - nES ADCX** (Dimming Photocell)

E. Networked System Power (Relay) Packs

1. Power Packs shall incorporate one Class 1 relay, a 0-10 VDC dimming output, and contribute low voltage power to the rest of the system. Secondary Packs shall incorporate the relay and 0-10 VDC or line voltage dimming output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.
2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.
3. All devices shall have two RJ-45 ports.

4. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.
5. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
6. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.
7. Power Packs and Power Supplies shall be available that are WiFi enabled.
8. Power Packs (Secondary) shall be available that provide up to 16 Amp switching of all lighting load types.
9. Power Packs shall be available that provide up to 5 Amps switching of all lighting load types as well as 0-10 VDC dimming or fluorescent ballasts/LED drivers.
10. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).
11. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120/277 VAC magnetic low voltage transformers.
12. Specific Secondary Packs shall be available that provide up to 4 Amps of switching and can dim 120 VAC electronic low voltage transformers.
13. Specific Power/Secondary Packs shall be available that are UL924 listed for switching of Emergency Power circuits.
14. Specific Secondary Packs shall be available that control louver/damper motors for skylights.
15. Specific Secondary Packs shall be available that provide a pulse on/pulse off signal for purposes of controlling shade systems via relay inputs.
16. Power (Secondary) Packs shall be available that provide up to 20 Amps switching of general purposed receptacle (plug-load) control.
17. Power (Relay) Packs and Supplies shall be the following nLight model numbers:
 - nPP16** (Power Pack w/ 16A relay)
 - nPP16 D** (Power Pack w/ 16A relay and 0-10VDC dimming output)
 - nPP16 WIFI** (Power Pack w/ 16A relay, WIFI enabled)
 - nEPP5 D** (Power Pack w/ 5A relay and 0-10VDC dimming output)
 - nSP16** (Secondary Pack w/ 16A relay)
 - nPP16 ER** (UL924 Listed Secondary Pack w/ 16A relay for switching emergency power circuits)
 - nPP16 D ER** (UL924 Listed Secondary Pack w/ 16A relay and 0-10VDC dimming output for switching/dimming emergency power circuits)
 - nSP5 PCD 2W** (Secondary Pack w/ 5A relay and incandescent dimming or 2-wire line voltage fluorescent dimming output)

nSP5 PCD 3W (Secondary Pack w/ 5A relay and 3-wire line voltage fluorescent dimming output)

nSP5 PCD MLV (Secondary Pack w/ 5A relay and magnetic low voltage dimming output)

nSP5 PCD ELV 120 (Secondary Pack w/ 4A relay and electronic low voltage dimming output)

nSP5 2P LVR (Louver/Damper Control Pack)

nSHADE (Pulse On/Off Control Pack)

nPP20 PL (Secondary Pack w/ 20A relay for general purpose receptacle load)

nPS 80 (Auxiliary Bus Power Supply)

nPS 80 WIFI (Auxiliary Bus Power Supply, WiFi enabled)

nAR 40 (Low voltage auxiliary relay pack)

F. Networked System Relay & Dimming Panels

1. Panel shall incorporate up to 4 normally closed latching relays capable of switching 120/277 VAC or up to 2 Dual Phase relays capable of switching 208/240/480 VAC loads.
2. Relays shall be rated to switch up to a 30A ballast load at 277 VAC.
3. Panel shall provide one 0-10VDC dimming output paired with each relay.
4. Panel shall power itself from an integrated 120/277 VAC supply.
5. Panel shall be capable of operating as either two networked devices or as one.
6. Panel shall supply current limited low voltage power to other networked devices connected via CAT-5.
7. Panel shall provide auxiliary low voltage device power connected wired directly to a dedicated terminal connection.
8. Power (Relay) Packs and Supplies shall be the following nLight model numbers:
 - nPANEL 4** (Panel w/ four 120/277 VAC relays and four 0-10 VDC dimming outputs)
 - nPANEL 2 480** (Panel w/ two dual phase relays (208/240/480 VAC) and two 0-10 VDC dimming outputs)

G. Networked Auxiliary Input / Output (I/O) Devices

1. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½" knockout.
2. Devices shall have two RJ-45 ports
3. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
4. Specific I/O devices shall have a dimming control output that can control 0-10 VDC dimmable ballasts or LED drivers by sinking up to 20 mA of current.
5. Specific I/O devices shall have an input that reads a 0-10 VDC signal from an external device.

6. Specific I/O devices shall have a switch input that can interface with either a maintained or momentary switch and run a switch event (toggle the lighting load) or run a local/remote control profile.
7. Specific I/O devices shall sense state of low voltage outdoor photocells.
8. Specific I/O devices shall enable RS-232 communication between lighting control system and Touch Screen based A/V control systems.
9. Specific I/O devices shall sense momentary and maintained contact closures, and either toggle a connected load after a momentary contact or ramp the load high/low during a maintained contact (stopping when the contact releases).
10. Auxiliary Input/Output Devices shall be the following nLight model numbers:
 - nIO D** (I/O device with 0-10 dimming output)
 - nIO 1S** or **nIO RLX** (I/O device with contact closure or 0-10VDC dimming input)
 - nIO NLI** (Input device for detecting state of low voltage outdoor photocell; sold in **nIO PC KIT** only)
 - nIO X** (Interface device for communicating with RS-232 enabled AV Touch Screens)

H. Networked System Wall Switches & Dimmers

1. Devices shall recess into single-gang switch box and fit a standard GFI opening.
2. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
3. All devices shall have two RJ-45 ports.
4. All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
5. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
6. Devices with mechanical push-buttons shall provide tactile and LED user feedback.
7. Devices with mechanical push-buttons shall be made available with custom button labeling
8. Devices with a single "on" button shall be capable of selecting all possible lighting combinations for a bi-level lighting zone such that the user confusion as to which of two buttons (as is present in multi-button scenarios) controls which load is eliminated.
9. Wall switches & dimmers shall be the following nLight model numbers, with device options as specified:
 - nPODM** (single on/off, push-buttons, LED user feedback)
 - nPODM DX** (single on/off, single dimming raise/lower, push-buttons, LED user feedback)
 - nPODM 2P** (dual on/off, push-buttons, LED user feedback)
 - nPODM 2P DX** (dual on/off, dual dimming raise/lower, push-buttons, LED user feedback)
 - nPODM 4P** (quad on/off, push-buttons, LED user feedback)
 - nPODM 4P DX** (quad on/off, quad dimming raise-lower, push-buttons, LED user feedback)

I. Networked System Graphic Wall Station

1. Device shall have a 3.5" full color touch screen for selecting up to 16 programmable lighting control preset scenes or acting as up to 16 on/off/dim control switches.
2. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
3. Device shall enable configuration of all switches, dimmers, and lighting preset scenes via password protected setup screens.
4. Device shall enable user supplied .jpg screen saver image to be uploaded.
5. Device shall surface mount to single-gang switch box.
6. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply.
7. Device shall have a micro-USB style connector for local computer connectivity.
8. Device shall have two RJ-45 ports for communication
9. Device shall be the following nLight model number:

nPOD GFX

J. Networked System Scene Controllers

1. Device shall have two, three, four, or eight buttons for selecting programmable lighting control profiles or acting as on/off switches.
2. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
3. Device shall recess into single-gang switch box and fit a standard GFI opening.
4. Devices shall provide LED user feedback.
5. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
6. All devices shall have two RJ-45 ports.
7. Device shall be capable of reprogramming other devices in its zone so as to implement user selected lighting scene.
8. Device shall be capable of selecting a lighting profile be run by the system's upstream Gateway so as to implement selected lighting profile across multiple zones (and not just its local zone).
9. Device shall have LEDs indicating current selection.
10. Scene Selector device shall be the following nLight model number:

nPODM 2S (2 Scene, push-button)

nPODM 4S (4 Scene, push-button)

nPODM 4S DX (4 Scene, push-button, On/Off/Raise/Lower)

nPODM 2L (2 Adjustable Preset Levels, push-button, On/Off)

nPODM 2L AB (2 Scene, push-button, On/Off/High/Low)

nPODM 4L DX (4 Adjustable Preset Levels, push-button, On/Off/Raise/Lower)

K. Communication Bridges

1. Device shall surface mount to a standard 4" x 4" square junction box.
2. Device shall have 8 RJ-45 ports.
3. Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to Control Gateway.
4. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a CAT-5 cabled connection.
5. Device shall be capable of redistributing power from its local supply and connect lighting control zones with excess power to lighting control zones with insufficient local power. This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.
6. Communication Bridge devices shall be the following nLight model numbers:

nBRG 8 (8 Ports)

2.4 **LIGHTING CONTROL PROFILES**

- A. Changes to the operation of the system shall be capable of being made in real-time or scheduled via lighting control profiles. These profiles are outlines of settings that direct how a collection of devices function for a defined time period.
- B. Lighting control profiles shall be capable of being created and applied to a single device, zone of devices, or customized group of zones.
- C. All relays and dimming outputs shall be capable of being scheduled to track or ignore information regarding occupancy, daylight, and local user switches via lighting control profiles.
- D. Specific device parameters (e.g. sensor time delay and photocell set-point) shall be configurable via a lighting control profile.
- E. All lighting control profiles shall be stored on the network control gateway device, with a system backup on the software's host server.
- F. Lighting control profiles shall be capable of being scheduled to run according to the following calendar options: start date/hour/minute, end date/hour/minute, and sunrise/sunset +/- timed offsets.
- G. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.
- H. Daylight savings time adjustments shall be capable of being performed automatically, if desired.
- I. Lighting control profile schedules shall be capable of being given the following recurrence settings: daily, weekday, weekend, weekly, monthly, and yearly.
- J. Software shall provide a graphical tool for easily viewing scheduled lighting control profiles.

2.5 **MANAGEMENT SOFTWARE**

- A. Every device parameter (e.g. sensor time delay and photocell set-point) shall be available and configurable remotely from the software

- B. The following status monitoring information shall be made available from the software for all devices for which it is applicable: current occupancy status, current PIR Status, current Microphonics Status, remaining occupancy time delay(s), current photocell reading, current photocell inhibiting state, photocell transitions time remaining, current dim level, device temperature, and device relay state(s).
- C. The following device identification information shall be made available from the software: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.
- D. A printable network inventory report shall be available via the software.
- E. A printable report detailing all system profiles shall be available via the software.
- F. Software shall require all users to login with a User Name and Password.
- G. Software shall provide at least three permission levels for users.
- H. All sensitive stored information and privileged communication by the software shall be encrypted.
- I. All device firmware and system software updates must be available for automatic download and installation via the internet.
- J. Software shall be capable of managing systems interconnected via a WAN (wide area network)

2.6 **BMS COMPATIBILITY**

- A. System shall provide a BACnet IP gateway as a downloadable software plug-in to its management software.
- B. BACnet IP connection shall also be available utilizing JACE-600 hardware unit.
- C. BACnet IP hardware shall be capable of supporting up to 1500 total devices across up to 5 total Gateways
- D. BACnet IP connection shall communicate information gathered by networked system to other building management systems.
- E. BACnet IP connection shall translate and forward lighting relay and other select control commands from BMS system to networked control devices via profiles stored in the system Gateway. All system devices shall be available for polling for devices status.
- F. BACnet IP hardware device shall be the following nLight model name:

nBACnet

2.7 **SYSTEM ENERGY ANALYSIS & REPORTING SOFTWARE**

- A. System shall be capable of reporting lighting system events and performance data back to the management software for display and analysis.
- B. Intuitive graphical screens shall be displayed in order to facilitate simple viewing of system energy performance.

- C. An “Energy Scorecard” shall be display that shows calculated energy savings in dollars, KWHr, or CO2.
- D. Software shall calculate the allocation of energy savings to different control measures (occupancy sensors, photocells, manual switching, etc).
- E. Energy savings data shall be calculated for the system as a whole or for individual zones.
- F. A time scaled graph showing all relay transitions shall be presented.
- G. A time scaled graph showing a zones occupancy time delay shall be presented
- H. A time scaled graph showing the total light level shall be presented.
- I. User shall be able to customize the baseline run-time hours for a space.
- J. User shall be able to customize up to four time-of-day billing rates and schedules.
- K. Data shall be made available via a .CSV file

2.8 **START-UP & SUPPORT FEATURES**

- A. To facilitate start-up, all devices daisy-chained together shall automatically be grouped together into a functional lighting control zone.
- B. All lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.
- C. Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.
- D. All system devices shall be capable of being given user defined names.
- E. All devices within the network shall be able to have their firmware upgraded remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.
- F. All sensor devices shall have the ability to detect improper communication wiring and blink it’s LED in a specific cadence as to alert installation/startup personnel.

2.9 **PREPARATION**

- A. Prior to beginning rough-in for the automatic lighting controls a pre-installation meeting is mandatory for all parties involved in the lighting control system installation, including the System Installer, the manufacturer’s Factory Authorized Representative and the Owner’s Representative if desired. All parties shall review the automatic lighting control shop drawings, the manufacturer’s installation instructions, applicable regulations and any site conditions pertinent to installation of the automatic lighting controls. Verify placement of sensors and installation criteria.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install equipment in accordance with the manufacturer's instructions in the locations indicated on the Drawings. Proper judgment must be exercised in executing the installation so as to ensure proper operation in the available space and to overcome local difficulties due to space limitations or interference of structural components.
- B. Locate and aim occupancy 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 habits of single or multiple occupants 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.
- C. 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.
- D. 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.
- E. Mount occupancy sensors and photocells 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.
- F. Mount exterior photocells on flush-mounted outlet boxes.
- G. Wiring shall be arranged as shown on the shop drawings. Wiring and cable shall be installed in raceways or cable trays, except low-voltage cables run above accessible ceilings. Raceways shall be grounded to the power system ground.
 - 1. CAT5 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 ceiling cavities shall be supported by means of suitable cable support devices 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.). Do not use CAT 5 cable for terminating to blocks.
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. CAT5 networked 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 Owner's Representative and the Commissioning Authority at least two (2) weeks in advance of the date of each test, to allow witnessing of the tests if desired.
- B. The automatic lighting control devices are subject to commissioning. Assist the Commissioning Authority with scheduling and coordinating commissioning activities, developing commissioning test procedures, conducting commissioning tests, preparing commissioning documentation, and developing a training plan in accordance with specific responsibilities as assigned in Section 01 9100 and Section 260510. Prior to the start of functional performance testing for commissioning purposes, complete all start-up and checkout procedures and verify that the equipment is completely ready to be tested. A knowledgeable electrician in the employ of the Electrical Installer shall be present during functional performance testing for commissioning purposes.
- 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 Architect's Consultant 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 direction received from the Architect's Consultant and/or sequence of operation. Default to IES light levels if information is not available at time of initial set up.
- G. Verify sensor placement, aiming, calibration and settings to ensure trouble-free operation. Final calibration of daylight harvesting sensors and controls shall be delayed until room finishes have been completed and window treatments have been installed and are operable. Lower blinds and set the blades perpendicular to the window before calibrating day lighting controls.
- 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 Owner's Representative. 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 Owner's Representative. 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 Owner's Representative 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 Commissioning Authority and the Owner's Representative. Insert a copy of the sign-off form and the training sign-in sheet into the Operating and Maintenance Manuals.

END OF SECTION 26 0943

**SECTION 26 2726
WIRING DEVICES**

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. 26 0533 - 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 26 0000 - 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. Catalog numbers shown are Hubbell unless noted otherwise. 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 20 AMP, 120V rated switches with UL listing for tungsten lamp loads or inductive loads without derating. Switches shall be as follows:

	20A Rated Switches
Single Pole	CAT. NO. 1221
Three-way	CAT. NO. 1223
Four-way	CAT. NO. 1224
Key Operated	CAT. NO. HBL1221-L
Momentary Cont.	CAT. NO. HBL1557
Double Pole	CAT. NO. 1222
Pilot Switch	CAT. NO. HBL1221-PL

- B. Other switch types shall be provided as called for on the Drawings or as required by the application.

2.3 RECEPTACLES

- A. Insofar as commercially available, receptacles shall be of nylon construction. Provide grounding type receptacles as follows, or as required to match equipment furnished in this or other divisions.

Single Phase, 3-Wire Devices		
15A-125V	CAT. NO. HBL 5262	NEMA #5-15R
15A-125V GFCI	CAT. NO. HBL GF-15LA	NEMA #5-15R
15A-250V Single	CAT. NO. HBL 5661	NEMA #6-15R
Clock hanger 125V	CAT. NO. HBL 5235	NEMA #5-15R
20A-125V USB Charger Tamper Resistant	CAT. NO. HBL USB20X2	NEMA #5-20R
20A-125V	CAT. NO. HBL 5362	NEMA #5-20R
20A-125V GFCI	CAT. NO. HBL GF-20LA	NEMA #5-20R
20A-125 SPD	CAT. NO. HBL 5362SA	NEMA #5-20R
20A-125V Tamper Resistant	CAT. NO. HBL 8300SG	NEMA #5-20R
20A-250V Single	CAT. NO. HBL 5461	NEMA #6-20R
30A-250V Dryer	CAT. NO. RR430F	NEMA #14-30R
50A-250V Range	CAT. NO. RR450F	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 as selected by Architect, unless otherwise noted.

2.5 DEVICE PLATES

- A. Device plates shall be satin finished Type 302 stainless steel, unless otherwise noted.
- B. Indoor device plates for surface mounted boxes shall be stainless or galvanized steel, with design to match the box and device type being used.
- 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" and "UL Listed". 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; TayMac; Specification Grade or approved equal.
- D. Label receptacle and light switch plates in accordance with Section 26 0553 – Identification for Electrical Systems.

2.6 PHOTOCELLS

A. Outdoor Photocells

1. Basis of design is Intermatic K4236C Stem and Swivel Mounting Photocell.
2. Photocell shall have minimum of 2400 V open type spark gap arrestor to protect against voltage surges.
3. Photocell shall be weatherproof or be provided with weatherproof case.

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 the downstream standard receptacle is located in the same room in close proximity to the upstream GFCI receptacle (e.g. within 20 feet). Protected receptacles downstream of GFCI receptacles shall be identified "GFCI Protected."
- 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. Occupancy sensors shall be installed in accordance with manufacturer's recommendations. Verify proper operation of 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.

END OF SECTION 26 2726

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