

PROJECT MANUAL

PROJECT NAME:

DOC 4JD CBC New Central Office Building

(Volume 2 of 2) (DIV 23 – DIV 31)
Including Appendix

PROJECT ADDRESS:

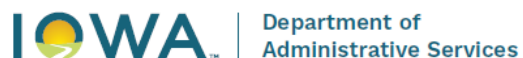
818 S 10th St.
Council Bluffs, Iowa 51501



PROJECT DATE: April 21, 2026

OWNER:

Iowa Department of Administrative Services
109 Southeast 13th Street
Des Moines, Iowa 50319



OWNER PROJECT NUMBER: 9488.00

OWNER REQUEST FOR BID NUMBER: RFB 948800-01

CONSTRUCTION MANAGER:

Samuels Group
2929 Westown Parkway, Suite 200
West Des Moines, IA 50266



Design
Construct
Furnish

CONSTRUCTION MANAGER PROJECT NUMBER: 7813

ARCHITECT:

Savage-Ver Ploeg & Associates
1466 28th St, Suite 200
West Des Moines, IA 50266



ARCHITECT PROJECT NUMBER: 25079

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END OF DOCUMENT

SECTION 230400
COMMON REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A This Section includes basic materials and methods to complement other Division 23 Sections.

1.2 WARRANTIES

- A Warrant all materials, workmanship and equipment against defects for a period of one year after the date of substantial completion.
- B Certain equipment shall be warranted beginning at the time of final acceptance or for longer periods of time as specified in those divisions of the Project Manual.
- C Repair or replace, at no additional cost to the Owner, any item which may become defective within the warrant period.
 - 1. Repair or replacement of compressorized equipment shall include a complete refrigerant charge.
- D Any manufacturers' warranties concerning any item installed will run to the benefit of the Owner.
- E The Contractor agrees not to void or impair, or to allow Sub-Contractors to void or impair, any warranties regarding products or items installed as part of this project.
- F The repair of faulty workmanship shall be considered to be included in the contract.

1.3 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

- A If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Architect for clarification.
- B Any definitive interpretation or clarification of the contract documents will be published by addenda, properly issued to each person holding documents, prior to the bid date.
- C Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents.
- D When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.
- E The Architect shall be the sole judge regarding interpretations of conflicts within contract documents.

1.4 CONTRACT DOCUMENT DISCREPANCIES

- A If any ambiguities should appear in the contract documents, request clarification from the Architect before proceeding with the work.
- B If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Architect.
- C Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work unless a written clarification from the Architect was requested and obtained before submission of proposed methods or materials.
- D The Architect shall be the sole judge regarding interpretations of conflicts within contract documents.

1.5 DEFINITIONS

- A The following definitions shall apply throughout the contract documents:
 - 1. Architect: Architect or Engineer
 - 2. Code: All applicable national, state and local code
 - 3. Mechanical: All plumbing, HVAC, & fire protection work required by the Contract Documents
 - 4. Electrical: All electrical and fire alarm work required by the Contract Documents
 - 5. Contractor: Any Contractor performing work required by the Contract Documents
 - 6. Indicated: Shown on drawings, noted, scheduled or specified
 - 7. Selected: Selected by the Architect or Engineer
 - 8. Provide: Furnish, install, connect and tested complete and ready for use
 - 9. Furnish: Supply and deliver to the site ready for installation
 - 10. Install: Install complete, per Contract Documents and manufacturer's requirements.
 - 11. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
 - 12. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
 - 13. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
 - 14. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
 - 15. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
 - 16. Dry Locations: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.
 - 17. Damp Locations: Locations protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture.
 - a. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold storage warehouses.

18. Wet Locations: Installations underground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather.

1.6 SYMBOLS

- A Items of equipment and materials are indicated on the drawings in accordance with the symbols shown on the plans.

1.7 ABBREVIATIONS

- A Refer to abbreviations list shown on the Drawings.

1.8 CODES

- A The work shall be performed by persons skilled in the trade involved and shall be done in a manner consistent with normal industry standards.
- B All work shall conform to all applicable sections of currently adopted editions of the following codes, standards, and specifications:
 1. International Building Code (IBC)
 2. International Fire Code (IFC)
 3. International Energy Conservation Code (IECC)
 4. International Fuel Gas Code (IFGC)
 5. International Plumbing Code (IPC)
 6. Uniform Plumbing Code(UPC)
 7. International Mechanical Code (IMC)
 8. Safety and Health Regulations for Construction
 9. Occupational Safety and Health Standards (OSHA), National Consensus Standards and Established Federal Standards
 10. National Electrical Code (NEC)
 11. National Fire Protection Association (NFPA)
 12. Life Safety Code (NFPA 101)
 13. American Gas Association (AGA)
 14. Underwriters' Laboratories, Inc. (UL)
 15. National Electrical Safety Code (NESC)
 16. All applicable national, state and local codes and amendments.

1.9 PERMITS

- A The Contractors shall familiarize themselves with all requirements regarding all permits, fees, etc., and shall comply with them.
- B All permits, licenses, inspections and arrangements required for the work shall be obtained by the Contractor at his expense.
- C All utilities shall be installed in accordance with the local rules and regulations and all charges shall be paid by the Contractor.

1.10 CODE COMPLIANCE

- A Work shall be in accordance with all applicable codes. Where the codes and drawings do not agree, the code shall take precedence; however, code shall take precedence over what is shown only when it is more stringent than that indicated. Items that are allowed by codes which are less stringent than that indicated shall not be substituted.
- B Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of systems. Wherever practical, install systems as indicated.
- C Where the National Electrical Code or applicable codes require controllers to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment.

1.11 MATERIALS AND EQUIPMENT MANUFACTURERS

- A Options in selecting materials and equipment are limited by requirements of the contract documents and governing regulations. They are not controlled by industry traditions or procedures experienced on previous construction projects.
- B Materials and equipment shall be provided in accordance with the following:
 - 1. Primary Design Products: Primary design products are those products around which the project was designed in terms of capacity, performance, physical size and quality.
 - 2. Primary design products are indicated by use of a single manufacturer's name, model number or similar data on drawings or schedules or within the specifications.
 - 3. Provide primary design products unless substitutions are made in accordance with the following paragraphs.
 - 4. Acceptable Equivalent Substitutions: Acceptable equivalent substitutions are products of manufactures other than those listed for the primary design products. Equivalent acceptable substitutions shall meet each of the following requirements:
 - a. The product shall be manufactured by one of the acceptable manufacturers listed in the Project Manual, drawings, or addenda.
 - b. The product shall meet or exceed the requirements of the contract documents in terms of quality, performance, suitability, appearance, and physical characteristics.
 - c. The Contractor providing the substitution shall bear the total cost of all changes due to substitutions. These costs may include additional compensation to the Architect for redesign and evaluation services, increased cost of work by the Owner or other Contractors, and similar considerations.
 - d. Performance Requirements: Where the contract documents list performance requirements or describe a product or assembly generically, provide products that comply with the specific requirements indicated and that are recommended by the manufacturer for the respective application.
 - e. Compliance with Standards, Codes and Regulations: Where the specifications require only compliance with an imposed standard, code or regulation, the Contractor has the option of selecting a product that complies with specification requirements, including the standards, codes and regulations.
 - f. Proposed substitutions will be judged on the basis of quality, performance, appearance and on the governing space limitations. The reputation of the manufacturer, delivery

time requirements, and the availability of repair or replacement parts may also be considered.

- g. The Architect shall be the sole and final judge as to the suitability of substitution items.

1.12 SUBMITTALS

A Shop Drawings, Product Data and Samples:

1. Other section in the Project Manual shall be adhered to if more stringent than the following paragraphs.
2. When required by other sections of this Project Manual, submit shop drawings, product data or samples to the Architect for review.
3. Submittals deemed unnecessary by the Architect shall be returned indicating "No Action Taken".
4. A completed copy of the transmittal form included with the Project Manual shall accompany each submittal.
5. Submittals shall be labeled indicating the specification number and title, shop drawing or product data description and the respective Part 2 paragraph and sub-paragraph numbers.
6. Submittals not listed in the Project manual shall reference the respective contract document.
7. Unless otherwise noted, submit one copy electronically of shop drawings and product data for review. Review comments will be returned electronically. A hard copy of the electronic submittal will be returned if requested.
 - a. Shop drawings and product data shall be in original searchable PDF format.
8. Shop drawings are drawings, diagrams, schedules and other data specifically prepared for this project by the Contractor, Manufacturer, Supplier, or Distributor to illustrate some portion of the work. Shop Drawings shall also detail fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment.
 - a. Shop drawings shall be drawn to accurate scale and of adequate size to illustrate required details.
9. Product data are illustrations, standard schedules, performance charts, instruction brochures, diagrams and other information furnished by the Contractor, Manufacturer, Supplier, or Distributor to illustrate a material, product or system for some portion of the work.
10. All submittals shall clearly indicate proposed items, capacities, characteristics and details in conformance with contract documents. All equipment items shall be marked with the same item number as used on drawings or schedules. Capacities, dimensions and special features required shall be certified by the manufacturer.
11. Submittals shall indicate manufacturer's delivery time for the item after review by the Architect.
12. The Architect shall review or take other appropriate action upon the Contractor's submittals such as shop drawings, product data and samples, but only to determine conformance with the design concept of the work and the information given in the contract documents.
13. Contractor shall not be relieved of responsibility for any deviation from the requirements of the contract documents by the Architect's review of shop drawings, product data or samples.
14. Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data or samples by the Architect's review of those drawings.

B Coordination Drawings: Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building

components. Show space requirements for installation and access. Indicate if sequence and coordination of installations are important to efficient flow of the Work.

1. Include the following:
 - a. Actual equipment being provided. Refer to manufacturer's data for physical size, access and maintenance requirements. Provide all code required clearances.
 - b. Planned piping layout, including valve and specialty locations and valve-stem movement.
 - c. Clearances for installing and maintaining insulation.
 - d. Clearances for servicing and maintaining equipment, accessories, and specialties, including space for disassembly required for periodic maintenance.
 - e. Equipment and accessory service connections and support details.
 - f. Exterior wall and foundation penetrations.
 - g. Fire-rated wall and floor penetrations.
 - h. Sizes and location of required concrete pads and bases.
 - i. Scheduling, sequencing, movement, and positioning of large equipment into building during construction.
 - j. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 - k. Reflected ceiling plans to coordinate and integrate installation of air outlets and inlets, light fixtures, communication system components, sprinklers, access doors or pabels and other ceiling-mounted items.
 - l. All Contractors are required to provide information concerning their part of the work needed to develop the coordination drawings.
 - m. Drawings shall contain all of the following that are applicable:
 - 1) Ductwork, equipment, and terminal devices (showing access and service requirements). Ductwork, equipment and terminal devices indicated in the coordination drawing content must be the same as that indicated in all submittals.
 - 2) Plumbing
 - 3) HVAC piping
 - 4) Recessed light fixtures
 - 5) Electrical conduit 2 inches and larger
 - 6) Cable tray
 - 7) Fire sprinkler piping
 - 8) Structure and general construction
 - 9) Access doors and panels
 - 10) Other areas indicated by the Contractor that involve congestion
 - n. Complete drawings after submitting product data on items included in coordination drawings.

C Operation and Maintenance Manuals:

1. Prepare electronic operation and maintenance manuals for the equipment furnished.
2. The manual shall be in original searchable PDF format with equipment organized by specification section. Bookmarking shall be provided in the PDF for each specification section and piece of equipment.
3. Manuals shall be submitted to the Architect for review and distribution to the Owner not less than 30 days prior to substantial completion of the project.
4. Manuals not meeting the requirements of this section may be rejected by the Architect.
5. Manual shall include, but shall not be limited to, the following:

- a. A cover page including:
 - 1) Project name and address
 - 2) Division of work covered by the manual
 - 3) Name, address and telephone number of Contractor and all Sub-Contractors including night or emergency numbers
- b. A Complete Index. Contractor may submit the index to the Architect for review prior to submittal of complete manuals if desired.
- c. Manufacturer's equipment product data O&M manuals and parts lists identified by the equipment mark used in the contract drawings.
- d. Names, Addresses and Telephone Numbers. This list shall include the manufacturer and local representative who stocks or furnishes repair parts for all items of equipment and shall be typed on a single page in front of the manual.
- e. Startup, Operation and Shutdown Procedures. Provide a written description of procedures for startup, operation and shutdown of each item or system. This description shall include motors to start, valves to open, etc., in proper sequence, and the location of switches, starters, pushbuttons and valves. Description shall include item references or labels used in the contract documents unless otherwise instructed in advance by the Owner.
- f. Seasonal Changeover Procedure. Provide a written description of the procedure for necessary seasonable changeover from heating to cooling and vice versa.
- g. Equipment Accessory Schedule. Upon completion of the work, furnish the Owner with a complete equipment accessory schedule listing each piece of equipment and the related size, type, number required and the manufacturer of all renewable items.
- h. Lubrication Schedule. Provide a chart listing each piece of equipment, the proper type of oil or grease required, and recommended frequency of lubrication.
- i. Emergency Procedures. Provide a written description of emergency operating procedures or a list of service organizations (including addresses and telephone numbers) capable of rendering emergency services to the various parts of the system.
- j. One copy of all shop drawings.
- k. Signed letters of certification of inspection and similar information.
- l. All manufacturers' warranty information.
- m. Provide documentation that training was performed for each item specified to include Owner training. Include name of Owner's representative(s) present, date and time of training.
- n. Normal Maintenance Schedule. Include a listing of work to be performed at various time intervals; i.e., 30, 90, 180 days and yearly.
- o. Provide documentation that Extra Materials were received by the Owner for each section requiring Extra Materials.
- p. Motor List. The list shall indicate motor location, equipment served (using labels indicated on drawings), horsepower, electrical characteristics, motor type, and rpm. Motors less than 1/2 horsepower need not be included.

1.13 OPERATING TRAINING

- A Complete operating instructions for each system and item of equipment shall be provided to the Owner's designated personnel.
- B Operation and Maintenance Manuals must be reviewed and accepted by the Architect and provided to the Owner prior to operating training.

- C Training shall be scheduled at the convenience of the Owner. A minimum of 2 hours, per system, of training shall be provided.
- D Training shall include instructions on the following:
 - 1. Startup and shutdown procedures
 - 2. Seasonal changeover
 - 3. Periodic maintenance
 - 4. Emergency operation
 - 5. Safety
- E In addition to the instructions required above, wherever possible perform the operations being described in order to fully illustrate system operation.
- F At the completion of training, turn over to the Owner all required keys and special tools for installed equipment. Each key or tool shall be labeled with its use.

1.14 QUALITY ASSURANCE

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

1.15 DELIVERY, STORAGE, AND HANDLING

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

1.16 COORDINATION

- A Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of systems. Wherever practical, install systems as indicated.
- B Provide offsets and elevation changes in piping, conduit and ductwork as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.

- C Arrange for spaces, chases, slots, and openings in building structure during progress of construction to allow for system installations.
- D Coordinate arrangement, mounting, and support of equipment.
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
- E Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the installations that follow.
 - 1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
- F Sequence, coordinate, and integrate installing materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- G Coordinate service connections to components furnished by utility companies.
 - 1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for metering components.
 - 2. Comply with requirements of authorities having jurisdiction and of utility company providing water, gas, electrical power and other services.
- H Coordinate location of access panels and doors for items that are concealed by finished surfaces.
- I Coordinate testing of items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

1.17 STRUCTURAL COORDINATION

- A In cases where the Contractor determines that superimposed loads such as suspended or floor mounted mechanical, electrical, plumbing system or equipment exist which exceed design loads indicated on structural contract documents, Contractor shall submit load data to Design Professionals for review prior to proceeding with work.
- B Distribute the maximum load hung from any structural member for mechanical, electrical, plumbing, ductwork, piping, etc. over the member's tributary area in a way that the design superimposed dead loads listed in structural contract documents are not exceeded. The Contractor shall coordinate the loads and provide additional support or distribution framing as required achieving the allowable load distribution.
- C Connections of systems designed by Contractor's engineer such as, but not limited to mechanical, electrical, plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for designing, furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

- D Coordinate locations of new fire suppression, plumbing and HVAC penetrations through existing structure and construction. Utilize all existing documentation of conditions for coordination. Verify penetrations utilizing GPR (Ground Penetrating Radar) as necessary to confirm penetration locations.

PART 2 - PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

- A See Drawings for Specific Notes and/or Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 SHORT-CIRCUIT CURRENT RATING (SCCR) FOR EQUIPMENT AND ASSOCIATED CONTROL PANELS

- A SCCR Compliance - Equipment manufacturers and suppliers shall provide a certified SCCR for all equipment and associated panels to be provided with equipment procured under these specifications. The certified SCCR rating shall be no less than the value of the available fault current at the switchboard or panel serving the equipment as indicated on the Division 26 Electrical Riser Diagrams. Manufacturer shall provide internal components that meet or exceed the SCCR rating required by these specifications. Manufacturer shall refer to the National Electrical Code (NEC), which is also known as NFPA 70, Article 100 for additional requirements
- B Supplemental SCCR Compliance Data - At the manufactures option, they may calculate the available fault current at the specific equipment connection point. Manufacturer shall obtain feeder size, breaker type and length of feeder from the Division 26 contractor. All calculations shall be submitted as part of the equipment submittal for review by the engineer.
- C Application of Labels - All equipment and control panels associated with equipment procured under these specifications shall have a permanently installed label provided by the manufacturer as a part of the equipment indicating the SCCR rating of the equipment. Labels shall comply with NEC Article 409 - Industrial Control Panels, and NEC Article 670 - Industrial Machinery.

2.3 CONTROL SYSTEM INTERFACES

- A Equipment and systems shall be able to interface and integrate to BMCS systems and sequences via vendor protocols including, as a minimum, BACnet, LonTalk and Modbus.

2.4 MATERIALS

- A Unless otherwise specified, all materials and equipment shall be new, unused and undamaged. Materials and equipment shall be the current and standard designs of manufacturers regularly engaged in their production.

2.5 MATERIALS AND EQUIPMENT FURNISHED BY OTHERS

- A Where materials and equipment are indicated as furnished by others and installed or connected under this contract, it shall be the Contractor's responsibility to verify installation details and requirements.

2.6 QUANTITY OF SPECIFIED ITEMS REQUIRED

- A Wherever in these specifications an article, device or piece of equipment is referred to in the singular number; such reference shall apply to as many such articles as are shown on the drawings or required to complete the installation.

2.7 ESCUTCHEONS

- A Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C One-Piece, Cast Brass Type: With set screw.
1. Finish: Polished chrome-plated.
- D Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
1. Finish: Polished chrome-plated.
- E One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.
- F Split-Plate, Stamped-Steel Type: With concealed hinge, set screw, and chrome-plated finish.
- G One-Piece, Floor-Plate Type: Cast-iron floor plate.
- H Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.8 PIPE OR CONDUIT PENTERATION HOUSING & HOODS

- A Manufacturer:
1. RPH; www.RoofPenetrationHousings.com
2. Or pre-approved equivalent.
- B References:
1. ICC-500, FEMA 320/361 – Third Party Tested to +225 mph
2. ICC 2015 Energy Code – Third Party Tested to ASTM E 2078-13 Standard Test Method for Air Permeance of Building Materials
3. ASTM E 1980 Solar Reflectance Index (SRI)
4. FEMA P749 – Seismic Provisions
- C Lid and housing lined with insulation to a minimum value of R-19.
- D Warranty: 20 years.
- E Roof Mounted: Engineered penetration housing, accommodating up to 18 pipes/conduits-- cables, water, refrigeration, and power in one roof penetration with high rain tight integrity.
- F Roof penetration system is constructed of 14 gauge UV powder coated, welded, galvanized steel or aluminum with stainless steel hardware.

1. Removable, gasketed lid to housing and housing to curb connection joints, pitched cover.
2. Exit seal construction to be manufactured in all aluminum construction and 100% Sil-X-14 silicone gaskets.
3. All seals must be protected from UV with an aluminum or stainless steel jacket.

G Coordinate size of housing and hoods with all trades utilizing the penetration.

H Furnish with 18-inch tall insulated curb and extensions for roof applications.

2.9 ROOF MOUNTED PIPE, DUCTWORK AND CONDUIT SUPPORT SYSTEMS

A Manufactures:

1. Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com.
2. Eaton, Dura-Blok.
3. Erico International Corporation: www.erico.com.
4. PHP Systems/Design, www.phpsd.com
5. Unistrut, UNIpier.
6. Or pre-approved equivalent.

B Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:

1. Bases: UV resistant material, molded polycarbonate resin, HDPE or rubber.
2. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
3. Stut style, galvanized steel horizontal and vertical supports, attaching hardware.
4. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
5. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
6. Height: Provide minimum clearance of 18 inches under pipe to top of roofing.
 - a. Adjustable mounting height.
7. Operating temperature: -30F to 150F.

2.10 GROUT

A Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.

1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psig, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.11 SEALANTS AND FIRESTOPPING

A Manufacturers:

1. Sealants:
 - a. Dow Corning
 - b. Pecora

- c. Sonneborn
 - d. Tremco
 - e. Or pre-approved equivalent.
- 2. Firestopping Materials and Systems:
 - a. A/D Fire Protection Systems Inc: www.adfire.com.
 - b. 3M Fire Protection Products: www.3m.com/firestop.
 - c. Hilti, Inc: www.us.hilti.com.
 - d. Nelson FireStop Products: www.nelsonfirestop.com.
 - e. Specified Technologies, Inc: www.stifirestop.com.
 - f. Tremstop Fyre-Sil Sealant - Tremco Sealants & Coatings
 - g. Or pre-approved equivalent.
- B Silicone Sealant: Single component, air curing, non-staining, non-bleeding, capable of continuous water immersion, non-sagging type for application in vertical joints and in horizontal joints, color as selected.
- C Primer: Non-staining type, recommended by sealant manufacturer to suit application.
- D Joint Cleaner: Non-corrosive and non-staining type, recommended by sealant manufacturer; compatible with joint forming materials.
- E Joint Backing: ANSI/ASTM D1056; round, closed cell, polyethylene foam rod; oversized 30% to 50% larger than joint width.
- F Bond Breaker: Pressure sensitive tape recommended by sealant manufacturer to suit application.
- G Firestopping Materials and Systems:
 - 1. UL Listed products and assemblies.
 - 2. Subject to compliance with the requirements of Division 07.

2.12 ACCESS DOORS

- A Manufacturers:
 - 1. Access Doors:
 - a. J. L. Industries
 - b. Karp Associates, Inc.
 - c. Larsons Mfg. Co.
 - d. Milcor, Inc.
 - e. Miller Limited Partnership
 - f. Nystrom, Inc.
 - g. Or pre-approved equivalent.
- B Prime coated 14 gauge steel, flush, with screwdriver operated cam lock, frame to accommodate construction type; size as indicated.

2.13 ELECTRICAL WIRE

- A All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable.

- B All wiring running exposed in return air plenums shall be plenum-rated cable for fire and smoke spread.

2.14 LOW VOLTAGE CONTROL WIRE AND CABLE

- A All wiring materials section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable.
- B Analog Input, Analog Output, Binary Input, Binary Output, 24 VAC, and General Purpose Cabling:
 - 1. Cable shall consist of copper conductors not less than #18 AWG stranded.
 - 2. Cable shall be two- or three-conductor twisted cable with a drain wire.
 - 3. Cable shall have a 100 percent overall shield.
 - 4. Cable shall be plenum rated.
 - 5. Cable shall meet or exceed NEC voltage rating of 300 volts.
 - 6. Cable shall be NEC type CMP.
 - 7. Cable shall meet or exceed UL temperature rating of +60 deg C.
- C Primary and Secondary Communications Network Cabling:
 - 1. Cable shall be of type recommended by the DDC system manufacturer.
 - 2. Cable shall be shielded.
 - 3. Cable shall be plenum rated.
 - 4. Cable shall meet or exceed NEC voltage rating of 150 volts.
 - 5. Cable shall meet or exceed UL temperature rating of +60 deg C.

PART 3 - EXECUTION

3.1 GENERAL

- A Fabrication, erection, and installation of the complete mechanical system shall be done by qualified personnel experienced in such work and shall proceed in an orderly manner so as not to hold up the progress of the project.
- B The Contractor shall check all areas and surfaces where mechanical equipment or materials are to be installed and report any unsatisfactory conditions before starting work.
- C Commencement of work signifies the Contractor's acceptance of the conditions as fit and proper for the execution of the mechanical work.
- D Equipment and systems shall be installed in accordance with manufacturer's instructions, requirements, or recommendations.

3.2 DELIVERY AND STORAGE OF MATERIALS

- A Take provisions for the delivery and safe storage of materials and shall make the required arrangements with other Contractors for the introduction into the building of equipment too large to pass through finished openings.
- B Materials shall be delivered at such stages of the work as will expedite the work as a whole and shall be marked and stored in such a way as to be easily checked and inspected.

- C Contractor shall be responsible for adequately protecting all supplies and equipment during cold weather.
- D All items subject to cold weather damage shall be protected by covering, insulating, or storing in a heated space.

3.3 COOPERATION WITH OTHER CONTRACTORS

- A Perform the work in conformance with the construction called for by other trades and afford other Contractors reasonable opportunity for the execution of their work.
- B Properly connect and coordinate the mechanical work with the work of other Contractors at such time and in such a manner as not to delay or interfere with their work.
- C Examine the contract documents for the General, Mechanical, and Electrical work and the work of other trades. Coordinate work accordingly.
- D Promptly report to the Architect any delay or difficulties encountered in the installation of the mechanical work which might prevent prompt and proper installation of work required from other trades.
- E Systems Test and Balance Contractors or personnel shall coordinate their work with the contractors who installed the systems being tested or balanced.
- F The Temperature Control Contractor or personnel shall be present during systems test and balance.

3.4 COORDINATION OF WORK

- A The list below is the precedence of assigned work items for space priority in descending order. Items not listed shall have the same precedence as similar items.
 - 1. Reflected ceiling with all light fixtures, access above light fixtures required for maintenance, sprinkler head locations, and all ceiling fixtures and devices.
 - 2. Space designed for future utility placement.
 - 3. Gravity flow plumbing waste, roof drainage, and other systems that rely upon gravity for flow.
 - 4. Ductwork and appurtenances, except that external bracing shall be relocated to accommodate local interference.
 - 5. Fire sprinkler piping.
 - 6. Cable tray with access identification 8 inches horizontal to 6 inches above tray.
 - 7. Electrical conduit over 2 inches in diameter.
 - 8. HVAC piping except for pressurized domestic water piping.
 - 9. Plumbing vents.
 - 10. Electrical conduit under 2 inches in diameter.
- B Plan all work so it proceeds with a minimum of interference with other trades.
- C It shall also be the responsibility of the Mechanical Contractor to inform the Contractor of all openings required in the building construction for the installation of the mechanical work.

- D The Contractor shall cooperate with all other contractors in furnishing material and information, in proper sequence, for the correct location of all sleeves, inserts, foundations, wiring, etc.
- E Provisions shall be made for all special frames, openings, and sleeves as required.
- F The Contractor shall pay for extra cutting and patching made necessary by his failure to properly direct such work at the correct time.

3.5 ELECTRICAL WIRING

- A Install wiring in accordance with National Electric Code, ANSI/NFPA 70.
- B All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable. All wiring running exposed in air plenums shall be plenum cable.
- C Install wiring (low and line voltage) in metal raceways or conduit unless inside control cabinet or unit enclosures.
 - 1. For concealed and accessible areas, plenum-rated wiring and cabling may be used.
- D Low voltage wiring not installed in conduit shall be supported every five feet from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations.
- E Low voltage control wiring and 24 VAC can be run in the same conduit. Power wiring 120 VAC and greater must be in a separate conduit.
- F Fastening shall be secured to walls or ceilings by means of appropriate screws, expansion screws anchors, toggle bolts, hollow wall screw anchors, nylon expansion anchors, or expansion shields. All-purpose plastic anchors are not acceptable.
- G Locate circuits, relays, transformers, or other equipment that contains or must be connected to voltages exceeding 130 volts, in separate cabinets, which may be adjacent to control panels; permanently label "DANGER 277 VOLTS" or appropriate volts.
- H All wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size shall be 3/4 inch.

3.6 CONTROL WIRING AND POWER CONNECTIONS

- A Provide all incidental control power and wiring required to make the equipment or systems fully operational. Coordinate with equipment manufacture incidental wiring requirements.
- B Unless indicated elsewhere, provide line voltage, 120VAC, 20 amp dedicated control power circuits and LAN outlet to each of the following and as indicated:
 - 1. BMCS Control panel, 1 circuit.
 - 2. Air handling Unit, 1 circuit.
 - 3. Air Terminal Unit Power supply transformer panel, 1 circuit per 20 terminal units.
 - 4. DDC Power supply and transformer panel. 1 circuit can power 30 terminal units.

5. Coordinate required 120V power circuits and LAN outlets with Electrical Contractor.
- C Incidental control wiring includes but not limited to:
1. Air Handling Units:
 - a. Fans
 - b. Damper Operators
 - c. Lights
 - d. Valve Operators
 2. Equipment Motors Starters
 3. Condensing Units
 - a. Provide 3/4 inch conduit with a minimum of eight distinctively colored or tagged #14 wires between units and remote panels or thermostats for control wiring
 4. HVAC Controls (Including but not limited to):
 - a. Manufacturer's Packaged Control Systems
 - b. Control Relays
 - c. Fan Powered Air Terminal Units
 - d. Air Terminal Units
 - e. Control Dampers and Valves
 - f. Transmitters
 5. Loose Motor Starters
 6. Manual Multi-Speed Switches (Furnished as an Accessory to Mechanical Equipment)
 7. Packaged Rooftop Units, Packaged Exhaust Fan
 - a. Provide 3/4 inch conduit with a minimum of eight distinctively colored or tagged #14 wires between units and remote panels or thermostats for control wiring
 8. Pushbutton Stations and Emergency Stop Switches
 9. Pumps
 10. Remote Monitoring and Control Panels (Provided by Equipment Manufacturers)
 11. Supply, Return and Exhaust Fans
 12. Temporary Heating/Cooling Equipment
 13. Unit Mounted Motor Starters, Contactors, Disconnect Switches, Thermal Overloads and Heaters
 14. Variable Frequency Controls.

3.7 LAYING OUT WORK

- A Carefully lay out all work in advance of installation using data and measurements from the site, the appropriate architectural and structural drawings, and shop drawings.
- B Equipment layout and all system layouts shall confirm adequate clearances for installation, operation, maintenance, and code-required clearances from the structure or other equipment and systems.
- C Provide offsets and elevation changes in piping, conduit and ductwork as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.
- D The layout shall not cause problems of operation, maintenance, or clearance for items installed by other Contractors.

- E Prior to installation of any work, make certain the location does not conflict with other items in or near the same location.
- F If the layouts so prepared indicate that the required conditions cannot be met in the space provided, inform the Architect prior to installation and shall request clarification.
- G Failure to properly coordinate and lay out the work will require correction by the Contractors at their own expense.

3.8 DATA AND MEASUREMENTS

- A Mechanical and electrical drawings are diagrammatic or schematic. Do not scale drawings.
- B The data given herein and on the drawings is as accurate as could be secured; absolute accuracy is not guaranteed.
- C Obtain exact locations, measurements, levels, etc., at the site and shall adapt their work to actual conditions.
- D Examine the general construction, mechanical, electrical, and other applicable drawings and the Specifications.
- E Only architectural drawings, structural drawings, and site measurements may be utilized in calculations.
- F Layout and coordinate all work prior to installation to provide clearances for operation, maintenance and codes. Verify non-interference with other work.

3.9 POSITION OF DEVICES

- A Locate devices mounted on finished surfaces with regard to paneling, furring, trim, etc. Where several devices occur in a room, they shall be symmetrically arranged as reviewed by the Architect.
- B Devices improperly located or installed shall be repaired, replaced or relocated at the Contractor's expense.
- C Devices shall be set plumb or horizontal and shall extend to the finished surface of the wall, ceiling, or floor without projecting beyond the surface.
- D Devices shown on wood trim, cases, or other fixtures shall be installed symmetrically and, where necessary, shall be set with the long dimension of the plate horizontal.
- E Coordinate their respective devices so as not to destroy the aesthetic effect of the surface in which the devices are mounted.
- F Coordinate the locations of all mechanical items with work furnished by other trades to avoid interference.

- G If the required coordination is not done, the outlets or devices shall be removed and relocated if so directed by the Architect and the damaged surfaces repaired at the Contractor's expense.
- H Devices shall be installed at the height shown below unless otherwise noted. All heights of devices are measured from finished floor to centerline of device.
- I Heights may be adjusted to correspond to nearest masonry course or as necessary to clear wall-mounted cabinets, fin tube convectors, unit heaters, etc.
 - 1. Temperature control panels: 60 inches
 - 2. Thermostats: 48 inches
 - 3. Carbon dioxide (CO2) sensors: 48 inches

3.10 PROTECTION OF APPARATUS

- A Take such precautions as necessary to properly protect all apparatus, fixtures, appliances, material, equipment, and installations from damage of any kind.
- B Failure to provide such protection to the satisfaction of the Architect shall be sufficient cause for the rejection of any particular piece(s) of material, apparatus, equipment, etc., concerned.

3.11 ACCESS TO EQUIPMENT

- A All motors, terminal boxes, valves, control devices, specialties, etc., shall be located to provide for easy access for operation, repair and maintenance; if concealed, access doors shall be provided.
- B Access doors required for access to equipment requiring inspection or service shall be provided.
- C Provide all access doors not already furnished by other Contractors but which are required for access to mechanical equipment.
- D Doors shall be 12 inches by 12 inches unless shown otherwise.
- E Person access doors shall be 18 inches by 18 inches minimum.

3.12 ROADWAYS, CURBS, AND WALKS

- A Use every possible precaution to prevent injuries to roadways, curbs, and walks on or adjacent to the site of the work.
- B Any damage shall be repaired at the Contractor's own expense. This shall also include damage necessary for installation of the mechanical work.

3.13 FRAMES

- A Ducts passing through masonry walls shall be installed in steel angle iron frames and sleeves.
- B All sleeves and frames shall be securely fastened to the walls. Provide for structural lintels in masonry wall openings.

- C Ducts passing through openings in poured concrete walls and floors need not have frames.

3.14 FINISHED SURFACES PENETRATIONS

- A All piping and ductwork penetrations of finished surfaces shall have escutcheons and/or closure plates.
- B Openings shall be cut only as large as required for the installation, sleeves, and/or frames installed flush with finished surfaces and grouted in place.
- C Surfaces around openings shall be left smooth and finished to match surrounding surface.
- D Duct frames and pipe sleeves through floors in concealed locations and in unfinished spaces such as mechanical rooms, etc., shall extend 2 inches above finished floor level and shall be caulked watertight.
- E All other sleeves shall extend approximately 1/4 inch above finished floor but shall allow placement of escutcheons.

3.15 FIRESTOPPING PENETRATIONS IN FIRE-RATED WALL/FLOOR ASSEMBLIES

- A Subject to compliance with the requirements of Division 07.
- B Provide proper sizing when providing sleeves or core-drilled holes to accommodate their work through penetrating items.
- C All voids between sleeve or core-drilled hole and pipe passing through shall be firestopped to meet the requirements of ASTM E814.
- D Install all materials complete, attached securely and permanently in place in accordance with manufacturers' printed directions.
- E Install materials in manner described in fire test report and in accordance with manufacturer's instructions, completely closing openings.
- F Do not cover installed firestopping until inspected by authority having jurisdiction.
- G Install labeling required by code.

3.16 PIPING AND/OR DUCTWORK SYSTEMS - COMMON REQUIREMENTS

- A General: Install as described below, unless individual Sections specify otherwise. Individual Sections specify unique installation requirements.
- B General Locations and Arrangements:
 - 1. Drawing plans, schematics, and diagrams indicate general, diagrammatic location and arrangement of systems.
 - 2. Indicated locations and arrangements were used to size pipe or ductwork and calculate friction loss, expansion, pump and fan sizing, and other design considerations.

3. Install systems as indicated, unless deviations to layout are approved on Coordination Drawings.
4. Provide offsets and elevation changes in ductwork, piping and conduit as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.
5. Refer to architectural reflected ceiling plans for exact diffuser, register, grille, and ceiling mounted device locations.
6. Do not run ductwork and piping above electrical panels or in code required clearance spaces.
7. Do not run ductwork, piping, and plumbing above or through information technology and data closets, IDF, and MDF rooms. Coordinate all routing with other trades.
8. Coordinate location of ductwork and piping with electrical cable tray. Provide a minimum of 6" of clear access above cable tray for installation of cables.
9. Install all horizontal ductwork and piping in mechanical rooms at a minimum of 7'-6" above finished floor.
10. Install exposed interior and exterior piping and ductwork at right angles or parallel to building walls.
 - a. Diagonal runs are prohibited, unless otherwise indicated.
11. Conceal ductwork and piping in walls, pipe chases, utility chases, above ceilings, below grade or floors, unless otherwise noted, except in mechanical rooms or service areas.
12. Install piping and ductwork to allow application of insulation plus 1-inch clearance around insulation.
13. Pipe hangers for insulated pipe with vapor barrier jackets shall be installed around the outside of the insulation and a metal insulation support shield provided to prevent crushing of the insulation.
14. Locate groups of pipes parallel to each other, spaced to permit insulation and valve servicing.
15. Dielectric nipples or flange insulation kits shall be utilized for all dissimilar pipe connections. Dielectric unions will not be accepted.
16. Install piping at indicated slope and as required by code.
17. Provide components with pressure rating equal to or greater than system operating pressure.
18. Install fittings for changes in direction and branch connections.
19. Install piping free of sags or bends with ample space between piping to permit proper insulation applications.
20. Install ductwork and piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building unless otherwise indicated.
 - a. Allow sufficient space above ceiling panels to allow for ceiling panel removal.
21. Install ductwork and piping to allow for expansion and contraction without stressing pipe, adjacent building structure or connecting equipment.
 - a. Provide expansion loops or compensators where indicated.
22. Do not use ceiling support system to bear weight of devices or systems unless ceiling support system is certified as suitable to do so.
23. During construction, avoid any undue loads, forces or strains on valves, equipment, pumps flanges, or building elements with piping connections or piping systems.
24. Keep all pipe, duct, and equipment openings closed during construction except when actual work is being performed on that item or system.
25. Leaking pipe and duct joints shall be remade using new materials.
26. Roof mounted piping, conduit and ductwork:
 - a. Coordinate all roof mounted support locations and loads with roofing contractor.

- b. Space supports per all applicable codes and as indicated.
- c. Provide 18" minimum under pipe, duct and conduit, to allow for roof repair.
- 27. Piping Penetrations:
 - a. Provide pipe escutcheons for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:
 - 1) Chrome-Plated Piping: Cast brass, one piece, with set screw, and polished chrome-plated finish. Use split-casting escutcheons if required, for existing piping.
 - 2) Uninsulated Piping Wall Escutcheons: Cast brass or stamped steel, with set screw.
 - 3) Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates.
 - 4) Insulated Piping: Cast brass or stamped steel; with concealed hinge, spring clips, and chrome-plated finish.
 - 5) Piping in Utility Areas: Cast brass or stamped steel, with set-screw or spring clips.
- C Contractor is responsible for any cutting and patching needed for mechanical installation. Patching must match existing.
- D Size and route refrigerant piping per manufacturers' recommendations.
- E Verify final equipment locations for roughing-in of all systems.
- F Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.17 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A Install equipment to provide maximum possible headroom, if mounting heights are not indicated.
- B Install equipment according to manufacturer's requirements and submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to Architect.
- C Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components.
- E Connect equipment for ease of disconnecting, with minimum interference to other installations.
- F Install equipment giving right of way to piping installed at required slope.
- G Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

3.18 CONCRETE BASES AND HOUSEKEEPING PADS

- A Anchor equipment to concrete base or pads according to equipment manufacturer's written instructions and according to applicable seismic codes.
 - 1. Provide bases and pads of dimensions and locations indicated, but not less than 6 inches larger in both directions than supported unit.

2. Use 3000-psi, 28-day compressive-strength concrete.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
4. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
8. Bases and pads poured on reinforced concrete slabs shall be a minimum of 4" thick, have 6 x 6 x 10/10 welded wire fabric and shall be doweled to the slab.
9. Self-supporting isolating bases and pads shall be a minimum of 12" thick, have #4 reinforcing bars at 8 inches center to center each way and shall have an expansion joint around the perimeter of the adjoining slab.

3.19 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- B Field Welding: Comply with AWS D1.1, "Structural Welding Code--Steel."

3.20 GROUTING

- A Install nonmetallic, non-shrink, grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's written instructions.
1. Clean surfaces that will come into contact with grout.
 2. Provide forms as required for placement of grout.
 3. Avoid air entrapment during placing of grout.
 4. Place grout, completely filling equipment bases.
 5. Place grout on concrete bases to provide smooth bearing surface for equipment.
 6. Place grout around anchors.
 7. Cure placed grout according to manufacturer's written instructions.

3.21 INCIDENTAL WORK

- A The following incidental work shall be furnished by the designated contractor under the supervision of the Temperature Control Contractor:
1. The Piping Contractor shall install automatic valves and separable wells that are specified to be furnished by the Temperature Control Contractor.
 2. The Piping Contractor shall provide all necessary valved pressure taps, water, drain, and overflow connections and piping.
 3. The Piping Contractor shall provide all necessary piping connections required for flow devices, valve position indicators, etc.
 4. The Air Distribution Contractor shall install all automatic dampers furnished by the Temperature Control Contractor.

5. The Air Distribution Contractor shall provide necessary blank-off plates (safing) required to install dampers that are smaller than duct size.
6. The Electrical Contractor shall provide power wiring to the variable frequency drives.
7. The Air Distribution Contractor shall assemble multiple section automatic dampers, furnished by the Temperature Control Contractor, with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper actuators.
8. The Air Distribution Contractor shall provide necessary sheet metal baffle plates to eliminate stratification while providing air volumes specified. Locate baffles by experimentation and affix and seal permanently in place only after stratification has been eliminated.
9. The Air Distribution Contractor shall provide access doors or other approved means of access through ducts for service to control equipment.
10. Supply and return air motorized smoke dampers shall be provided by the Air Distribution Contractor on all air handling units 15,000 cfm and larger, as required by NFPA 90A, and shall be controlled by the Temperature Control Contractor. Dampers shall close when fan stops and open when fan starts.

3.22 EQUIPMENT AND SYSTEM SOFTWARE INTERFACES TO THE BMCS

- A Contractor shall coordinate with the BMCS Contractor to determine the points that are to be mapped from the equipment and systems to the BMCS. Contractor shall provide details of the method of integration and the information to be transferred between the systems as part of the submittal package.
- B Contractor shall provide the necessary software communication ports specifically for the interfacing of the systems to the BMCS.
- C Contractor cannot document that the exact same interface has been performed between the selected BMCS and the equipment and/or system, then the interfaces shall be tested prior to installations at an offsite location. The equipment shall not be installed at the project location until all software interfaces to the BMCS have been successfully demonstrated or documented.
- D Documentation regarding the software interfaces shall be provided in sufficient detail as to enable a person reasonably skilled in the writing of real time software applications to add/delete points mapped from one system to the other. The documentation shall include a detailed description of each protocol used and the model, version and firmware details of any protocol converter (gateway) that is used.
- E Refer to BMCS specifications for coordination and testing requirements.

3.23 LUBRICATION, TESTING AND TEST REPORTS

- A Upon completion of the work, the entire system shall be tested and proven for capacity of equipment, balance of system, proper operation of controls, and comfort of conditioned spaces.
 1. Prior to beginning systems testing, adjusting and balancing, replace all filter media with new media.
 2. Test and balance procedures and documentation shall be in accordance with AABC, NEBB, or SMACNA unless indicated otherwise.
 3. Take air and water flow readings and submit copy of same to demonstrate proper flow according to the performances shown on the plans and noted in the specifications.

4. Motors shall be checked for overload and belts adjusted.
 - a. Align pulleys and install belts according to manufacturer's written instructions.
 - b. Tension according to manufacturer's written instructions.
5. Lubricate moving parts and clean or replace filters.
 - a. Run in all bearings and, after they are run in, drain and flush bearings and refill with a new oil charge.
 - b. Equipment shall be so arranged that tools (screwdrivers, wrenches, etc.) will not be required to make lubrication points accessible.
 - c. Extensions on grease or oil fittings shall be provided where required for access to lubricate.
6. Test piping systems per applicable codes and standards.
7. Test ductwork systems per SMACNA and applicable codes and standards.
8. Submit all test reports to the Architect for review prior to date of substantial completion.
9. Equipment and systems discrepancies shall be corrected prior to final acceptance.

END OF SECTION

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SECTION 230513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A General construction and requirements.
- B Applications.
- C Single phase electric motors.
- D Three phase electric motors.
- E Electronically Commutated Motors (ECM).

1.2 REFERENCE STANDARDS

- A ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings.
- B IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
- C NEMA MG 00001 - Motors and Generators.
- D NFPA 70 - National Electrical Code.

1.3 SUBMITTALS

- A Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- B Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.
- C Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.4 QUALITY ASSURANCE

- A Comply with NFPA 70.
- B 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 Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Baldor Electric Company/ABB Group: www.baldor.com.
- B Leeson Electric Corporation: www.leeson.com.
- C Regal-Beloit Corporation (Century): www.centuryelectricmotor.com.
- D General Electric
- E U.S. Motors
- F Or pre-approved equivalent.

2.2 GENERAL CONSTRUCTION AND REQUIREMENTS

- A Construction:
 - 1. Open drip-proof type except where specifically noted otherwise.
 - 2. Design for continuous operation in 104 degrees F environment.
 - 3. Design for temperature rise in accordance with NEMA MG 00001 limits for insulation class, service factor, and motor enclosure type.
- B Explosion-Proof Motors: UL approved and labelled for hazard classification, with over temperature protection.
- C Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.
- D Wiring Terminations:
 - 1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
 - 2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.3 APPLICATIONS

- A Exception: Motors less than 250 watts, for intermittent service may be the equipment manufacturer's standard and need not comply with these specifications.
- B Single phase motors for shaft mounted fans, oil burners, and centrifugal pumps: Split phase type.

- C Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.
- D Single phase motors for pumps and air compressors: Capacitor start type.
- E Single phase motors for fans and blowers: Capacitor start, capacitor run type.
- F Motors located in exterior locations, wet air streams downstream of sprayed coil dehumidifiers, draw through cooling towers, air cooled condensers, humidifiers, direct drive axial fans, roll filters, explosion proof environments, and dust collection systems: Totally enclosed type.
- G Motors located in outdoors, in wet air streams downstream of sprayed coil dehumidifiers, in draw through cooling towers, and in humidifiers: Totally enclosed weatherproof epoxy-treated type.
- H Motors located outdoors and in draw through cooling towers: Totally enclosed weatherproof epoxy-sealed type.

2.4 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- A Starting Torque: Less than 150 percent of full load torque.
- B Starting Current: Up to seven times full load current.
- C Breakdown Torque: Approximately 200 percent of full load torque.
- D Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
- E Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.5 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- A Starting Torque: Exceeding one fourth of full load torque.
- B Starting Current: Up to six times full load current.
- C Multiple Speed: Through tapped windings.
- D Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

2.6 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A Starting Torque: Three times full load torque.
- B Starting Current: Less than five times full load current.
- C Pull-up Torque: Up to 350 percent of full load torque.

- D Breakdown Torque: Approximately 250 percent of full load torque.
- E Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings.
- G Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.7 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A Starting Torque: Between 1 and 1-1/2 times full load torque.
- B Starting Current: Six times full load current.
- C Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- D Design, Construction, Testing, and Performance: Comply with NEMA MG 00001 for Design B motors.
- E Insulation System: NEMA Class B or better.
- F Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- G Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- I Sound Power Levels: To NEMA MG 00001.
- J Part Winding Start Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- K Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
- L Nominal Efficiency: NEMA MG 1-2006 Premium.
- M Inverter Duty: NEMA MG 1 Part 31.4.4.2.

2.8 ELECTRONICALLY COMMUTATED MOTORS (ECM)

- A Manufacturers:
 - 1. US Motors, a brand of NIDEC Motor Corporation: www.usmotors.com.
 - 2. Or pre-approved equivalent.
- B Starting Torque: Exceeding one fourth of full load torque.
- C Soft start and soft speed change ramps.
- D Breakdown Torque: Approximately 250 percent of full load torque.
- E Motors: Synchronous rotation. Variable speed direct current brushless. Permanent magnet type. Near zero rotor losses. Permanently lubricated ball bearings. Integrated controller/inverter operates the wound stator and senses rotor position to electronically commutate the stator.
- F Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.9 SHAFT GROUNDING

- A Manufacturers:
 - 1. AEGIS SGR
 - 2. Helwig Carbon Products
 - 3. Or pre-approved equivalent.
- B Shaft grounding system for each three-phase AC motor to prevent electrical damage to motor bearings and to extend motor life by safely channeling harmful shaft currents to ground.
- C Provide shaft grounding on all motors controlled by variable frequency controllers and as indicated.
- D Electrographite construction. Integral shunt with quick disconnect terminal and mount.
- E Continuous spring loaded brush holder, conductive carbon brush or carbon fiber ring technology.
- F Replaceable without motor removal or uncoupling..
- G Internal:
 - 1. Integral to motor housing.
- H External:
 - 1. Bolted to motor exterior.
 - 2. Slide ring over the end of the motor shaft and locking it in place with screw on mounting brackets.

PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- C Check line voltage and phase and ensure agreement with nameplate.

3.2 SCHEDULE

- A NEMA Open Motor Service Factors.
 - 1. 3/4 hp:
 - a. 3600 rpm: 1.25.
 - b. 1800 rpm: 1.25.
 - c. 1200 rpm: 1.15.
 - d. 900 rpm: 1.15.
 - 2. 1 hp:
 - a. 3600 rpm: 1.25.
 - b. 1800 rpm: 1.15.
 - c. 1200 rpm: 1.15.
 - d. 900 rpm: 1.15.
 - 3. 1.5-150 hp:
 - a. 3600 rpm: 1.15.
 - b. 1800 rpm: 1.15.
 - c. 1200 rpm: 1.15.
 - d. 900 rpm: 1.15.

END OF SECTION

SECTION 230548

VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Vibration isolation requirements.
- B Vibration-isolated engineered roof curbs.
- C In-curb sound attenuation treatment.

1.2 REFERENCE STANDARDS

- A ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications.
- B ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate selection and arrangement of vibration isolation and/or seismic control components with the actual equipment to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 - 4. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

- A Design Documents: Prepare and submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, details, and calculations.
- B Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
 - 1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification methods for spring element load capacities.
- C Shop Drawings - Vibration Isolation Systems:
 - 1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators; indicate equipment weights and static deflections.

2. Vibration Isolation* including calculations, Drawings, etc. Submittal data shall include size, type, load and deflection of each isolator selected and shall clearly outline procedures for setting and adjusting all isolation devices.
3. Shop Drawings shall be submitted to the Project Structural Engineer for review of loads exceeding 500 lb. imposed on the building structure. The Shop Drawing shall be submitted to the Engineer for review after review by the Project Structural Engineer.

1.5 QUALITY ASSURANCE

- A Comply with applicable building code.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 VIBRATION ISOLATION REQUIREMENTS

- A Provide vibration isolation systems to reduce vibration transmission to supporting structure from vibration-producing HVAC equipment and/or HVAC connections to vibration-isolated equipment.
- B Comply with applicable general recommendations of ASHRAE (HVACA), where not in conflict with other specified requirements:
- C General Requirements:
1. Select vibration isolators to provide required static deflection.
 2. Select vibration isolators for uniform deflection based on distributed operating weight of actual installed equipment.
 3. Select vibration isolators for outdoor equipment to comply with wind design requirements.
 4. Select vibration-isolated equipment support bases and associated vibration isolators to provide minimum 2-inch operating clearance beneath base unless otherwise indicated.

2.2 MANUFACTURERS

- A Isolation Technology, Inc: www.isolationtech.com.
- B Kinetics Noise Control, Inc: www.kineticsnoise.com.
- C Mason Industries: www.mason-ind.com.
- D Metraflex: www.metraflex.com.
- E Vibration Eliminator Company, Inc: www.veco-nyc.com.
- F Vibration Isolation Co., Inc.
- G Vibration Mountings & Controls/Korfund.

H Or pre-approved equivalent.

2.3 VIBRATION ISOLATORS

A General Requirements:

1. Resilient Materials for Vibration Isolators: Oil, ozone, and oxidant resistant.
2. Spring Elements for Spring Isolators:
 - a. Color code or otherwise identify springs to indicate load capacity.
 - b. Lateral Stability: Minimum lateral stiffness to vertical stiffness ratio of 0.8.
 - c. Designed to operate in the linear portion of their load versus deflection curve over deflection range of not less than 50 percent above specified deflection.
 - d. Designed to provide additional travel to solid of not less than 50 percent of rated deflection at rated load.
 - e. Selected to provide designed deflection of not less than 75 percent of specified deflection.
 - f. Selected to function without undue stress or overloading.

B Vibration Isolators for Nonseismic Applications:

1. Resilient Material Isolator Pads:
 - a. Description: Single or multiple layer pads utilizing elastomeric (e.g., neoprene, rubber) or fiberglass isolator material.
 - b. Pad Thickness: As required for specified minimum static deflection; minimum 0.25 inch thickness.
 - c. Multiple Layer Pads: Provide bonded, galvanized sheet metal separation plate between each layer.
2. Resilient Material Isolator Mounts, Nonseismic:
 - a. Description: Mounting assemblies for bolting equipment to supporting structure utilizing elastomeric (e.g., neoprene, rubber) or fiberglass isolator material; fail-safe type.
3. Open (Unhoused) Spring Isolators:
 - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) without a housing.
 - b. Bottom Load Plate: Nonskid, molded, elastomeric isolator material or steel with nonskid elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - c. Furnished with integral leveling device for positioning and securing supported equipment.
4. Housed Spring Isolators:
 - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) within a metal housing.
 - b. Furnished with integral elastomeric snubbing elements, nonadjustable type, for limiting equipment movement and preventing metal-to-metal contact between housing elements.
 - c. Bottom Load Plate: Steel with nonskid, elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - d. Furnished with integral leveling device for positioning and securing supported equipment.
5. Restrained Spring Isolators, Nonseismic:

- a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) within a metal housing designed to prevent movement of supported equipment above an adjustable vertical limit stop.
- b. Bottom Load Plate: Steel with nonskid elastomeric isolator pad with provisions for bolting to supporting structure as required.
- c. Furnished with integral leveling device for positioning and securing supported equipment.
- d. Provides constant free and operating height.
- 6. Resilient Material Isolator Hangers, Nonseismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing elastomeric (e.g., neoprene, rubber) or fiberglass isolator material for the lower hanger rod connection.
- 7. Spring Isolator Hangers, Nonseismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) in series with an elastomeric element for the lower hanger rod connection.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.
- 8. Combination Resilient Material/Spring Isolator Hangers, Nonseismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) for the lower hanger rod connection and elastomeric (e.g., neoprene, rubber) or fiberglass isolator material for the upper hanger rod connection.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.
- 9. Thrust Restraints:
 - a. Description: Assembly utilizing free-standing, laterally stable steel spring designed for resisting horizontal motion due to thrust (e.g., air pressure from a fan), and intended for installation in pairs.

2.4 VIBRATION ISOLATED ENGINEERED ROOF CURBS

A Manufacturers:

- 1. Vibration-Isolated Engineered Roof Curbs:
 - a. Kinetics Noise Control, Inc: www.kineticsnoise.com.
 - b. Mason Industries: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc: www.veco-nyc.com.
 - d. Vibro-Acoustics: www.vibro-acoustics.com.
 - e. Grinnel Corporation <https://www.grinnell.com/>
 - f. Victaulic Corporation <https://www.victaulic.com/noise-and-vibration-attenuation/>
 - g. Or pre-approved equivalent.
- 2. Unless otherwise noted, the vibration isolation devices described herein are products of the Mason Industries Inc.

B Roof Curb Rails:

- 1. Lower Support Assembly: Sheet-metal "Z" section containing adjustable and removable steel springs that support upper floating frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist wind and seismic forces.

- Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.
2. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
 - a. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
 - 1) Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
 - 2) Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3) Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4) Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
 - 5) Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - b. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 - 1) Material: Standard neoprene or Bridge-bearing neoprene, complying with AASHTO M 251.
 - 2) Durometer values range from 30 to 70 and are measures of hardness or, indirectly, deflection. Lower durometer values indicate softer material with more deflection.
 - 3) Durometer Rating: 45.
 - 4) Use multiple layers, separated by steel shims, depending on supported equipment load. See manufacturer's data for load capacities.
 - 5) Number of Layers: 2.
 3. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.
 4. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

2.5 IN-CURB SOUND ATTENUATION TREATMENT

- A Description: Prefabricated composite acoustical panels for installation in equipment curb. Designed to attenuate sound transfer from mechanical equipment into spaces below curb.
- B Sound Transmission Class: Not less than 30 when tested in accordance with ASTM E90.

PART 3 EXECUTION

3.1 CODE-REQUIRED SPECIAL INSPECTIONS

- A Arrange work to accommodate tests and/or inspections performed by Special Inspection Agency employed by Owner or Architect in accordance with Section 014533 and statement of special inspections as required by applicable building code.
- B Frequency of Special Inspections: Where special inspections are designated as continuous or periodic, arrange work accordingly.
 - 1. Continuous Special Inspections: Special Inspection Agency to be present in the area where the work is being performed and observe the work at all times the work is in progress.
 - 2. Periodic Special Inspections: Special Inspection Agency to be present in the area where work is being performed and observe the work part-time or intermittently and at the completion of the work.
- C Prior to starting work, Contractor to submit written statement of responsibility to authorities having jurisdiction and to Owner acknowledging awareness of special requirements contained in the statement of special inspections.
- D Special Inspection Agency services do not relieve Contractor from performing inspections and testing specified elsewhere.

3.2 SCHEDULE

- A Equipment Isolation: As indicated below
 - 1. The following system pumps require isolation:
 - a. Rooftop unit
 - b. Ceiling fans
- B Ceiling mounted fans
 - 1. Neoprene grommet at each hanging rod support point, isolating the hanger from the fan housing.
- C Thrust Restraint Applications:
 - 1. Use thrust restraints to resist horizontal motion due to thrust for fan heads, suspended fans, and base-mounted and suspended air handling equipment operating at 2.0 inches wg or greater total static pressure.
 - 2. Minimum Static Deflection: Same as static deflection of equipment.
 - 3. Limit lateral movement to 0.25 inch or less unless otherwise indicated.

3.3 INSTALLATION

- A Install products in accordance with manufacturer's instructions.
- B Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C Secure fasteners according to manufacturer's recommended torque settings.
- D Install flexible piping connections to provide sufficient slack for vibration isolation and/or seismic relative displacements as indicated or as required.

- E Vibration Isolation Systems:
1. Vibration-Isolated Equipment Support Bases:
 - a. Provide specified minimum clearance beneath base.
 2. Spring Isolators:
 - a. Position equipment at operating height; provide temporary blocking as required.
 - b. Lift equipment free of isolators prior to lateral repositioning to avoid damage to isolators.
 - c. Level equipment by adjusting isolators gradually in sequence to raise equipment uniformly such that excessive weight or stress is not placed on any single isolator.
 3. Isolator Hangers:
 - a. Use precompressed isolator hangers where required to facilitate installation and prevent damage to equipment utility connection provisions.
 - b. Locate isolator hangers at top of hanger rods in accordance with manufacturer's instructions.
 4. Thrust Restraints:
 - a. Adjust restraint movement under normal operating static pressure.
 5. Clean debris from beneath vibration-isolated equipment that could cause short-circuiting of isolation.
 6. Use elastomeric grommets for attachments where required to prevent short-circuiting of isolation.
 7. Adjust isolators to be free of isolation short circuits during normal operation.
 8. Do not overtighten fasteners such that resilient material isolator pads are compressed beyond manufacturer's maximum recommended deflection.
- F All wiring connections to mechanical equipment on vibration isolators (either spring or neoprene type) shall be made with a minimum 36 inch long flexible conduit. Coordinate wiring connections with the Electrical Installer.

3.4 FIELD TESTING

- A After installation and prior to "Substantial Completion", the isolation manufacturer's factory trained technician shall check all the various isolators and certify in writing to the Subcontractor and Owner that they have been installed properly and are in accordance with the manufacturer's recommendations.

3.5 FIELD QUALITY CONTROL

- A Inspect vibration isolation components for damage and defects.
- B Vibration Isolation Systems:
1. Verify isolator static deflections.
 2. Verify vibration isolation performance during normal operation; investigate sources of isolation short circuits.
- C Correct deficiencies and replace damaged or defective vibration isolation and/or seismic control components.

END OF SECTION

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SECTION 230553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Nameplates.
- B Tags.
- C Pipe markers.
- D Ceiling Grid Markers.

1.2 REFERENCE STANDARDS

- A ASME A13.1 - Scheme for the Identification of Piping Systems.
- B ASTM D709 - Standard Specification for Laminated Thermosetting Materials.

1.3 SUBMITTALS

- A List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- B Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- C Product Data: Provide manufacturers catalog literature for each product required.
- D Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- A Air Handling Units, RTU: Nameplates.
- B Air Terminal Units: Nameplates.
- C Control Panels: Nameplates.
- D Dampers: Ceiling grid markers, where located above lay-in ceiling.
- E Piping: Pipe markers.
- F Relays: Tags.

- G Small-sized Equipment: Tags.
- H Thermostats: Nameplates. Coordinate with owner on exact method. Nameplates should be of proper size to not be a distraction.
- I Valves: Tags and ceiling grid markers where located above lay-in ceiling.

2.2 MANUFACTURERS

- A Advanced Graphic Engraving: www.advancedgraphicengraving.com.
- B Brady Corporation: www.bradycorp.com.
- C Brimar Industries, Inc.: www.pipemarker.com.
- D Champion America, Inc: www.Champion-America.com.
- E Craftmark Pipe Markers: www.craftmarkid.com/#sle.
- F Kolbi Pipe Marker Co: www.kolbipipemarkers.com.
- G Seton Identification Products: www.seton.com/aec.
- H Or pre-approved equivalent.

2.3 NAMEPLATES

- A Description: Laminated three-layer plastic with engraved letters.
 - 1. Letter Color: White.
 - 2. Letter Height: 1/4 inch.
 - 3. Background Color: Black.
 - 4. Plastic: Comply with ASTM D709.

2.4 TAGS

- A Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch octagonal.
- B Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch octagonal with smooth edges.
- C Valve Tag Schedule: In Valve and Equipment Binder.

2.5 PIPE MARKERS

- A Color: Comply with ASME A13.1.

- B Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- C Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.
- D Underground Plastic Pipe Markers: Bright-colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil, 0.004 inch thick, manufactured for direct burial service.
- E Color code as follows:
 - 1. Heating, Cooling, and Boiler Feedwater: Green with white letters.
 - 2. Toxic and Corrosive Fluids: Orange with black letters.
 - 3. Compressed Air: Blue with white letters.

2.6 CEILING GRID MARKERS

- A Marker Description: Self-adhering vinyl, 7/8 inch diameter, color coded.
- B Color code as follows:
 - 1. HVAC Equipment: Yellow.

PART 3 EXECUTION

3.1 PREPARATION

- A Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

- A Install plastic nameplates with corrosive-resistant mechanical fasteners.
- B Install tags with corrosion resistant chain.
- C Install plastic pipe markers in accordance with manufacturer's instructions.
- D Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E Use tags on piping 3/4 inch diameter and smaller.
 - 1. Identify service, flow direction, and pressure.
 - 2. Install in clear view and align with axis of piping.
 - 3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- F Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.

- G Identify control panels and major control components outside panels with plastic nameplates.
- H Identify valves in main and branch piping with tags.
- I Identify air terminal units stencilled painting and valves with numbered tags.
- J Locate ceiling grid markers to locate valves above T-bar type panel ceilings. Locate on grid closest to equipment.

3.3 TAGS

- A Install tags with corrosion-resistant chain.
- B Identify valves in main and branch piping with tags.
- C Identify air terminal units coil valves with numbered tags.
- D Tag automatic controls, instruments, and relays. Keep to control schematic.
- E Identify small devices such as in-line pumps with tags.
- F Identify pipe 1 inch and smaller with tags.

3.4 PIPE MARKERS

- A Install plastic pipe markers in accordance with manufacturer's instructions.
- B Install plastic tape pipe markers complete/around pipe in accordance with manufacturer's instructions.
- C Identify piping, concealed or exposed, with plastic pipe markers. Identify service, flow direction. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure and at each obstruction.
- D All underground piping systems shall have a non-metallic warning tape, with appropriate warning, buried 24 inches above top of pipe.

3.5 NAME PLATES

- A Install plastic name plates with stainless steel screws.
- B Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates.
- C Identify control panels and major control components outside panels with plastic nameplates.

3.6 VALVE AND EQUIPMENT SCHEDULE BINDER

- A Provide 3-ring binder for all valve and equipment schedules with tabs and plastic page protectors for each system. Schedules to be on standard - size bond paper with following information:
1. Valve Schedules:
 - a. Valve number
 - b. Piping system
 - c. System abbreviation (as shown on valve tag)
 - d. Location of valve (room or space)
 - e. Area served
 - f. Normal operating position (opened, closed, modulating)
 - g. Indicate emergency shutoff or similar special uses.
 2. As-Built Record Building Plans:
 - a. Indicate all valve and equipment locations
 - b. Provide in electronic format, .pdf or .dwg

END OF SECTION

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SECTION 230593**TESTING, ADJUSTING, AND BALANCING FOR HVAC****PART 1 GENERAL****1.1 SECTION INCLUDES**

- A Testing, adjustment, and balancing of air systems and components.
- B Testing, adjustment, and balancing of plumbing systems and components specified under Division 22.
- C Measurement of final operating condition of HVAC systems.

1.2 DEFINITIONS

- A Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.
- C Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
- D Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- E NC: Noise criteria.
- F Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- G RC: Room criteria.
- H Report Forms: Test data sheets for recording test data in logical order.
- I Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- J Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- K System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

- L System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- M TAB: Testing, adjusting, and balancing.
- N Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- O Test: A procedure to determine quantitative performance of systems or equipment.
- P Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.3 REFERENCE STANDARDS

- A AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition.
- B ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.
- C NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems.
- D SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing.
- E TABB - Testing, Adjusting, and Balancing Bureau.

1.4 SUBMITTALS

- A TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
 - 1. Submit to Architect.
 - 2. Submit six weeks prior to starting the testing, adjusting, and balancing work.
 - 3. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified below and in Part 3.
 - 4. Include certification that the plan developer has reviewed Contract Documents, the equipment and systems, and the control system with the Architect and other installers to sufficiently understand the design intent for each system.
 - 5. Include at least the following in the plan:
 - a. Preface: An explanation of the intended use of the control system.
 - b. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - d. Identification and types of measurement instruments to be used and their most recent calibration date.

- e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - f. Final test report forms to be used.
 - g. Detailed step-by-step procedures for TAB work for each system and issue, including:
 - 1) Terminal flow calibration (for each terminal type).
 - 2) Diffuser proportioning.
 - 3) Branch/submain proportioning.
 - 4) Total flow calculations.
 - 5) Rechecking.
 - 6) Diversity issues.
 - h. Expected problems and solutions, etc.
 - i. Criteria for using air flow straighteners or relocating flow stations and sensors; analogous explanations for the water side.
 - j. Details of how TOTAL flow will be determined; for example:
 - 1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
 - 2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
 - k. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.
 - l. Confirmation of understanding of the outside air ventilation criteria under all conditions.
 - m. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
 - n. Method of checking building static and exhaust fan and/or relief damper capacity.
 - o. Proposed selection points for sound measurements and sound measurement methods.
 - p. Methods for making coil or other system plant capacity measurements, if specified.
 - q. Time schedule for TAB work to be done in phases (by floor, etc.).
 - r. Description of TAB work for areas to be built out later, if any.
 - s. Time schedule for deferred or seasonal TAB work, if specified.
 - t. False loading of systems to complete TAB work, if specified.
 - u. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
 - v. Interstitial cavity differential pressure measurements and calculations, if specified.
 - w. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
 - x. Procedures for formal progress reports, including scope and frequency.
 - y. Procedures for formal deficiency reports, including scope, frequency and distribution.
- B Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
- 1. Revise TAB plan to reflect actual procedures and submit as part of final report.
 - 2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
 - 3. Provide reports in electronic, word searchable, .pdf format binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of

- reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
 5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
 6. Units of Measure: Report data in I-P (inch-pound) units only.
 7. Include the following on the title page of each report:
 - a. Name of Testing, Adjusting, and Balancing Agency.
 - b. Address of Testing, Adjusting, and Balancing Agency.
 - c. Telephone number of Testing, Adjusting, and Balancing Agency.
 - d. Project name.
 - e. Project location.
 - f. Project Architect.
 - g. Project Engineer.
 - h. Project Contractor.
 - i. Project altitude.
 - j. Report date.
 - k. Certification sheet signed and sealed by the certified testing and balancing engineer.
- C Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.
- D Project Record Documents: Record actual locations of flow measuring stations, balancing dampers, balancing valves and rough setting, balancing dampers, and balancing dampers.
- E As-Balanced Record Pump and Fan Curves: Record actual balanced points on the manufacture's submitted pump and fan curves.
1. Record system curves and actual RPM data for all fans.
 2. Record system curves, actual RPM and final impeller diameter for all pumps.
- F Final Report Contents: In addition to certified field report data, include the following:
1. Pump curves.
 2. Fan curves.
 3. Manufacturers' test data.
 4. Field test reports prepared by system and equipment installers.
 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

1.5 PROJECT CONDITIONS

- A The entire TAB process shall be completed prior to Owner Occupancy.

1.6 COORDINATION

- A Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B Provide seven days' advance notice for each test. Include scheduled test dates and times.
- C Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 WARRANTY

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

PART 2 PRODUCTS

2.1 DUCT TEST HOLES

- A Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- B Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

- A Perform total system balance in accordance with one of the following:
 - 1. AABC (NSTSB), AABC National Standards for Total System Balance.
 - 2. SMACNA (TAB).
 - 3. Maintain at least one copy of the standard to be used at project site at all times.
- B Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D TAB Agency Qualifications:
 - 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.

2. Certified by one of the following:
 - a. AABC, Associated Air Balance Council: www.aabc.com/#sle; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
 - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org/#sle.

E TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.2 EXAMINATION

- A Verify that systems are complete and operable before commencing work. Ensure the following conditions:
1. Systems are started and operating in a safe and normal condition.
 2. Temperature control systems are installed complete and operable.
 3. Proper thermal overload protection is in place for electrical equipment.
 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 5. Duct systems are clean of debris.
 6. Fans are rotating correctly.
 7. Fire and volume dampers are in place and open.
 8. Air coil fins are cleaned and combed.
 9. Access doors are closed and duct end caps are in place.
 10. Air outlets are installed and connected.
 11. Duct system leakage is minimized.
 12. Hydronic systems are flushed, filled, and vented.
 13. Pumps are rotating correctly.
 14. Proper strainer baskets are clean and in place.
 15. Service and balance valves are open.
 16. Balancing dampers and devices are installed.
 17. Pressure/Temperature test fittings are installed on each pump.
- B Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory.
- C Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- D Examine system and equipment test reports.
- E Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

- F Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- G Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- H Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.
- I Examine strainers for clean screens and proper perforations.
- J Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- K Examine system pumps to ensure absence of entrained air in the suction piping.
- L Examine equipment for installation and for properly operating safety interlocks and controls.
- M Examine automatic temperature control and building automation system components to verify the following:
 - 1. Check the sequence of operation of control devices are according to the Contract Documents..
 - 2. Dampers, valves, and other controlled devices are operated by the intended controller.
 - 3. Dampers and valves are in the position indicated by the controller.
 - 4. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in variable-air-volume terminals.
 - 5. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
 - 6. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 - 7. Sensors are located to sense only the intended conditions.
 - 8. Controller set points are set at indicated values. Controllers are calibrated and commissioned. Record controller settings and note variances between set points and actual measurements.
 - 9. Changeover from heating to cooling mode occurs according to indicated values.
 - 10. Transmitter and controller locations and note conditions that would adversely affect control functions.
 - 11. Operation of limiting controllers (i.e., high- and low-temperature controllers).
 - 12. Free travel and proper operation of control devices such as damper and valve operators.
 - 13. Interaction of electrically operated switch transducers.
 - 14. Interaction of interlock and lockout systems.
 - 15. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
 - 16. Note operation of electric actuators using spring return for proper fail-safe operations.
- N Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.
- O Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

- A Hold a pre-balancing meeting at least one week prior to starting TAB work.
 - 1. Require attendance by all installers whose work will be tested, adjusted, or balanced.
- B Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect to facilitate spot checks during testing.

3.4 ADJUSTMENT TOLERANCES

- A Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply and return systems.
- B Outdoor and Exhaust Systems: Minimum shown on documents to plus 10 percent.
- C Air Outlets and Inlets: Adjust individual devices to within plus 10 percent and minus 5 percent of design to space.
- D Kitchen hood supply and exhaust: Minus 5 percent to plus 5 percent. Exhaust airflow shall exceed supply airflow.
- E Hydronic Systems: Adjust to within plus or minus 5 percent of design.

3.5 GENERAL PROCEDURES FOR TESTING AND BALANCING

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

3.6 RECORDING AND ADJUSTING

- A Field Logs: Maintain written logs including:
 - 1. Running log of events and issues.
 - 2. Discrepancies, deficient or uncompleted work by others.
 - 3. Contract interpretation requests.
 - 4. Lists of completed tests.

- B Ensure recorded data represents actual measured or observed conditions.
- C Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- D Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.
- E After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- F Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- G Check and adjust systems approximately six months after final acceptance and submit report.

3.7 AIR SYSTEM PROCEDURE

- A Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- B Check dampers for proper position to achieve desired airflow path.
- C Check for airflow blockages.
- D Check condensate drains for proper connections and functioning.
- E Check for proper sealing of air-handling unit components.
- F Check for proper sealing of air duct system.
- G Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- H Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- I Measure air quantities at air inlets and outlets.
- J Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- K Adjusting:
 - 1. After installation, adjust diffusers, registers, and grilles to air patterns indicated, as directed and as required to prevent drafts before starting air balancing.
 - 2. Adjust air patterns per manufactures recommendations based on installed conditions.

- L Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- M Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- N Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- O Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- P Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- Q Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- R Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
- S Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.
- T On fan powered terminal units, adjust air flow switches for proper operation.
- U On electric heating coils, adjust system to provide required minimum airflow or downstream pressure differential to activate controls.
- V Compensating for Diversity in Variable Volume Systems: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

3.8 PROCEDURES FOR TEMPERATURE MEASUREMENTS

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

3.9 SCOPE

- A Test, adjust, and balance the following:
 - 1. Electric Water Coolers.
 - 2. Plumbing Pumps.
 - 3. Domestic Hot Water thermal mixing valves
 - 4. Packaged Roof Top Heating/Cooling Units.
 - 5. Air Coils.
 - 6. Air Handling Units.
 - 7. Fans.
 - 8. Air Filters.
 - 9. Air Terminal Units.
 - 10. Air Inlets and Outlets.

3.10 MINIMUM DATA TO BE REPORTED

- A Electric Motors:
 - 1. Manufacturer.
 - 2. Model/Frame.
 - 3. HP/BHP.
 - 4. Phase, voltage, amperage; nameplate, actual, no load.
 - 5. RPM.
 - 6. Service factor.
 - 7. Starter size, rating, heater elements.
 - 8. Sheave Make/Size/Bore.
 - 9. Motors Driven by Variable-Frequency Controllers:
 - a. Test for proper operation at speeds varying from minimum to maximum.
 - b. Test the manual bypass for the controller to prove proper operation.
 - c. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.
- B V-Belt Drives:
 - 1. Identification/location.
 - 2. Required driven RPM.
 - 3. Driven sheave, diameter and RPM.
 - 4. Belt, size and quantity.
 - 5. Motor sheave diameter and RPM.
 - 6. Center to center distance, maximum, minimum, and actual.
- C Pumps:
 - 1. Identification/number.
 - 2. Manufacturer.
 - 3. Size/model.
 - 4. Impeller.
 - 5. Service.
 - 6. Design flow rate, pressure drop, BHP.
 - 7. Actual flow rate, pressure drop, BHP.
 - 8. Discharge pressure.

9. Suction pressure.
10. Total operating head pressure.
11. Shut off, discharge and suction pressures.
12. Shut off, total head pressure.

D Air Cooled Condensers:

1. Identification/number.
2. Location.
3. Manufacturer.
4. Model number.
5. Serial number.
6. Entering DB air temperature, design and actual.
7. Leaving DB air temperature, design and actual.
8. Number of compressors.

E Cooling Coils:

1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Air flow, design and actual.
6. Entering air DB temperature, design and actual.
7. Entering air WB temperature, design and actual.
8. Leaving air DB temperature, design and actual.
9. Leaving air WB temperature, design and actual.
10. Water flow, design and actual.
11. Water pressure drop, design and actual.
12. Entering water temperature, design and actual.
13. Leaving water temperature, design and actual.
14. Saturated suction temperature, design and actual.
15. Air pressure drop, design and actual.

F Heating Coils:

1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Air flow, design and actual.
6. Water flow, design and actual.
7. Water pressure drop, design and actual.
8. Entering water temperature, design and actual.
9. Leaving water temperature, design and actual.
10. Entering air temperature, design and actual.
11. Leaving air temperature, design and actual.
12. Air pressure drop, design and actual.

G Electric Heaters:

1. Manufacturer.

2. Identification/number.
3. Location.
4. Model number.
5. Design kW.
6. Number of stages.
7. Phase, voltage, amperage.
8. Test voltage (each phase).
9. Test amperage (each phase).
10. Air flow, specified and actual.
11. Temperature rise, specified and actual.

H Air-Handling Unit:

1. Unit identification.
2. Location.
3. Make and type.
4. Model number and unit size.
5. Manufacturer's serial number.
6. Unit arrangement and class.
7. Discharge arrangement.
8. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - g. Variable frequency controller position.
9. Total airflow rate in cfm.
10. Return air flow, specified and actual
11. Outside air flow, specified and actual
12. Total system static pressure in inches wg.
13. Fan rpm.
14. Discharge static pressure in inches wg.
15. Filter static-pressure differential in inches wg.
16. Outside-air damper position.
17. Return-air damper position.

I Supply and Return Fans:

1. Unit identification.
2. Location.
3. Manufacturer.
4. Model number.
5. Serial number.
6. Arrangement/Class/Discharge.
7. Air flow, specified and actual.
8. Return air flow, specified and actual.
9. Outside air flow, specified and actual.

10. Total static pressure (total external), specified and actual.
11. Inlet pressure.
12. Discharge pressure.
13. Sheave Make/Size/Bore.
14. Number of Belts/Make/Size.
15. Fan RPM.

J Return Air/Outside Air:

1. Identification/location.
2. Design air flow.
3. Actual air flow.
4. Design return air flow.
5. Actual return air flow.
6. Design outside air flow.
7. Actual outside air flow.
8. Return air temperature.
9. Outside air temperature.
10. Required mixed air temperature.
11. Actual mixed air temperature.
12. Design outside/return air ratio.
13. Actual outside/return air ratio.

K Exhaust Fans:

1. Location.
2. Manufacturer.
3. Model number.
4. Serial number.
5. Air flow, specified and actual.
6. Total static pressure (total external), specified and actual.
7. Inlet pressure.
8. Discharge pressure.
9. Sheave Make/Size/Bore.
10. Number of Belts/Make/Size.
11. Fan RPM.

L Duct Traverses:

1. System zone/branch.
2. Duct size.
3. Area.
4. Design velocity.
5. Design air flow.
6. Test velocity.
7. Test air flow.
8. Duct static pressure.
9. Air temperature.
10. Air correction factor.

M Air Monitoring Stations:

SVPA No. 25079

Iowa DAS – DOC 4JD CBC New Central Office Building
Council Bluffs, IA

TESTING, ADJUSTING, AND BALANCING
FOR HVAC
230593 - 14

1. Identification/location.
2. System.
3. Size.
4. Area.
5. Design velocity.
6. Design air flow.
7. Test velocity.
8. Test air flow.

N Flow Measuring Stations:

1. Identification/number.
2. Location.
3. Size.
4. Manufacturer.
5. Model number.
6. Serial number.
7. Design Flow rate.
8. Design pressure drop.
9. Actual/final pressure drop.
10. Actual/final flow rate.
11. Station calibrated setting.

O Air Terminal Unit Data:

1. Manufacturer.
2. Type, constant, variable, single, dual duct.
3. Identification/number.
4. Location.
5. Model number.
6. Size.
7. Minimum static pressure.
8. Minimum design air flow.
9. Maximum design air flow.
10. Maximum actual air flow.
11. Inlet static pressure.

P Air Distribution Tests:

1. Air terminal number.
2. Room number/location.
3. Terminal type.
4. Terminal size.
5. Area factor.
6. Design velocity.
7. Design air flow.
8. Test (final) velocity.
9. Test (final) air flow.
10. Percent of design air flow.

Q Instrument Calibration Reports:

SVPA No. 25079

Iowa DAS – DOC 4JD CBC New Central Office Building
Council Bluffs, IA

TESTING, ADJUSTING, AND BALANCING
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1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

R Control System Verification/Validation Reports

3.11 ADDITIONAL TESTS AND INSPECTIONS

- A Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.
- B Make an inspection in building during opposite season in which initial adjustments were made, and at that time make any necessary modifications to initial adjustment required to produce optimum operation of system components to produce proper conditions in each conditioned space. At time of opposite season checkout, Owner's representative shall be timely notified before any readings or adjustments.

END OF SECTION

SECTION 230713
DUCT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Duct insulation.
- B Duct liner.

1.2 REFERENCE STANDARDS

- A ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- B ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation.
- C ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
- D ASTM C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings; 2008.
- E ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- F ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.
- G ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- H SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
- I UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.3 SUBMITTALS

- A Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations. Show details for application of field-applied jackets.
- B Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

1.4 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section

- B Applicator Qualifications: Company specializing in performing the type of work specified in this section

1.5 DELIVERY, STORAGE, AND HANDLING

- A Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density, thickness, and appropriate ASTM standard designation.
- B Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.6 FIELD CONDITIONS

- A Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, UL 723, ASTM E84, or UL 723.
- B Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- C Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- D Insulation products shall not contain asbestos, lead, mercury, mercury compounds, or formaldehyde.
- E Products shall be certified by UL GREENGUARD GOLD or Indoor Advantage Gold.
- F Products shall certified to meet or exceed UL Standard 2818 -2013 Gold Standard for Chemical Emissions for Building Materials, Finishes and Furnishings
- G Provide insulation thickness based on 2018 International Energy Conservation Code minimum requirements.
- H Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

2.2 GLASS FIBER, FLEXIBLE

- A Manufacturer:
 - 1. CertainTeed Corporation: www.certainteed.com.
 - 2. Johns Manville Corporation; : www.jm.com.

3. JP Lamborn Co: www.jpflex.com.
4. Knauf Insulation: www.knaufinsulation.com.
5. Manson Insulation, Inc.: www.mansoninsulation.com
6. Owens Corning Corp; : www.owenscorning.com.
7. Or pre-approved equivalent.

B Vapor Barrier Jacket:

1. FSK: Kraft paper with glass fiber scrim yard and bonded to aluminized film; 0.0032 inch vinyl.
2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
3. Secure with pressure-sensitive tape.

C Vapor Barrier Tape:

1. Aluminized foil film, with pressure sensitive acrylic based adhesive, 3 inches wide, 6.5 mils thick, 58-ounce force/inch adhesion, 23 lbf/inch tensile strength. Service temperature -40 - 250 degree F.

2.3 GLASS FIBER, RIGID

A Manufacturer:

1. CertainTeed Corporation: www.certainteed.com.
2. Johns Manville Corporation; : www.jm.com.
3. Knauf Insulation: www.knaufinsulation.com.
4. Manson Insulation, Inc.: www.mansoninsulation.com
5. Owens Corning Corporation: www.ocbuildingspec.com.
6. Or pre-approved equivalent.

B Vapor Barrier Jacket:

1. FSK: Kraft paper with glass fiber scrim yard and bonded to aluminized film; 0.0032 inch vinyl.
2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
3. Secure with pressure-sensitive tape.

C Vapor Barrier Tape:

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive, 3 inches wide, 6.5 mils thick, 90-ounce force/inch adhesion, 40 lbf/inch tensile strength.

D Indoor Vapor Barrier Finish:

1. Manufacturers:
 - a. Fosters Model Vapor Out 30-33.
 - b. Childers Model Chil Out, CP-33.
 - c. Or pre-approved equivalent.
2. Cloth: Untreated; 9 oz/sq yd min. weight, glass fabric.
3. Vinyl emulsion type acrylic, compatible with insulation, white color.

4. Characteristics: 0.07 perm water-vapor permeance per ASTM E96, Procedure B at 45 mil dry film thickness; -20 degrees F to +180 degrees F temperature range; solid content, 55 percent by volume and 68 percent by weight per ASTM D 1644; white color.

2.4 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A Manufacturers:
1. Aeroflex USA, Inc: www.aeroflexusa.com.
 2. Armacell LLC: www.armacell.us.
 3. K-Flex USA LLC: www.kflexusa.com.
 4. Or pre-approved equivalent.
- B Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
1. Minimum Service Temperature: Minus 40 degrees F.
 2. Maximum Service Temperature: 180 degrees F.
 3. Connection: Waterproof vapor barrier adhesive.
- C Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.
- D Weather Barrier Coating: Air dried, contact adhesive, compatible with insulation and ASTM E84 compliant.

2.5 DUCT LINER

- A Manufacturers:
1. Aeroflex USA, Inc: www.aeroflexusa.com.
 2. Armacell LLC: www.armacell.us.
 3. CertainTeed Corporation: www.certainteed.com.
 4. Ductmate Industries, Inc, a DMI Company: www.ductmate.com.
 5. Johns Manville: www.jm.com.
 6. Owens Corning Corporation: www.ocbuildingspec.com.
 7. RBX Corporation.
 8. Or pre-approved equivalent.
- B Elastomeric Foam Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
1. Minimum Service Temperature: Minus 40 degrees F.
 2. Maximum Service Temperature: 180 degrees F.
 3. Fungal Resistance: No growth when tested according to ASTM G21.
 4. Apparent Thermal Conductivity: Maximum of 0.28 at 75 degrees F.
 5. Minimum Noise Reduction Coefficients:
 - a. 1/2 inch Thickness: 0.30.
 - b. 1 inch Thickness: 0.40.
 - c. 1-1/2 inches Thickness: 0.50.
 - d. 2 inch Thickness: 0.60.
 6. Erosion Resistance: Does not show evidence of breaking away, flaking off, or delamination at velocities of 10,000 fpm when tested in accordance with ASTM C1071.
 7. Connection: Waterproof vapor barrier adhesive.

8. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation. Comply with ASTM C916.
- C Polyester Fiber Insulation:
 1. Insulation: Non-corrosive, incombustible, thermally bonded, polyester fiber complying with ASTM C1071; rigid board; impregnated surface with FSK facing and edges coated water based coating.
 - a. Thickness: 1 inch.
 - b. Zero VOCs: ASTM D5116.
 - c. Fungi Resistance: ASTM G21.
 - d. Apparent Thermal Conductivity: Maximum of .24 at 75 degrees F.
 - e. Service Temperature: Up to 250 degrees F.
 - f. Rated Velocity on Coated Air Side for Air Erosion: 4000 fpm, minimum.
 - g. Minimum Noise Reduction Coefficients:
 - 1) 1/2 inch Thickness: 0.30.
 - 2) 1 inch Thickness: 0.45.
 - 3) 1-1/2 inches Thickness: 0.60.
 - 4) 2 inch Thickness: 0.70.
 2. Adhesive: Waterproof, fire-retardant type, ASTM C916.
 3. Liner Fasteners: Galvanized steel, self-adhesive pad with integral head.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install in accordance with NAIMA National Insulation Standards.
- C Insulated Ducts Conveying Air Below Ambient Temperature:
 1. Provide insulation with vapor barrier jackets, with minimum installed R-value of 6.0.
 2. Finish with tape and vapor barrier jacket.
 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 4. Insulate entire system, including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- D Insulated Ducts Conveying Air Above Ambient Temperature:
 1. Provide with or without standard vapor barrier jacket, with minimum installed R-value of 6.0.
 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- E Duct and Plenum Liner Application:
 1. Adhere insulation with adhesive for 100 percent coverage.
 2. Secure insulation with mechanical liner fasteners. Refer to SMACNA (DCS) for spacing.
 3. Seal and smooth joints. Seal and coat transverse joints.

4. Seal liner surface penetrations with adhesive.
5. Duct dimensions indicated are net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.
6. Lined ducts shall be fabricated to provide the net inside dimensions shown.
7. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
8. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
9. Butt transverse joints without gaps and coat joint with adhesive.
10. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
11. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
12. Apply adhesive coating on all longitudinal seams.
13. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.
14. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

3.3 DUCT INSULATION

- A Provide insulation thickness based on 2012 International Energy Conservation Code minimum requirements.
- B Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- C Items Not Insulated:
1. Fibrous-glass ducts.
 2. Metal ducts and plenums with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 3. Factory-insulated flexible ducts.
 4. Factory-insulated plenums and casings.
 5. Flexible connectors.
 6. Vibration-control devices.
 7. Factory-insulated access panels and doors.

3.4 INSULATION AND JACKET SCHEDULE

- A Duct Liner
1. Duct liner shall not be used on the following locations:
 - a. Ahead of any coil on all air distribution systems.

2. Transfer Ducts, Sound Traps and Boots and as indicated: 1-inch liner.
3. Terminal Units:
 - a. Supply Air: 1-inch liner 5 feet downstream.
4. Rooftop Units (Where liner provides insulation properties equal or exceeding duct wrap, duct wrap can be omitted for the portion of ductwork noted lined):
 - a. Supply Air: 2-inch liner 10 feet downstream, including one elbow.
 - b. Return Air: 2-inch liner 10 feet upstream, including one elbow.

B Indoor Duct and Plenum

1. Supply Air:
 - a. Concealed, supply-air duct insulation shall be any of the following:
 - 1) Glass-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.
 - b. Concealed, supply-air plenum insulation shall be any of the following:
 - 1) Flexible Elastomeric: 1 inch thick.
 - c. Exposed in Finished Space, rectangular, supply-air duct insulation shall be any of the following:
 - 1) Duct Liner: 1 inch thick.
 - d. Exposed in Finished Space, round or flat oval, supply-air duct insulation shall be any of the following:
 - 1) Duct Liner: 1 inch thick or double wall insulated duct as indicated.
 - e. Exposed in mechanical room, rectangular, supply-air duct insulation shall be any of the following:
 - 1) Glass-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.
 - f. Exposed in mechanical room, round or flat oval, supply-air duct insulation shall be any of the following:
 - 1) Glass-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.
 - g. Exposed in mechanical room, supply-air plenum shall be any of the following:
 - 1) Glass-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.
 - h. Supply Diffuser Plenums and Back Panels (Including Linear type):
 - 1) Glass-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.
2. Return Air:
 - a. None.
3. Exhaust Air:
 - a. Exhaust and Relief Ducts for a Distance of 36 Inches from Outside Wall/Roof:
 - 1) Glass fiber blanket, 1-1/2 inches thick nominal density.

END OF SECTION

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SECTION 230913.13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Control panels.
- B Unitary Controllers
- C Power Supplies and Transformers.
- D Low Voltage Control Cable.
- E Control Dampers.
- F Humidistats:
 - 1. Room humidistats.
- G Input/Output Sensors:
 - 1. Temperature sensors.
 - 2. Humidity sensors.
 - 3. Static pressure (air pressure) sensors.
- H Thermostats:
 - 1. Outdoor reset thermostats.
 - 2. Immersion thermostats.
 - 3. Airstream thermostats.
 - 4. Electric low limit duct thermostats.
 - 5. Electric high limit duct thermostats.
- I Transmitters:
 - 1. Building static pressure transmitters.
 - 2. Thermowells.
- J Output Devices.

1.2 REFERENCE STANDARDS

1.3 ADMINISTRATIVE REQUIREMENTS

- A Preinstallation Meeting: Conduct a preinstallation meeting one week before starting work of this section; require attendance by all affected installers.

1.4 SUBMITTALS

- A Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.
 - 1. Manufacturer's printed data sheets for all control system components clearly identify data by component.
 - 2. General catalog sheets, including details of construction, ratings, and dimensions for each component.
- B Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.
 - 1. Show complete details of interconnections between temperature control systems and control specified with equipment or systems.
 - 2. Provide dampers schedule indicating dimension and descriptions of blank-offs, installation location, arrangement, velocities, static pressure drop, damper features, identification, and part number.
 - 3. Control panel locations indicated on plans.
 - 4. Control panel interior layout drawings indicating the following:
 - a. Overall panel size.
 - b. Device locations and labeling within panel.
 - c. Spare and space locations.
 - d. Power supplies and transformers.
 - e. Wiring and cabling pathways.
 - 5. Clearly note the proposed deviations from specified sequences and equipment, and substantiate with written explanation.
- C Samples: Submit two of each type of room thermostat and cover.
- D Manufacturer's Instructions: Provide for all manufactured components.
- E Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.
- F Project Record and Closeout Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.
 - 1. Complete Index of Contents.
 - 2. Revise shop drawings to reflect actual installation and operating sequences.
 - 3. Red-mark "Record" control system drawings and then turn them over to the Owner's Representative.
 - 4. Provide directions for calibration, adjustment, and maintenance instructions for each type of component.
 - 5. Shop drawings of control system showing devices, interconnections between devices, and connections to items provided by others.
 - 6. Specifications data sheets on each device.

- G Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

- A Designer Qualifications: Design system under direct supervision of a Professional Engineer experienced in design of this work and licensed at the State in which the Project is located.
- B Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section.
- C Installer Qualifications: Company specializing in performing the work of this section.
- D Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.6 WARRANTY

- A Correct defective work within a one year period after Substantial Completion.

1.7 MAINTENANCE SERVICE

- A Provide service and maintenance of control system for two years from Date of Substantial Completion.
- B Provide complete service of controls systems, including call backs. Make minimum of 8 complete normal inspections of approximately 40 hours total duration in addition to normal service calls to inspect, calibrate, and adjust controls, and submit written reports.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A As indicated.
- B Or pre-approved equivalent.

2.2 EQUIPMENT - GENERAL

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

2.3 CONTROL PANELS

- A Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gages, pilot lights, push buttons and switches flush on cabinet panel face.
- B Provide common keying for all panels.

- C Control panels shall meet the following minimum requirements:
1. Outdoors: Control panels located outdoors shall comply with NEMA 3R or 4X requirements.
 - a. Other Locations: Control panels in other locations, including but not limited to occupied spaces, above ceilings, and plenum returns shall comply with NEMA 1 requirement.
 2. Provide panels of adequate size to accommodate instruments for future expansion of approximately 25% beyond space required for this scope of work.
 3. Cabling shall be terminated on rugged and easily accessible terminal strips. Each termination shall be clearly marked and shall be as detailed in the shop and record drawings.
 4. Panels mounted on vibrating equipment shall have vibration isolation protection that ensures their satisfactory operation.
- D Local Control Panels:
1. In general, the control panels shall consist of the controller(s), display module, and I/O devices - such as relays, transducers, and so forth - that are not required to be located external to the control panel due to function. The display module shall be flush mounted in the panel face unless otherwise noted.
 2. All I/O connections on the controller shall be extended to a numbered, color-coded, and labeled terminal strip for ease of maintenance and expansion. Wiring to I/O devices shall be made from this terminal strip.
 3. All other wiring in the panel, internal and external, shall be made to additional line or low-voltage, color-coded, and labeled terminal strips. Low and line voltage wiring shall be segregated. All terminal strips and wiring shall be UL listed, 300-volt service, and provide adequate clearance for field wiring.
 4. All wiring for every control panel shall follow a common color-coded format. All terminal strip color coding and numbering shall follow a common format. All wiring shall be neatly installed in plastic trays or tie-wrapped.
 5. A convenience 120 VAC duplex receptacle, fused on/off power switch, and required transformers shall be provided in each enclosure.

2.4 GENERAL FOR UNITARY CONTROLLERS FOR COOLING AND HEATING TERMINAL UNITS

- A Unitary Controllers (UC) shall be fully programmable controllers with operating sequences maintained in EEPROM or flash ROM. Customization of sequences of operation, operating parameters, control loop parameters, control constants, and schedules shall be changeable on-site by the subcontractor technician or Owner's representative. UC shall provide an interface via PIM to the field instrumentation and final control elements of the following types of equipment:
1. One terminal unit.
 2. Miscellaneous input monitoring.
- B All other types of equipment and systems shall be controlled by panels meeting the requirements of DCP.
- C Provide as part of the UC differential pressure transducers for the monitoring of the terminal unit primary air flowrate. The differential pressure transducer shall meet, at minimum, the requirements:
1. Monitor the differential pressures generated by a multi-point averaging device located in the primary air duct. The terminal unit manufacturer shall provide the multi-point averaging sensors. Coordinate with the terminal unit manufacturer for range of pressure differential.

- D The differential pressure sensors, where required for the equipment served, shall monitor the flowrates with an accuracy of + or - 5 percent with a the velocity pressure minimum of +/- 0.002 inch w.c. with a working pressure range of 0-2 inch w.c.. The BMCS subcontractor shall assist the Testing and Balancing subcontractor to calibrate each differential pressure sensor in the field following installation.
- E Provide a wall mounted space temperature sensor for the monitoring of each equipment/terminal unit space temperature.
 - 1. The pressure differential transducers shall be on the UC. The terminal unit manufacturer as part of the factory installation shall provide tubing from these sensors to the multi-point averaging devices.
 - 2. Provide a one-micron filter on the pressure differential sensor if it monitors a moving air stream.
 - 3. If an automatic calibration program requires the automatic zeroing of the flow sensor and transducer, provide a coordinated sequence of operation that ensures the associated AHU is not operating during the automatic calibration procedure.

2.5 UNITARY CONTROLLERS - COOLING AND HEATING AIR TERMINAL UNITS

- A Provide as part of the UC differential pressure transducers for the monitoring of the terminal unit primary air flowrate. The differential pressure transducer shall meet, at minimum, the requirements:
 - 1. Monitor the differential pressures generated by a multi-point averaging device located in the primary air duct. The terminal unit manufacturer shall provide the multi-point averaging sensors. Coordinate with the terminal unit manufacturer for range of pressure differential.
- B Local Keypad and Display for each Controller:
 - 1. Use for interrogating and editing data.
 - 2. The pressure differential transducers shall be on the UC. The terminal unit manufacturer as part of the factory installation shall provide tubing from these sensors to the multi-point averaging devices.
 - 3. System security password prevents unauthorized use.

2.6 POWER SUPPLIES AND TRANSFORMERS

- A The terminal unit manufacturer shall provide the following components for each fan powered terminal unit for interface and mounting of the UC:
 - 1. 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.
 - 2. Primary air dampers to be controlled by the UC.
 - 3. Input: 120 VAC +10 percent, 60 Hz.
 - 4. Output: 24 VDC.
 - 5. Enclosure to house the UC and associated components or suitable mounting brackets within the terminal unit enclosure.
 - 6. Multi-point averaging type flow sensor at the primary air inlet to the terminal unit.
 - 7. 24 VAC control transformer.
 - 8. 24 VAC contacts for each stage of electric heat.
 - 9. 0-10 Vdc fan flowrate and start/stop controller to the ECM motor.

10. Line Regulation: +0.05 percent for 10 percent line change.
11. Load Regulation: +0.05 percent for 50 percent load change.
12. Ripple and Noise: 1 mV rms, 5 mV peak to peak.
13. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
14. A power disconnect switch shall be provided next to the power supply.

B Transformers and Air Terminal Unit Power:

1. Input frequency of 50/60 Hz.
2. Internal circuit breaker.
3. Foot Mounted
4. Temperature range of 32 Deg. F. to 104 Deg. F.
5. Sized to provide volts and amps as required for connected load.
6. Input voltage shall be as required for the specific application.
7. Transformers shall be panel mounted:
 - a. Panels located in mechanical or electrical rooms shall comply with NEMA 4 requirements.
 - b. Panels in other locations, including but not limited to occupied spaces, above ceilings, and plenum returns shall comply with NEMA 1 requirement.
 - c. Transformers and UPS can occupy the same panel enclosure.
 - d. Transformer panels cannot contain other BMCS compoenets unless properly shielded.

C DDC Power Supply Panel with Transformers:

1. Transformer: 500 VA
2. Over Current Protection: Circuit Breaker
3. Primary: 480/277/240/120 VAC
4. Frequency: 50/60 Hz
5. Nominal Dimensions: 12" x 12" x 6"
6. Approvals: Class 2 (UL Approved UL5085-3), UL916, UL508, C-UL, CE, RoHS
7. Housing: NEMA1 Metal Enclosure, Plenum Rated
8. Weight: 30.16 lbs.
9. 5 Secondaries: 24 VAC, with LED Indicators
10. 24 VAC ON/OFF: On / Off Switch & Breaker
11. Input: 480/277/240/120 VAC, Finger-Safe Terminals
12. Output: 5 Isolated, Floating 100 VA Class 2 24 Vac Terminals
13. Ambient Temperature Derating: 4A up to 40 degrees C; 3A up to 50 degrees C ; 2A up to 55 degrees C (When All 5 Outputs Operated Simultaneously)
14. Standby Wattage: 48.5 W @ 120 VAC
15. Full Load Primary Current: 4.6 A @ 120 VAC
16. Basis of Design: Functional Devices, Inc. Model no.: PSH500A, Enclosed Power Supply. Or pre-approved equivalent.

D Uninterruptable Emergency Power Supplies (UPS):

1. Output:
 - a. Output Power Capacity: 1920 Watts / 1920 VA
 - b. Max Configurable Power: 1980 Watts / 2200 VA
 - c. Nominal Output Voltage: 120V
 - d. Output Voltage Distortion: Less than 5%

- e. Output Frequency (sync to mains): 50/60Hz +/- 3 Hz
- f. Topology: Line Interactive
- g. Waveform Type: Sine wave
- h. Output Connections: (8) NEMA 5-15R, (2) NEMA 5-20R
- 2. Input:
 - a. Nominal Input Voltage: 120V
 - b. Input Frequency: 50/60 Hz +/- 3 Hz (auto sensing)
 - c. Input Connections: NEMA 5-20P
 - d. Cord Length: 6 feet (1.83 meters)
 - e. Input voltage range for main operations: 82 - 144V
 - f. Input voltage adjustable range for mains operation: 75 - 154V
- 3. Batteries & Runtime:
 - a. Battery Type: Maintenance-free sealed Lead-Acid battery with suspended electrolyte : leakproof
 - b. Typical recharge time: 3 hour(s)
- 4. Energy Use/Efficiency:

<u>Load</u>	<u>Efficiency</u>
b. 25%	97.4%
c. 50%	98.2%
d. 75%	98.2%
e. 100%	98.1%
- 5. Communications & Management:
 - a. Interface Port(s): (1) SmartSlot
 - b. Control panel: Multi-function LCD status and control console
 - c. Audible Alarm: Alarm when on battery : distinctive low battery alarm : configurable delays
 - d. Emergency Power Off (EPO)
- 6. Surge Protection and Filtering:
 - a. Surge energy rating: 530 Joules
 - b. Filtering: Full time multi-pole noise filtering : 0.3% IEEE surge let-through : zero clamping response time : meets UL 1449
- 7. Environmental:
 - a. Operating Environment: 32 - 104 °F
 - b. Operating Relative Humidity: 0 - 95%
 - c. Operating Elevation: 0-10000 feet
 - d. Storage Temperature: 5 - 113 °F
 - e. Storage Relative Humidity: 0 - 95%
 - f. Storage Elevation: 0-50000 feet
 - g. Audible noise at 1 meter from surface of unit: 45.00 dBA
 - h. Online Thermal Dissipation: 275.00 BTU/h
- 8. Conformance:
 - a. Regulatory Approvals: CSA, ENERGY STAR (USA), FCC Part 15 Class A, UL 1778
 - b. Standard Warranty: 3 years repair or replace (excluding battery) and 2 year for battery, optional on-site warranties available, optional extended warranties available

2.7 LOW VOLTAGE CONTROL CABLE

- A All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable.
- B All wiring running exposed in air plenums shall be plenum cable.
- C Analog Input, Analog Output, Binary Input, Binary Output, 24 VAC, and General Purpose Cabling:
 - 1. Cable shall consist of copper conductors not less than #18 AWG stranded.
 - 2. Cable shall be two- or three-conductor twisted cable with a drain wire.
 - 3. Cable shall have a 100 percent overall shield.
 - 4. Cable shall be plenum rated.
 - 5. Cable shall meet or exceed NEC voltage rating of 300 volts.
 - 6. Cable shall be NEC type CMP.
 - 7. Cable shall meet or exceed UL temperature rating of +60 deg C.
 - 8. Cable shall be labeled at a minimum of every 18 inches with the DDC system manufacturer's name and the type of signal carried within the cable, i.e., analog input, analog output, binary input, binary output, 24 VAC.
- D Primary and Secondary Communications Network Cabling:
 - 1. Cable shall be of type recommended by the DDC system manufacturer.
 - 2. Cable shall be shielded.
 - 3. Cable shall be plenum rated.
 - 4. Cable shall meet or exceed NEC voltage rating of 150 volts.
 - 5. Cable shall meet or exceed UL temperature rating of +60 deg C.

2.8 CONTROL DAMPERS

- A Frames: Galvanized steel, welded or riveted with corner reinforcement, minimum 12 gage, 0.1046 inch.
- B Blades: Galvanized steel, maximum blade size 8 inches wide, 48 inches long, minimum 22 gage, 0.0299 inch, attached to minimum 1/2 inch shafts with set screws.
 - 1. Dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required.
 - 2. Dampers used for mixing of airstreams (OA & RA) shall be parallel blade type arranged for mixing, with blades directing the airstreams together.
 - 3. Multiple section dampers may be jack shafted to allow mounting of actuators. Each end of the jack shaft shall receive at least one actuator to reduce jack shaft twist.
 - 4. Airfoil blade dampers of double-skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 fpm or system pressure exceeds 2.5 inches w.c., but no more than 4000 fpm or 6 inches w.c.
- C Blade Seals: Synthetic elastomeric, inflatable, mechanically attached, field replaceable.
- D Jamb Seals: Spring stainless steel.

- E Shaft Bearings: Lubricant free, stainless steel, single row, ground, flanged, radial, antifriction type with extended inner race.
- F Linkage Bearings: Oil impregnated sintered bronze.
- G Leakage: Less than one percent based on approach velocity of 2000 ft per min and 4 inches wg.
- H Maximum Pressure Differential: 6 inches wg.
- I Temperature Limits: Minus 40 to 200 degrees F.
- J Blade Position Switch:
 - 1. Type: Damper-blade attached lever.

2.9 HUMIDISTATS

- A Room Humidistats:
 - 1. Wall mounted, proportioning type.
 - 2. Throttling Range: Adjustable 2 percent relative humidity.
 - 3. Operating Range: 30 to 80 percent.
 - 4. Maximum Temperature: 110 degrees F.
 - 5. Cover: Set point indication.

2.10 INPUT/OUTPUT SENSORS

- A Temperature Sensors:
 - 1. Use thermistor or RTD type temperature sensing elements with characteristics resistant to moisture, vibration, and other conditions consistent with the application without affecting accuracy and life expectancy.
 - 2. Construct RTD of nickel or platinum with base resistance of 1000 ohms at 70 degrees F.
 - 3. 100 ohm platinum RTD is acceptable if used with project DDC controllers.
 - 4. Temperature Sensing Device: Compatible with project DDC controllers.
 - 5. Performance Characteristics:
 - a. RTD:
 - 1) Room Sensor Accuracy: Plus/minus 0.50 degrees F minimum.
 - 2) Duct Averaging Accuracy: Plus/minus 0.50 degrees F minimum.
 - 3) Chilled Water Accuracy: Plus/minus 0.50 degrees F minimum.
 - 4) All Other Accuracy: Plus/minus 0.75 degrees F minimum.
 - 5) Range: Minus 40 degrees F through 220 degrees F minimum.
 - b. Thermistor:
 - 1) Accuracy (All): Plus/minus 0.36 degrees F minimum.
 - 2) Range: Minus 25 degrees F through 122 degrees F minimum.
 - 3) Heat Dissipation Constant: 2.7 mW per degree C.
 - c. Temperature Transmitter:
 - 1) Accuracy: 0.10 degree F minimum or plus/minus 0.20 percent of span.
 - 2) Output: 4 to 20 mA.
 - d. Sensing Range:

- 1) Provide limited range sensors if required to sense the range expected for a respective point.
- 2) Use RTD type sensors for extended ranges beyond minus 30 degrees F to 230 degrees F.
- 3) Use temperature transmitters in conjunction with RTD's when RTD's are incompatible with DDC controller direct temperature input.
- e. Wire Resistance:
 - 1) Use appropriate wire size to limit temperature offset due to wire resistance to 1.0 degree F or use temperature transmitter when offset is greater than 1.0 degree F due to wire resistance.
 - 2) Compensate for wire resistance in software input definition when feature is available in the DDC controller.
- f. Outside Air Sensors: Watertight inlet fitting shielded from direct rays of the sun.
 - 1) Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
 - 2) Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
- g. Immersion Temperature Sensors: A sensor encased in a corrosion-resistant probe with an indoor junction box service entry body.
- h. Ceiling and Recessed Mount Temperature Sensors: Ceiling-mounted sensor in a low-profile housing.
- i. Room Security Sensors: Stainless steel cover plate with insulated back and security screws.
- j. Room Temperature Sensors User Adjustment with Occupancy Override:
 - 1) Construct for surface or wall box.
 - 2) Manual occupancy override and indication of occupancy status.
- k. Duct Averaging Temperature Sensors:
 - 1) Application: Air handling applications where the coil or duct area is greater than 10 square feet, or the air is affected by stratification regardless of duct size. .
 - 2) The averaging sensor tube shall contain at least one thermistor for every 3 feet, with a minimum tube length of 6 feet.
 - 3) Provide sensor tube length to adequately cover the duct cross-sectional area. Multiple sensors shall be utilized as required to ensure a representative temperature reading in large ducts.
 - 4) Use on duct sensors for ductwork 10 sq ft or larger.
 - 5) Use averaging elements where prone to stratification with sensor length 8 ft or 16 ft.
 - 6) Provide for all mixed air and heating coil discharge sensors regardless of duct size.
 - 7) The averaging sensor shall be constructed of rigid or flexible copper tubing.
 - 8) Duct Mounted Averaging Sensor Requirements:
 - (a) Sensor Type: Thermistor.
 - (b) Accuracy: +/-2.7 °F at 77 °F.
 - (c) Operating Temperature: -13 to 221 °F.
 - (d) Sensor Tube Material: Copper.
- l. Insertion Elements:
 - 1) Use in ducts not affected by temperature stratification or smaller than 11 sq inches.

- 2) Provide dry type, insertion elements for liquids, installed in immersion wells, with minimum insertion length of 2.5 inches.
 - m. Duct Probe Temperature Sensors:
 - 1) Application: Air handling applications where the coil or duct area is less than 10 square feet, and the air is not affected by stratification.
 - 2) Sensor probe length shall be selected to provide the most representative reading from the sensed airstream.
 - 3) Duct Mounted Sensor Requirements:
 - (a) Sensor Type: Thermistor.
 - (b) Accuracy: ± 0.4 °F over a 32 to 158 °F range.
 - (c) Measurement Resolution: 0.1 °F.
 - (d) Enclosure Material: Stainless Steel.
 - n. Outside Air Temperature Sensor:
 - 1) The sensing element shall be fully encapsulated in potting material within a stainless-steel probe.
 - 2) Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure.
 - 3) Sensor Requirements:
 - (a) Operating range: -40 to 122 °F.
 - (b) Accuracy: ± 0.2 °F.
 - (c) Enclosure Material: ABS Plastic.
 - o. Insertion Elements:
 - 1) Use in ducts not affected by temperature stratification or smaller than 11 sq inches.
 - 2) Provide dry type, insertion elements for liquids, installed in immersion wells, with minimum insertion length of 2.5 inches.
- B Humidity Sensors:**
- 1. Duct Mounted Sensor: Voltage type encased in a die-cast metal, weather-proof housing.
 - a. Input Power, Voltage Type: Class 2; 12-30 VDC/24 VAC, 15mA max.
 - b. Input Power, mA Type: Class 2; Loop powered 12-30 VDC only, 30 mA max.
 - c. Output Voltage Type: 3-wire observed polarity.
 - d. Output mA Type: 2-wire, not polarity sensitive (clipped and capped).
 - e. Humidity:
 - 1) HS Element: Digitally profiled thin-film capacitive.
 - 2) Accuracy 1 percent at 10 to 80 percent relative humidity at 77 degrees F, multi-point calibration, NIST traceable.
 - (a) Plus/minus 1 percent at 20 to 40 percent RH in mA output mode; (multi-point calibration, NIST traceable).
 - 3) Scaling: 0 to 100 percent RH.
 - f. Temperature Effect:
 - 1) Duct Mounted: Plus/minus 0.18 percent per degree F.
 - 2) Outdoor Mounted: 4 to 20mA version: $(0.0013 \times \%RH \times (T_{\text{degreeC}} - 25))$.
 - g. Hysteresis: 1.5 percent typical.
 - h. Linearity: Included in accuracy specification.
 - i. Reset Rate: 24 hours.
 - j. Stability: Plus/minus 1 percent at 68 degrees F (20 degrees C) annually, for two years.
 - k. Temperature Monitoring:

- 1) Temperature Transmitter Output: Digital, 4 to 20mA (clipped and capped) or 0-5V/0-10V output.
 - (a) HO Transmitter Accuracy: Plus/minus 2.3 degrees F.
 - (b) HD Transmitter Accuracy: Plus/minus 1.0 degree F.
 - I. Operating Environment:
 - 1) Operating Humidity Range: 0 to 100 percent RH noncondensing.
 - 2) Operating Temperature Range: Minus 40 degrees F to 122 degrees F.
 2. Wall Mounted Sensor: Voltage type encased in a plastic housing.
- C Static Pressure (Air Pressure) Sensors:
1. Unidirectional with ranges not exceeding 150 percent of maximum expected input.
 2. Temperature compensate with typical thermal error or 0.06 percent of full scale in temperature range of 40 to 100 degrees F.
 3. Accuracy: One percent of full scale with repeatability 0.3 percent.
 4. Output: 0 to 5 vdc with power at 12 to 28 vdc.
- D Carbon Dioxide Sensors, Duct and Wall:
1. General: Provide non-dispersive infrared (NDIR), diffusion sampling CO2 sensors with integral transducers and linear output.
 2. Air Temperature: Range of 32 to 122 degrees F.
 3. Relative Humidity: Range of 0 to 95 percent (non-condensing).
 4. Power Input: Class 2; 12 to 30VDC or 24VAC 50/60 Hz; 100mA max.
 5. Calibration Characteristics:
 - a. Automatically compensating algorithm for sensor drift due to sensor degradation.
 - b. Maximum Drift: 2 percent.
 - c. User calibratable with a minimum calibration interval of 5 years.
 6. Construction:
 - a. Sensor Chamber: Non-corrosive material for neutral effect on carbon dioxide sample.
 - b. Provide duct mounted sensors with duct probe designed to protect sensing element from dust accumulation and mechanical damage.
 - c. Housing: High impact plastic.
- E Air Filter Status Sensor:
1. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for two amps at 120 VAC.
 2. A complete installation kit shall be provided, including static pressure tops, tubing, fittings, and air filters.
 3. Provide appropriate scale range and differential adjustment for intended service.
- F Air Pressure Safety Sensor:
1. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for two amps at 120 VAC.
 2. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.

2.11 THERMOSTATS

A Outdoor Reset Thermostats:

SVPA No. 25079

Iowa DAS – DOC 4JD CBC New Central Office Building
Council Bluffs, IA

INSTRUMENTATION AND CONTROL
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1. Remote bulb or bimetal rod and tube type, proportioning action with adjustable throttling range, adjustable setpoint.
 2. Scale range: Minus 10 to 70 degrees F.
- B Immersion Thermostats:
1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint and adjustable throttling range.
- C Airstream Thermostats:
1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint in middle of range and adjustable throttling range.
 2. Averaging service remote bulb element: 7.5 feet.
- D Electric Low Limit Duct Thermostats:
1. Snap acting, single pole, single throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint,
 2. Bulb length: Minimum 20 feet.
 3. Provide one thermostat for every 20 sq ft of coil surface.
 4. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.
- E Electric High Limit Duct Thermostats:
1. Snap acting, single pole, single throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above setpoint,
 2. Bulb length: Minimum 20 feet.
 3. Provide one thermostat for every 20 sq ft of coil surface.
 4. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

2.12 TRANSMITTERS

- A Building Static Pressure Transmitters:
1. One pipe, direct acting, double bell, scale range 0.01 to 6.0 inch wg positive or negative, and sensitivity of 0.0005 inch wg. Transmit electronic signal to receiver with matching scale range.
- B Thermowells:
1. When thermowells are required, the sensor and well shall be supplied as a complete assembly, including well head and Greenfield fitting.
 2. Thermowells shall be pressure rated and constructed in accordance with the system working pressure.
 3. Thermowells and sensors shall be mounted in a threadolet or 1/2-inch NPT saddle and allow easy access to the sensor for repair or replacement.
 4. Thermowells shall be constructed of brass.

2.13 OUTPUT DEVICES

- A Control Relays:
 - 1. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
 - 2. Mounting bases shall be snap mount.
 - 3. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
 - 4. Contacts shall be rated for 10 amps at 120 VAC.
 - 5. Relays shall have an integral indicator light and check button.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify existing conditions before starting work.
- B Verify that systems are ready to receive work.
- C Beginning of installation means installer accepts existing conditions.
- D Sequence work to ensure installation of components is complementary to installation of similar components in other systems.
- E Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
- F Ensure installation of components is complementary to installation of similar components.
- G Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

3.2 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Check and verify location of thermostats with plans and room details before installation. Locate 48 inches above floor. Align with lighting switches and humidistats. Refer to Section 262726.
- C Mount freeze protection thermostats using flanges and element holders.
- D Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
- E Provide separable sockets for liquids and flanges for air bulb elements.
- F Provide guards on thermostats in entrances. Coordinate style with owner.
- G Provide insulated mounting bases on thermostats and other temperature sensing devices in the following locations:
 - 1. Exterior walls.

2. Masonry/CMU walls.
 3. Interior walls that back up to mechanical/utility rooms and other non-conditioned spaces.
- H Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
- I Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.
- J Provide boxes, conduit and electrical wiring in accordance with Section 260583. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.
1. Provide boxes and conduit pathways (to ceiling spaces), for all wall mounted thermostats and sensors and wiring. Refer to Division 26.

3.3 CONTROL PANELS

- A Control panel for each system where more than one control device requires field mounting, (air handling units, exhaust fans, miscellaneous control systems including pump controls, heat exchanger controls, etc.). Single devices may be mounted on piping, wall or ductwork. Install local control panel where indicated on Drawings or suitable location adjacent to system served.
- B Mount panels on wall with suitable brackets or on self-supporting stand. Mount top of panels no higher than 6 ft above floor. Install panels so front cover door can swing fully open without interference.
- C Panels mounted on vibrating equipment shall have vibration isolation protection that ensures their satisfactory operation.
- D All control panels located in accessible areas be provided with keyed locks. Locks shall utilize a single master key. Provide 2 spare key sets to Owner.
- E Panel Layout:
1. Locate controllers in lower half of panel first and upper half second.
 2. Locate terminal strips either horizontally in upper half of back panel or vertically. Do not locate terminal strips below 2'-0" or above 6' above finished floor.
 3. Separate 24 VDC and 120 VAC, wire, cable, and devices by 6" minimum space.
 4. Enclose wire and cable in wireways or bundle w/ wire ties and secure to back-panel. This does not apply to wire exiting wireways to terminal strips or panel mounted devices.
 5. Space controllers according to manufacturer's requirements with 3" minimum between controllers and other devices on panel and 6" between controller front and door mounted devices. Ensure adequate space is allowed for device heat dissipation.

3.4 SENSORS AND INPUT/OUTPUT DEVICES

- A All input and output devices shall be installed per the manufacturer's recommendation.

- B Building Differential Air Pressure Applications: Transmitter's exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
 - 1. Unless indicated otherwise, locate the exterior sensing tip near the building's main entrance.
 - 2. The interior sensing tip shall be inconspicuous and located within a central corridor on the same level as the entrance.
- C Outside Air Humidity Sensors: Outside air relative humidity sensors shall be installed with a rain-proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with seal-tight fittings and stainless steel bushings.
- D Outside Air Sensors: Outside air sensors shall be mounted on the north wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air temperatures accurately. Sensors exposed to solar radiation must be installed with solar shields. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.
- E Low Temperature Limit Switches: Mount element horizontally across duct in a serpentine pattern ensuring each square foot of coil is protected by one foot of sensor. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
- F Duct Mount Sensors:
 - 1. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
 - 2. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
 - 3. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

3.5 ELECTRICAL WIRING

- A Install wiring in accordance with National Electric Code, ANSI/NFPA 70.
- B All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable. All wiring running exposed in air plenums shall be plenum cable.
- C Install wiring (low and line voltage) in metal raceways or conduit unless inside control cabinet or unit enclosures. For concealed and accessible areas, plenum-rated wiring and cabling may be used.
- D Class 2 wiring not installed in conduit shall be supported every five feet from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations.
- E Low voltage control wiring and 24 VAC can be run in the same conduit. Power wiring 120 VAC and greater must be in a separate conduit.

- F Fastening shall be secured to walls or ceilings by means of appropriate screws, expansion screws anchors, toggle bolts, hollow wall screw anchors, nylon expansion anchors, or expansion shields. All-purpose plastic anchors are not acceptable.
- G Locate circuits, relays, transformers, or other equipment that contains or must be connected to voltages exceeding 130 volts, in separate cabinets, which may be adjacent to control panels; permanently label "DANGER 277 VOLTS" or appropriate volts.
- H All wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size shall be 3/4 inch.

3.6 CONTROL WIRING AND POWER CONNECTIONS

- A Provide all incidental control power and wiring required to make the equipment or systems fully operational. Coordinate with equipment manufacture incidental wiring requirements.
- B Unless indicated elsewhere, provide line voltage, 120VAC, 20 amp dedicated control power circuits and LAN outlet to each of the following and as indicated:
 - 1. BMCS Control panel, 1 circuit.
 - 2. Rooftop Unit, 1 circuit.
 - 3. Fire/Domestic water pump room, 1 circuit.
 - 4. Main electrical room, 1 circuit.
 - 5. Air Terminal Unit Power supply transformer panel, 1 circuit per 20 terminal units.
 - 6. DDC Power supply and transformer panel. 1 circuit can power 30 terminal units.
 - 7. Coordinate required 120V power circuits and LAN outlets with Electrical Contractor.
- C Incidental control wiring includes but not limited to:
 - 1. Rooftop Units:
 - a. Fans
 - b. Damper Operators
 - c. Lights
 - d. Valve Operators
 - 2. Condensing Units
 - a. Provide 3/4 inch conduit with a minimum of eight distinctively colored or tagged #14 wires between units and remote panels or thermostats for control wiring
 - 3. HVAC Controls (Including but not limited to):
 - a. Manufacturer's Packaged Control Systems
 - b. Control Relays
 - c. Air Terminal Units
 - d. Control Dampers and Valves
 - e. Flow and BTU Meters
 - f. Current Sensors
 - g. Transmitters
 - 4. Loose Motor Starters
 - 5. Manual Multi-Speed Switches (Furnished as an Accessory to Mechanical Equipment)
 - 6. Packaged Rooftop Units
 - a. Provide 3/4 inch conduit with a minimum of eight distinctively colored or tagged #14 wires between units and remote panels or thermostats for control wiring

7. Pumps
8. Remote Monitoring and Control Panels (Provided by Equipment Manufacturers)
9. Supply, Return and Exhaust Fans
10. Temporary Heating/Cooling Equipment
11. Unit Mounted Motor Starters, Contactors, Disconnect Switches, Thermal Overloads and Heaters
12. Variable Frequency Controls.

3.7 START-UP SERVICES

- A Verify proper location of each device and point-to-point system integrity. Correct as needed.
- B When installation is complete and automatic control system is placed in operation, adjust and calibrate all instruments and devices in system and ensure that system is operating in accord with specified sequences.
- C Diagnose component and system problems. Communicate irregularities to the appropriate contractor for correction.
- D Attend construction meetings as required to coordinate with other contractors and provide input during problem resolution.

3.8 IDENTIFICATION STANDARDS

- A If the owner utilizes a specific equipment or system identification or naming convention, the contractor shall use for all systems, nameplates and equipment references in all project documentation.
- B Field Devices: All field devices shall be identified by a typed (not handwritten) securely attached tag label.
- C Controller Identification: All controllers shall be identified by typed (not handwritten) securely attached tag label.
- D Panel Identification: All local control panels shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.
- E Panel Devices: All panel devices shall be identified by a typed label securely fastened to the back plate of the local control panel.
- F Raceway Identification: All the covers to junction and pull boxes of the control system raceways shall be painted blue or have identification labels stating "Control System Wiring" affixed to the covers. Labels shall be typed, not handwritten.
- G Wire Identification: All low and line voltage control wiring shall be identified by a number or name, as referenced to the associated control diagram, at each end of the conductor cable. Identification number or name shall be permanently secured to the conductor or cable and shall be typed.

END OF SECTION

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SECTION 230923

BUILDING MANAGEMENT-DIRECT-DIGITAL CONTROL SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A System description.
- B Contractor Qualifications
- C Definitions
- D Work by Others
- E Control System Interfaces
- F Controllers.
- G Power supplies and line filtering.
- H System Architecture.
- I Enterprise Server and Operator Workstations (OIW)
- J General Administration and Programming Software.
- K Web-based Operator Software.
- L Network Building Controllers.
- M Fieldbus Controllers.
- N Power supplies and line filtering.
- O BMCS Installation Requirements.
- P BMCS Software Configuration and Programming Requirements.

1.2 SUMMARY

- A Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration, and installation for complete Building Management Control System (also identified as BMCS, Direct Digital Control (DDC) System For HVAC) including all necessary hardware and all operating and applications software as required for the complete performance of the Work, as shown on the Drawings, and as specified herein.

- B Related Sections: This Section includes the Building Management Control System (BMCS) control equipment for HVAC systems and components, including open protocol control components for terminal heating and cooling units. The complete specification has numerous sections that interface to this section. BMCS Contractor is to familiarize themselves with all of the Contract Documents. Related sections and subsections include, but shall not be limited to, the following:
1. 230913.13 Instrumentation and Control Devices for HVAC.
 2. 230993 Sequence of Operations for HVAC Controls.
 3. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
 4. Applicable general requirements for electrical Work specified within Division 26 Specification Sections apply to this Section.
- C Network level components of the system – workstations, servers, etc. shall communicate using the BACnet protocol, as defined by ASHRAE Standard 135-2004.
- D Except as otherwise noted, the control system shall consist of all necessary Ethernet Network Controllers, Standalone Digital Control Units, Room Controllers, workstations, software, sensors, transducers, relays, valves, dampers, damper operators, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system. Except as otherwise specified, provide operators for equipment such as dampers if the equipment manufacturer does not provide these. Coordinate requirements with the various Contractors.
- E The BMCS system supplier shall review and study all HVAC drawings and the entire specification to familiarize themselves with the equipment and system operation and to verify the quantities and types of dampers, operators, alarms, etc. to be provided.
- F All interlocking wiring, wiring and installation of control devices associated with the BMCS shall be provided under this Contract. When the BMCS system is fully installed and operational, the BMCS system supplier and representatives of the Owner will review and check out the system per System Acceptance and Testing section of this document. At that time, the BMCS system supplier shall demonstrate the operation of the system and prove that it complies with the intent of the drawings and specifications.
- G Provide services and manpower necessary for commissioning of the system in coordination with the HVAC Contractor, Balancing Contractor, and Owner's representative.

1.3 CONTRACTOR QUALIFICATIONS

- A The BMCS contractor shall:
1. Have been a factory-certified representative for the BMCS manufacturer for a minimum of five years for design, installation, and maintenance of the proposed systems.
 2. The BMCS contractor shall have a full-service facility within 100 miles of the project that is staffed with engineers trained and certified by the manufacturer in the configuration, programming, and service of the automation system. The contractor's technicians shall be fully capable of providing instructions and routine emergency maintenance service on all system components.
 3. The BMCS contractor shall have 24 hours/day, 7 days/week emergency service available.

4. Maintain local, or have approved local contracted access to, supplies of essential expendable parts.

1.4 WORK BY OTHERS

- A Cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others' work.
- B Furnish all Airflow Stations, Control Dampers, Control Valves, Flow Meters, Flow Switches, Refrigerant Pressure/Transducers, Sensor Wells as required by the Sequence of Operations and Points List for installation by the Mechanical Contractor.
- C Provide field supervision to the designated contractor for the installation of the following:
 1. Automatic control dampers.
 2. Blank-off plates for dampers that are smaller than duct size.
 3. Sheet metal baffles plates to eliminate stratification.
 4. Control valves, flow meters, flow switches, and sensor wells.
 5. The Electrical Contractor shall provide:
 - a. All 120VAC power wiring to motors, heat trace, junction boxes for power to BMCS panels.
 - b. Smoke detectors and wiring for the building fire alarm system. BMCS contractor to hardwire to fan shut down.
- D The water and natural gas meters will be furnished and installed by the Mechanical Contractor. The electric meters shall be provided by the Electrical Contractor. The BMCS contractor shall be responsible for connecting the meters to the BMCS to monitor real-time usage.

1.5 REFERENCE STANDARDS

- A General Code Compliance - The codes listed below form a part of this Specification to the extent referenced. The codes are referred to in the text by the basic designation only. The edition/revision of the referenced code shall be the latest date as of the date of the Contract Documents
- B ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks.
- C MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests.
- D NFPA 70 - National Electrical Code.
- E UL (DIR) - Online Certifications Directory.
- F All equipment or piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.

- G Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.
- H Provide BMCS components and ancillary equipment, which are UL-916 listed and labeled.

1.6 DEFINITIONS

- A Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.
- B Responsibilities
 - 1. Provide: Furnish, install, commission, test, and warrant.
 - 2. Furnish: Purchase and deliver to the appropriate installing Contractor, complete with every appurtenance, document, commission, and warranty.
- C General:
 - 1. ASHRAE: American Society Heating, Refrigeration, Air Conditioning Engineers
 - 2. AHU: Air Handling Unit.
 - 3. ATU: Air Terminal Unit.
 - 4. BACnet: Building Automation and Control Network
 - 5. BMCS: Building Management Control System
 - 6. BTL: BACnet Testing Laboratory
 - 7. CA: Certification Authority
 - 8. DDC: Direct Digital Control
 - 9. ESTCP: Environmental Security Technology Certification Program
 - 10. HVAC: Heating, Ventilation, and Air Conditioning
 - 11. I/O: Inputs/Outputs
 - 12. MER: Mechanical Equipment Room
 - 13. PICS: Protocol Implementation Conformance Statement
 - 14. PID: Proportional, Integral, Derivative
 - 15. RTC: Real Time Clock
 - 16. VAV: Variable Air Volume Box
- D Communication and protocols
 - 1. BACnet: Building Automation and Control Network
 - 2. FTT: Free Topology Transceivers
 - 3. HTTP: Hyper Text Transfer Protocol
 - 4. IP: Internet Protocol
 - 5. LAN: Local Area Network
 - 6. LON: Echelon Communication – Local Operating Network
 - 7. MS/TP: Master Slave Token Passing
 - 8. MQTT: Message Queuing Telemetry Transport
 - 9. RSTP: Rapid Spanning Tree Protocol
 - 10. SC: BACnet Secure Connect
 - 11. SMTP: Simple Mail Transfer Protocol Secure
 - 12. SQL: Structured Query Language
 - 13. TLS: Transport Layer Security

- E Controllers and Components
 1. B-AAC: BACnet Advanced Application Controller
 2. APW: Administration and Programming Workstation
 3. ASC: Application Specific Controller
 4. B-BC: BACnet Building Controller
 5. EPMS: Electrical Power Monitoring System
 6. HHD: Hand Held Device
 7. NBC: Network Building Controller
 8. SDCU: Standalone Digital Control Units
 9. WOW: Web-based Operator Workstation
- F Tools and software
 1. SIEM: System Information and Event Monitoring

1.7 SYSTEM DESCRIPTION

- A In accordance with the scope of work the system shall provide a graphical, web-based, operator interface that allows for instant access to any system through a standard browser. Provide PC-based programming workstations, operator workstations and microcomputer controllers of modular design providing distributed processing capability and allowing future expansion of both input/output points and processing/control functions.
- B For this project, the system shall consist of the following components:
 1. Enterprise Server: Enterprise Server hardware and software, and architecture. The enterprise server must be running the standard enterprise software developed and tested by the manufacturer of the workstation software, web-based operator workstations, Network Building Controllers and the standalone controllers supporting BACnet.
 - a. Provide Enterprise Server as required by specification or system architecture.
 2. Administration and Programming Workstations: Administration and Programming Workstation Operation hardware and software and architecture. These workstations must be running the standard workstation software developed and tested by the manufacturer of the Network Building Controllers and the standalone controllers. Workstations must conform to the B-OWS BACnet device profile.
 3. Web-Based Operator Workstations: Furnish licenses for web connection to the BMCS system. Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and shall be able to control setpoints and other parameters. All engineering work, such as trends, reports, graphics, etc. that are accomplished from the WorkStation shall be available for viewing through the web browser interface without additional changes. The web-based interface must conform to the B-OWS BACnet device profile. There will be no need for any additional computer-based hardware to support the web-based user interface and they shall operate on the facility intranet with no connection to the internet.
 4. Ethernet-based Network Building Controllers: The BMCS system supplier shall furnish the needed quantity of Ethernet-based Network Building Controllers (NBCs). There shall be a minimum of one Network Building Controller located in each building on the campus. These controllers will connect directly to the Operator Workstations and BMCS server over an Ethernet Facility network at a minimum of 100 mbps and provide communication to the Standalone Digital Control Units and/or other Input/Output Modules. Network Building

- Controllers shall conform to BACnet device profile B-BC. Network Controllers shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Building Controllers (B-BC).
5. Fieldbus Controllers: Provide the necessary quantity and types of Standalone Digital Control Units (SDCUs) to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment. Each BACnet protocol SDCU shall conform to the BACnet device profile B-AAC. BACnet SDCUs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Advanced Application Controllers (B-AAC).
 6. Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation of Mechanical Equipment Room (MER) valves and dampers and electronic actuation of terminal equipment valves and actuators as specified in Section 230913.13 in order to perform the sequence of operation specified in Section 230993.
- C The system shall enable an open architecture that utilizes ANSI / ASHRAE™ Standard 135-2004, BACnet functionality to assure interoperability between all system components. Native support for the BACnet, LonTalk, Modbus protocols, and WebServices shall be provided.
 - D Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans and are required to meet the functional intent, shall be provided without additional cost.
 - E All inputs and outputs associated with a required sequence of operation for a piece of mechanical equipment shall reside on a single controller such that failure of any one BMCS controller shall not have an impact on more than one controlled system.

1.8 CONTROL SYSTEM INTERFACES

- A System shall fully support a multi-vendor environment and be able to interface and integrate third party systems via vendor protocols including, as a minimum, BACnet, LonTalk and Modbus.
- B The BMCS contractor shall coordinate with all contractors and the associated manufacturers responsible for the systems and shall determine the points that are to be mapped from the BMCS to the third party system and the points that are to be mapped from the third party system to the BMCS.
- C Control Interface Coordination Meeting(s):
 1. The BMCS contractor shall meet with the contractors, equipment suppliers, manufacturers, etc. furnishing the equipment to coordinate information details and functions between the equipment and BMCS. Each contractor/supplier shall provide complete details of the proposed interface including the PICS (Protocol Implementation Conformance Statement) for BACnet equipment, hardware and software identifiers, wiring requirements, communication speeds and required network accessories.
 2. The purpose of this meeting is to ensure that there are no unresolved issues regarding the integration of equipment into the BMCS network and final coordination of all Sequences of Operation.
 3. The meeting(s) shall include the Owner's Representative and Commissioning Authority.
 4. Submittals for this equipment will not be reviewed prior to the completion of these meetings.

- D System and Equipment to BMCS Interfaces shall be provided for, but not limited to:
1. Manufacturer's packaged system control panels.
 2. Packaged Unitary Equipment.
 3. Plumbing Pumps.
 4. Variable Frequency Controllers.
 5. Roof-Top Units.
 6. Split system condensing units and indoor units
 7. Outdoor air quality and wind sensor.
 8. As an example, the BMCS shall interface to the systems via the following:
 - a. HVAC equipment variable frequency controllers (VFC).
 - 1) Method: Variable frequency controllers shall interface with the BMCS utilizing BACnet IP.
 - 2) Connection Point: The variable frequency controllers shall be connected to the BMCS via a BACnet IP subnetwork connected to a Network Building Controller.
 - 3) Connection Location: VFC's shall be connected to the same Network Building Controller as is used to control the other aspects of the related equipment or system associated with the VFC.
 - b. Outdoor air quality and wind sensor.
 - 1) Method: The outdoor air quality sensor and wind shall transfer data to the BMCS via a BACnet MS/TP and Modbus MS/TP connections.
 - 2) Connection Point: The outdoor air quality and wind sensor shall be connected to a subnetwork of the Network Building Controller.
 - 3) Connection Location: Network Building Controller.
- E Where it is possible to map points from one system to the other that are not identified in these Contract Documents, the BMCS contractor shall advise the Owner, Consultant, and Engineer; and they shall determine whether additional points are to be mapped from one system to the other.
- F Provide mapping, alarm configuration, and graphic creation of, at minimum, twice the listed point quantities within these documents and as directed by the Owner.
- G Provide details of the method of integration and the information to be transferred between the systems as part of the shop drawing package.
- H Equipment manufacturer/contractor shall provide communication port specifically for the interfacing of the system to the BMCS.
- I The BMCS contractor shall be responsible for all cable, conduit, and suitable cable connectors to the port on the system and the BMCS and other components as necessary for the software communications link from the system to the BMCS.
- J The fact that the points are mapped from systems to the BMCS shall be transparent to the operator. It shall not be necessary for the BMCS operator to know that the points are mapped from another system in order to implement such functions as adding and deleting a mapped point on a report/graphic, adjusting schedules and alarm limits associated with a mapped point, including a mapped point in a sequence of operations, etc.

- K If the BMCS contractor cannot document that the exact same interface has been performed between the BMCS and the systems, then the interfaces shall be tested prior to installations at an offsite location. If the test is successful, the BMCS contractor shall advise the Owner and Engineer and a time shall be established that is acceptable to the Owner and Engineer when the interface can be demonstrated.
- L The BMCS hardware shall not be installed at the project location until all system interfaces to the BMCS have been successfully demonstrated or documented.
- M Contractor shall be responsible for providing all equipment necessary to perform the demonstration and for ensuring the presence at the testing of suitably skilled personnel from system manufacturer/contractor. The testing of the interface between the two systems shall verify, at minimum, that:
1. All data points mapped from the system to the BMCS are displayed correctly on the BMCS monitor and have the same functionality as points directly monitored/controlled by the BMCS.
 2. All data points mapped from the BMCS to the system are displayed correctly on the systems monitor.
 3. All mapped points are identical with regard to value, engineering units, and significant digits on both systems.
 4. All points mapped from the system to the BMCS meet all of the specifications detailed in the contract documents for points directly monitored/controlled by the BMCS.
 5. The communications watchdog is functioning correctly.
 6. Communications speed between the two systems is satisfactory.
 7. Both systems restart and communications between the two systems resume following a power failure without operator intervention.
- N Site tests similar to those detailed above shall be repeated as part of the final acceptance testing.
- O Documentation regarding the BMCS software interfaces shall be provided in sufficient detail as to enable a person reasonably skilled in the writing of real time software applications to add/delete points mapped from one system to the other. At minimum, the documentation shall include a detailed description of each protocol used and the model, version, and firmware details of any protocol converter (gateway) that is used.
- P A watchdog procedure must be implemented that enables the identification of the point of failure, i.e., where in the communications chain between the two systems did the failure occur. The watchdog function must operate at a frequency that detects a failure within 60 seconds.

1.9 SUBMITTALS

- A Shop drawings and product data shall be in original searchable PDF format.
- B Product data shall be presented according to an included table of contents.
- C Product Data: Provide data for each system component and software module. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification.

D Shop Drawings:

1. Indicate trunk cable schematic showing programmable control unit locations, and trunk data conductors.
2. List connected data points, including connected control unit and input device.
3. Include a BMCS network riser diagram depicting locations of all controllers, workstations, servers, and connected 3rd party devices with associated network wiring.
4. Include individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typical drawings will be allowed where appropriate.
5. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software.
6. All components and controllers inclusive or 3rd party shall have a points list for each. Deviation from contract documents shall be reported to design team with alternates and/or a reason for deviation.
7. Control drawings shall have a completed system architecture. Controllers and components inclusive to the control system as well as 3rd party controllers and components to be integrated and/or communicated with.
8. Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations. Provide demonstration digital media containing graphics.
9. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
10. Indicate description and sequence of operation of operating, user, and application software.

E Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.

1. Installation data sheet for each component.
2. Installation design details for each I/O device.

F Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.

1. Record actual locations of control components, including control units, thermostats, and sensors.
2. Revise shop drawings to reflect actual installation and operating sequences.
3. Include submittals data in final "Record Documents" form.
4. All wiring pathways, connections, junctions, transformers, etc. shall be as-built of a floor plan drawings and included with record drawings.
5. The following is a list of post construction submittals that shall be updated to reflect any changes during construction and re-submitted as "As-Built".
 - a. System architecture drawing.
 - b. Layout drawing for each control panel.
 - c. Wiring diagram for individual components.
 - d. System flow diagram for each controlled system.
 - e. Instrumentation list for each controlled system.
 - f. Product data sheet for each component.
 - g. Valve, damper and air flow station schedules indicating the size, configuration, capacity and location of all equipment.

- h. Sequence of control.
 - i. Binding map.
 - j. A matrix sheet detailing all system addresses and communication settings for the following:
 - 1) All IP network addresses & settings.
 - 2) All BMCS device addresses & communication settings.
 - k. Licenses, guarantees, and warranty documents for equipment and systems.
 - l. Operation and Maintenance Manuals.
- G Operation and Maintenance Data:
- 1. Include interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
 - 2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
 - 3. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 - 4. Provide product manuals for the key software tasks including, but not limited to:
 - a. Operating the system.
 - b. Adminstrating the system.
 - c. Engineering the operator workstation.
 - d. Application programming.
 - e. Engineering the network.
 - f. Setting up the web server.
 - g. Report creation.
 - h. Graphics creation.
 - i. All other engineering tasks.
 - 5. List of recommended maintenance tasks associated with the system servers, operator workstations, data servers, web servers, controllers, instrumentation, and web clients including the following.
 - a. Define the task.
 - b. Recommend a frequency for system maintenance tasks.
 - c. Reference the product manual that includes instructions on executing the task.
 - 6. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
 - 7. Licenses, guarantees, and warranty documents for equipment and systems.
 - 8. Provide the owner with a copy of the following:
 - a. Software installed on the servers and workstations.
 - b. All licensing information for all software installed on the servers and workstations.
 - c. Software used to execute the project even if the software was not installed on the servers and workstations.
 - d. All licensing information for all of the software used to execute the project.
 - e. Software revisions shall be as installed at the time of the system acceptance.
 - f. Firmware files that were downloaded to or pre-installed on any devices installed as part of this project. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
 - g. Application files that were created during the execution of the project.
 - h. Graphic page files created during execution of the project.

- H Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.10 QUALITY ASSURANCE

- A Perform work in accordance with NFPA 70.
- B Manufacturer Qualifications: Company specializing in manufacturing products specified in this section.
- C Installer Qualifications: Company specializing in performing work of the type specified.
- D Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for purpose specified and indicated.
- E Comply with ASHRAE 135 for DDC system control components. BTL listed.
- F Security Standards and Reference Guides:
1. The BMCS system manufacturer shall meet the following criteria.
 - a. Certified to Security Development Lifecycle process that is certified to IEC 62443-4-1 by a reputable third-party independent lab.
 - b. Subjected to regular and verifiable best practice cyber security testing. Results of this testing shall be made available upon request prior to deployment of the system.
 - c. Provide cyber security service incident escalation through a help desk on a 7/24/365 basis.
 2. The BMCS system must provide the following functionality.
 - a. Support configuration for inactivity auto log-off of logged clients
 - b. Support Self-Signed Certificates, Default Certificates and/or Certification Authority (CA) certificates.
 - c. Allow configuration in disabling all devices and software that support HTTP and require access via HTTPS.
 - d. Alarm or generate notification on failed access attempts
 - e. Servers shall support SNMP V3 monitoring of network performance and stack statistics for the purpose of managing denial of service attacks.
 - f. Support the feature to alarm on a predetermined period of time until the default password for each device is changed from the default factory setting.
 - g. Support encrypted password authentication for all web services whether serving or consuming.
 - h. Have the capability to use blacklisted and whitelisted IPs/MAC addresses to gate access.
 - i. Have the capability to differentiate, limit or enable user access depending on Client's IP address/range (where) and time of day (when) the user is accessing the system.
 3. Reference Guides
 - a. Transport Layer Security (TLS) TLS 1.3 (August 2018).
 - b. Environmental Security Technology Certification Program (ESTCP) Cybersecurity Guidelines.
 - c. Security in Internet-Connected Building Automation and Energy Management System.

1.11 WARRANTY

- A All components, system software, and parts furnished and installed by the BMCS system supplier shall be guaranteed against defects in materials and workmanship for 2 years of substantial completion. Labor to repair, reprogram, or replace these components shall be furnished by the BMCS system supplier at no charge during normal working hours during the warranty period. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks.
- B The Contractor shall respond to the owner's request for warranty service within 24 standard working hours.
- C Provide five year manufacturer's warranty for field programmable micro-processor based units.

1.12 MAINTENANCE SERVICE

- A Provide service and maintenance of the BMCS for two years from Date of Substantial Completion to include the following:
 - 1. Provide complete service of systems, including call backs.
 - 2. Conduct a minimum of two (2) complete normal inspections per year, one in cooling season and one in heating season, to inspect, calibrate, and adjust controls as required with each inspection being approximately 16 hours in duration, in addition to normal service calls to inspect, calibrate, and adjust controls, and submit written reports.
 - 3. During the performance of maintenance service the BMCS contractor shall utilize the onsite workstation to perform all service related activities. The connection of BMCS contractor owned or other devices to the network will not be allowed during system configuration or maintenance.

1.13 PROTECTION OF SOFTWARE RIGHTS

- A The Owner shall retain licenses to software for this project.
- B The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition off this contract. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software. The software license agreement shall have provisions for the following:
 - 1. Limiting use of software to equipment provided under these specifications.
 - 2. Limiting copying.
 - 3. Preserving confidentiality.
 - 4. Prohibiting transfer to a third party.
- C The licensing agreement shall not preclude the use of the software by individuals under contract to the owner for commissioning, servicing or altering the system in the future. Use of the software by individuals under contract to the owner shall be restricted to use on the owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.

- D All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:
1. Server and workstation software.
 2. Application programming tools.
 3. Configuration tools.
 4. Network diagnostic tools.
 5. Addressing tools.
 6. Application files.
 7. Configuration files.
 8. Graphic files.
 9. Report files.
 10. Graphic symbol libraries.
 11. All documentation.

1.14 COORDINATION

- A Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
- B Coordinate equipment from other divisions including to achieve compatibility with equipment that interfaces with those systems.
- C Coordinate supply of conditioned electrical circuits for control units, server, and operator workstations.
- D Coordinate with the Facility local area network supplier the required locations for BMCS connections to the Facility local area network.
- E Coordinate with the Owner's Representative on locations for NBC's, Ethernet communication cabling and TCP/IP.
- F Coordinate with the Owner's Representative on requirements for Enterprise Server hardware, Administration and Programming Workstation hardware, and Web-based Operator Workstation hardware to be used in conjunction with the BMCS.
1. Provide Enterprise Server as required by specification or system architecture.
- G Coordinate with the Owner's Representative on requirements for hand held mobile devices to be used in conjunction with the BMCS.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Subject to compliance with requirements, provide products by one of the following prequalified Building Automation Manufacturers:
1. Automated Logic: WebCTRL Building Automation System
 2. Distech Controls
 3. Honeywell: Honeywell Building Management System

4. Johnson Controls, Inc.: Metasys Building Automation System
5. Schneider Electric: EcoStruxure Building Automation Systems.
6. Siemens Industry, Inc.: Siemens Building Automation System
7. Tridium Niagara Open Automation Solutions.
8. Or pre-approved equivalent.

2.2 SYSTEM DESCRIPTION

- A Automatic temperature control field monitoring and control system using field programmable micro-processor based units.
- B Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
- C Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.
- D Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units. Individual terminal unit control is specified in the Instrumentation and Control Devices for HVAC Section.
- E Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
- F Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.
- G BMCS Contractor shall be responsible for all electrical work associated with the BMCS.
 1. Perform all wiring in accordance with all local and national codes.
 2. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the division 26 specifications, NEC and local building code.
 3. Provide extension of 120 volt, 20 amp circuits and circuit breakers from Emergency power panels for all BMCS equipment, transformers and panel power. Provide and install local UPS Power supply for all BMCS system panels and equipment.
 4. Surge transient protection shall be incorporated in design of system to protect electrical components in all BMCS Controllers and operator's workstations.
 5. All low voltage electrical control wiring throughout the building whether in exposed areas shall be run in conduit in accordance with the division 26 specifications, local building code and the NEC.
 6. Provide all miscellaneous field device mounting and interconnecting wiring for all mechanical systems including fuel oil system, emergency generators, chillers, water treatment, AC units, condensing units, expansion tanks, VFD, unit heaters, filtration systems, terminal units, fan coil units, electric heater's, chiller control system.
 7. All systems requiring interlock wiring shall be hardwired interlocked and shall not rely on the BMCS to operate (e.g. emergency generator to fuel oil pump interlock, emergency

generator damper interlock, etc.) Interlock wiring shall be run in separate conduits from BMCS associated wiring.

2.3 SYSTEM ARCHITECTURE

- A The Building Automation System shall consist of an Enterprise Server, Administration and Programming Workstations (APWs), Web-based Operator Workstations (WOWs), Automated Fault Detection and Diagnostics (AFDD) system, Network Building Controllers (NBCs), and a family of Standalone Digital Control Units (SDCUs). The BMCS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility.
 - 1. Provide Enterprise Server as required by specification or system architecture.
- B All graphics, alarms, schedules, trends, programming, and configuration are to be accessible from a single Workstation simultaneously for operations and engineering tasks.
- C The Enterprise Level BMCS shall support the following:
 - 1. Built-in reporting functionality.
 - 2. Standard accessing of data for third-party reporting or analytics software.
 - 3. The ability to host sufficient Network Building Controllers beneath it to fulfill the requirements of this project with the capability to support an additional 20% spare.
- D The system shall be designed to operate on a top-level Ethernet network using the BACnet/IP protocol.
- E The BMCS shall support BACnet Secure Connect (SC) node, hub and router functions as defined in the Annex AB of ANSI/ASHRAE Standard 135-2020
- F Support for BACnet IP, BACnet MS/TP, Modbus RTU/ASCII (and J-bus), Modbus TCP, BACnet MS/TP, BACnet IP, LonTalk FTT-10A, and WebServices shall be provided at each Network Building Controller location including all required software ready for current and future connection.
- G A sub-network of SDCUs using the BACnet IP protocol shall connect the local, stand-alone controllers with Ethernet-level Network Building Controllers. BMCS contractor shall provide and install all sub-networks for SDCUs including Ethernet cable and required switches.
- H All inputs and outputs associated with a required sequence of operation for a piece of mechanical equipment shall reside on a single controller such that failure of any one BMCS controller shall not have an impact on more than one controlled system.
- I The SDCU BACnet IP sub-network shall utilize Rapid Spanning Tree Protocol (RSTP) network protocol installed in a ring configuration.
- J All NBCs, Workstation(s) and Servers shall reside directly on the Ethernet TCP/IP LAN OT Network.
- K System Expansion

1. The BMCS shall be scalable and expandable at all levels of the system using the same software interface, and the same TCP/IP level and fieldbus level controllers.
2. The system shall be able to operate normally and without restriction at multiple software version levels with the only requirement that each element of the hierarchy be at least as new a version as the newest version in the level below it.
3. Design the system such that it has the following future expansion capabilities:
 - a. Each control panel enclosure should be sized to support the necessary components required for this project with ample space to add 20% additional components in the future.
 - b. Any software license that is regulated by the number of attached I/O or system variables should be provided to support a minimum of 30% additional I/O and system variables.
 - c. An adequate number of Network Building Controllers should be provided such that each NBC can support the addition of an additional 20% future sub-network controllers.

2.4 GENERAL ADMINISTRATION AND PROGRAMMING SOFTWARE

- A The General Administration and Programming Software shall include all software required to service, program, create graphics, and define alarms in a user interface accessible by the owner.
- B The operator workstation portion of the BMCS shall consist of full-powered configuration and programming workstations, and web-based operator workstations. For this project provide a minimum of twelve (12) client licenses at the enterprise level. Client licenses shall be configurable for variable designations of the users choosing including operator, engineering, or web capabilities.
- C The programming and configuration workstation software shall allow any user with adequate permission to create and/or modify any or all parts of the NBC and/or Enterprise Server database.
- D The application software shall be capable of communication to all Network Building Controllers and shall feature high-resolution color graphics, alarming, trend charting. It shall be user configurable for all data collection and data presentation functions.
- E Physical Workstations shall reside on the Ethernet network. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations since the changes are accomplished to the databases within the NBC.
- F System architecture shall be truly client server in that the Workstation shall operate as the client while the NBCs shall operate as the servers. The client is responsible for the data presentation and validation of inputs while the server is responsible for data gathering and delivery.
- G The workstation functions shall include monitoring and programming of all DDC controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.
- H Programming of SDCUs shall be capable of being done either off-line or on-line from any operator workstation. All information will be available in graphic or text displays stored at the NBC. Graphic displays will feature animation effects to enhance the presentation of the data, to alert operators

of problems, and to facilitate location of information throughout the DDC system. All operator functions shall be selectable through a mouse.

I User Interface

1. The BMCS workstation software shall allow the creation of a custom, browser-style interface linked to the user when logging into any workstation. It shall also be possible to create customized workspaces that can be assigned to user groups.
2. The user interface shall support the creation of hot-spots that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software.
3. The BMCS user interface must be able to be configured to become a user's PC Desktop with all the links that a user needs to run other applications enabling the system administrator to setup workstation accounts that not only limit the capabilities of the user within the BMCS software, but may also limit what a user can do on the PC and/or LAN.
4. Webstations shall have the capability to automatically re-direct to an HTTPS connection to ensure more secure communications.
5. Personalized layouts and panels within workstations shall be extended to webstations to ensure consistent user experiences between the two user interfaces.
6. Webstations shall give the user similar capabilities within the graphics pages as are given within the workstation.
7. Workstation shall indicate at all times the communication status between it and the server.
8. The BMCS web interface shall enable presentation mode whereby any functionality for interactivity shall be disabled.
9. The BMCS web interface shall automatically respond and adapt to different screen sizes and orientations from smart phone to smart televisions of any size.
10. The BMCS web interface shall support full screen mode displaying Alarm views / graphics / dashboards / Custom Reports.

J User Access and Permissions

1. The BMCS system shall allow for creation of one account per user.
2. The BMCS shall support Groups where User Accounts associated with the group can inherit group permissions.
3. The BMCS shall be able to specify each user account or user group accessibility at granularity of "Object Property" level.
4. The BMCS shall be able to report on the permission level across account / group for review / archiving / audit.
5. This username/password combination shall be linked to a set of capabilities within the software, set and editable only by user with system administrator privileges. The sets of capabilities shall include: Edit or View only, Acknowledge alarms, Enable/disable Program and Change Values.
6. The BMCS shall support integration with Windows Active Directory for user log on credentials.
7. The BMCS shall support Single Sign On via SAML 2.0 Authentication scheme over HTTPS enabling secure navigation across multiple systems without the need to login
8. The BMCS shall support configurable reminder for "Days until password expires".
9. The BMCS shall support configurable password policy across the following.
 - a. Minimum number of characters

- b. Minimum number of lowercase characters
 - c. Minimum number of numeric characters
 - d. Minimum number of special characters
 - e. Number of consecutive unique passwords before reuse
 - f. No more than three repeating identical characters
10. The BMCS user account management shall support password policy with the following components.
- a. Mandatory change of password at first logon with default credentials
 - b. Disabling of all imported user accounts by default
 - c. Custom password complexity rules and its enforcement
 - d. Custom password reuse and its enforcement
 - e. Configurable black listing of passwords to limit the use of common known passwords (e.g. password)
 - f. Password aging rules
11. The BMCS shall be capable of enabling an anonymous access (guest account) to previously engineered views such as dashboards, graphics, etc. with configurable permissions and without username or password.
12. It shall be possible to configure the BMCS system so that the guest account is used by default to simplify presentation of Kiosk Mode across multiple screens
13. The BMCS shall provide time configurability to logout the user and to revert to a preconfigured presentation view, such as offered by the Guest account functionality.
14. The BMCS shall provide configurability in managing access and permission levels based on location, IP addresses and address ranges, Schedule and Time of day and combination thereof.
15. The BMCS Shall support option of disabling batch operation (Multi Alarm Acknowledgement) on Alarms to force operator to analyze and act on each alarm individually.

K Configuration Interface

- 1. The workstation software shall use a familiar Windows Explorer style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a “network map” of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions.
- 2. The configuration interface shall also include support for user defined object types. These object types shall be used as building blocks for the creation of the BMCS database. They shall be created from the base object types within the system input, output, string variables, setpoints, etc., alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of user defined object types shall be able to be set up as a predefined aggregate of systems and subsystems. The configuration interface shall support copying/pasting and exporting/importing portions of the database. The system shall also maintain a link to all “child” objects created.

L Color Graphic Displays

- 1. The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain

- point information from the database including any attributes associated with the point (engineering units, etc.).
2. Operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.
 3. Requirements of the color graphic subsystem include the following.
 - a. The user shall have the ability to import .gif, .png, .bmp, .jpeg, .tif, and CAD generated picture files as background displays, and layering shall be possible.
 - b. The system shall support HTML5 enabled graphics.
 - c. The graphics editor shall support the use JavaScript to customize the behavior of each graphic.
 - d. Software shall have a built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, and graphs which can be “dropped” on a graphic. These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels.
 - e. Support for high DPI icons shall be included and automatically chosen if viewing on a high definition display such as Retina or 4K displays.
 - f. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
 - g. Status changes or alarm conditions shall be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
 - h. Graphic displays shall be linked through user defined objects, alarm testing, or the result of a mathematical expression. Operators shall be able to change from one graphic to another by selecting an object with a mouse.
 - i. It shall be possible to create and save graphical components and JavaScript code in reusable and transferrable, customized libraries.
 - j. Graphics should rescale based on whatever monitor or viewing device is being used.
 - k. Support the creation of graphics on varying layers that can be moved and repeated.
 - l. Support the creation of graphics within varying window panes that can be moved and/or re-referenced.
 - m. Provide the ability to create re-usable cascading menus.
 - n. Provide the ability to have multiple instances of a graphic and edit one instance to change all.
 4. The Graphics Editor portion of the Engineering Software shall provide the following capabilities:
 - a. Create and save pages.
 - b. Group and ungroup symbols.
 - c. Modify an existing symbol.
 - d. Modify an existing graphic page.
 - e. Rotate and mirror a symbol.
 - f. Place a symbol on a page.
 - g. Place analog dynamic data in decimal format on a page.
 - h. Place binary dynamic data using state descriptors on a page.
 - i. Create motion through the use of animated .gif files or JavaScript.
 - j. Place test mode indication on a page.
 - k. Place manual mode indication on a page.
 - l. Place links using a fixed symbol or flyover on a page.
 - m. Links to other graphics.

- n. Links to web sites.
 - o. Links to notes.
 - p. Links to time schedules.
 - q. Links to any .exe file on the operator work station.
 - r. Links to .doc files.
 - s. Assign a background color.
 - t. Assign a foreground color.
 - u. Place alarm indicators on a page.
 - v. Change symbol/text/value color as a function of an analog variable.
 - w. Change a symbol/text/value color as a function of a binary state.
 - x. Change symbol/text/value as a function of a binary state.
- M The software shall allow for the automatic collection of data and reporting from any controller or NBC. The frequency of data collection shall be user-configurable.
- N Alarm Management
- 1. The software shall be capable of accepting alarms directly from NBCs or controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm shall be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.
 - 2. Alarm management features shall include the following.
 - a. A minimum of 1000 alarm notification levels at the NBC, workstation, and webstation levels.
 - b. Each notification level shall establish a unique set of parameters for controlling alarm display, distribution, acknowledgment, keyboard annunciation, and record keeping.
 - c. At the Enterprise level the minimum number of active and viewable alarms shall be 10,000.
 - d. It shall be possible for the user to sort, filter and search on any available criteria such as priority, category, origin, alarm type, etc.
 - e. An active alarm viewer shall be included which can be customized for each user or user type to a hide or display any alarm attributes.
 - f. It shall be possible to present alarms with configurable colors based on priority, category, origin, alarm type, etc.
 - g. It shall be possible to linking files/documents/hyperlinks/navigation links/graphics link to an alarm for easy access upon occurrence.
 - h. Automatic logging in the database of the alarm message, point name, point value, source device, timestamp of alarm, username and time of acknowledgement, username and time of alarm silence.
 - i. Alarm notifications shall support multiple distribution methods within one notification.
 - j. On alarm, it shall be possible to notify via email to a preconfigured list of recipients through a Simple Mail Transfer Protocol (SMTP) or secure email using Simple Mail Transfer Protocol Secure (SMTPS). The email notification shall be able to be sent to an individual user or a user group.
 - k. On alarm, it shall be possible to notify via SNMP

- l. On alarm, it shall be possible to notify via file (on disk) that would be consumable by other alarm management services
- m. An operator shall have the capability to assign an alarm to another user of the system.
- n. Individual alarms shall be able to be assigned to a user automatically via a preconfigured list of users and date/time.
- o. Playing an audible sound on alarm initiation or return to normal.
- p. It shall be possible assigning a custom audio sound to each alarm / alarm-criteria (priority, category, origin, alarm type, etc.)
- q. The active alarm viewer can be configured such that an operator must confirm that all of the steps in a check list have been accomplished prior to acknowledging the alarm.
- r. The active alarm viewer shall, if filtered, show the quantity of visible and total number of alarms that are not equal to 'normal' and the quantity of disabled and hidden alarms.
- s. The alarm viewer can be configured to auto hide alarms when triggered.
- t. An operator shall have the capability to save and apply alarm favorites.
- u. Alarms shall be configurable such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms.
- v. Alarms shall be configurable such that an operator must type in text in an alarm entry and/or pick from a drop-down list of causes for certain alarms.
- w. It shall be possible to configure user-actions via user/group permissions when responding to an alarm
- x. All operator actions responding to an alarm shall be audit trailed.

O Reporting

- 1. The BMCS Software and Network Servers shall have built-in reporting capability.
- 2. The system shall be capable of generating custom reports manually, via schedule, alarm triggered, or custom conditions.
- 3. The Custom Reporting shall have the capability of reporting on the full range of available data, most recent to historical data.
- 4. It shall be possible to generate reports containing current active alarms.
- 5. The BMCS software shall be capable of producing custom reports in txt, xlxs and pdf file formats.
- 6. The Custom Report capability at the BMCS software shall support digital signing of pdf for traceability and authenticity.

P Dashboards

- 1. Dashboards shall provide rapid identification of real-time and historical trends, including energy use, operational efficiencies and critical metrics.
- 2. System shall allow for dashboard view customization and selection of data points via the web browser and without any tools or prior training.
- 3. A basic set of dashboard components shall be provided as part of the project. At a minimum, the following dashboard components functionality shall be provided for the Owner's use.
 - a. Resource Utilization
 - 1) The system shall graphically illustrate comparative consumption of a resource (like energy) over a flexible time period.
 - 2) The information is ordered by metered location and multiple locations may be plotted on the same columnar chart for clear analysis and comparison.
 - b. Utility Performance Index

- 1) The system shall graphically illustrate one or more Key Performance Index (KPI) charts for comparisons of resource utilization efficiencies for multiple systems or subsystems.
- c. Real time Gauges
- d. Historical Gauges
- e. Period over Period Comparison
4. Custom dashboard components shall be able to present any information from the BMCS (e.g. system health data, alarms, trends, events, user access, etc.)
5. The BMCS shall allow creation of customized dashboard components.
6. The BMCS shall be configured to contain preconfigured visual dashboards for BMCS Alarms and Events that enables interactive visualization, analysis and supporting organizational KPIs. There shall be pre-configured visual dashboard elements available to the user including the following.
 - a. Interactive Alarms and Events Sankey Chart with drill down capability across Category, origin: Server/Controller, Priority, Types, assigned vs unassigned, Status and user activity, and Assignment.
 - b. Historical Alarm Count widget that shows how number of alarms have evolved overtime
 - c. Interactive Pie Chart for alarms and events to illustrate proportion of user defined attribute vs all the total alarm/events in the system for a user defined timeline.
 - d. Interactive Pareto Chart enables focusing on the higher impact alarms and events depending on the occurrence.
 - e. Tracking of Alarms, Event KPIs, and Alarm Counts, filtered by different parts of the system and/or areas of the building.

Q Scheduling

1. The BMCS shall support the capability to configure and download schedules for any of the controllers on the network.
2. Time of day schedules shall be in a calendar style and viewable in both a graphical and tabular view.
3. Schedules shall be programmable for a minimum of one year in advance.
4. To change the schedule for a particular day, a user shall simply select the day and make the desired modifications.
5. Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.
6. It shall be possible to assign a lead schedule such that shadow/local schedules are updated based upon changes in the Lead.
7. It shall be possible to assign a list(s) of exception event days, dates, date ranges to a schedule.
8. It shall be possible to view combined views showing the calendar and all prioritized exemptions.
9. Values should be able to be controlled directly from a schedule, without the need for special program logic.

R Programmer's Environment

1. Programming of the NBC shall be available offline from system prior to deployment into the field.

2. The programmer's environment will include access to a superset of the same programming language supported in the SDCUs.
3. It shall be possible to save custom programs as libraries for reuse throughout the system. A tool shall be available for loading programs from a library file in the program editor.
4. The system shall be capable of creating 'custom types'. These types can be created within the programming environment, graphics, or as full controller 'templates' that can be pushed to any other variable pertaining to it to allow for singular reference to multiple objects.
5. It shall be possible to view graphical programming live and real-time from a Workstation.
6. Applications should be able to be assigned different priorities and cycle times for a prioritized execution of different function.
7. The system shall be able to create objects that allow common objects such as power meters, VFD drives, etc. to be integrated into the system with simple import actions without the need of custom programming or configuration setups

S Saving/Reloading

1. The workstation software shall have an application to save and restore NBC and field controller memory files.

T Audit Trail

1. The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.
2. It shall be possible to view a history of alarms, user actions, and commands for any system object individually or at least the last 5,000 records of all events for the entire system from Workstation.
3. The Enterprise server shall be able to store up to 5 million events.
4. The event view shall support viewing of up to 100,000 events.
5. It shall be possible to save custom filtered views of event information that are viewable and configurable in Workstation.
6. It shall be capable to search and view all forced values within the system.

U Fault Tolerant Enterprise Server Operation

1. A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.

2.5 WEB-BASED BMCS OPERATOR SOFTWARE

- A** Web-based Operator Workstations shall provide the ability for the BMCS to support communication to a user interface device running only a standard web browser connected to the BMCS Local Area Network either physically or through Wi-Fi, without the need for additional software running on the device. There shall not be a requirement to connect to the internet for this capability.
- B** The web-based operator software shall be accessible to anyone with proper logon credentials either physically connected onsite or connected by WIFI onsite to the BMCS LAN to interact with the system through a standard web browser interface to perform functions as defined by their

predefined level of access. Physical and Wi-Fi connection points shall be as detailed in the Electrical specifications and contract documents.

- C The system shall be able to be accessed on site via a handheld device such as a PDA, Smart Phone, or tablet with browser agnostic connectivity, including viewing graphics, monitoring points and alarms, and control devices. Based on the user's level of access, the following functionality shall be available, but not limited to, via a handheld device.
 - 1. Setpoint adjustment.
 - 2. Alarm acknowledgement.
 - 3. Scheduling.
 - 4. Summary information.
 - 5. Trends.
 - 6. High level security access to override every controllable point for troubleshooting and diagnostics.
- D Day-to-day operation of the system shall be accessible through a standard web browser interface running on a desktop computer, allowing technicians, operators, and occupants to view any part of the system from anywhere on the network based on their access level.
- E User level of access for the web-based operator software shall be the same level of access they are permitted at a Configuration and Programming Workstation.
- F Through the browser interface, operators must be able to view pre-defined groups of points, with their values updated automatically.
- G The BMCS System and NBCs shall support Message Queuing Telemetry Transport (MQTT) subscribe and publish capability.
- H The BMCS shall support tagging of data following a globally recognized schema that can be both human and machine interpretable.
- I Graphic Displays: The browser-based interface shall share the same graphical displays as the Administration and Programming Workstation, presenting dynamic data on site layouts, floor plans, and equipment graphics. The functionality of the web-based graphics will include, but are not limited to, the following:
 - 1. Support commands to change setpoints, enable/disable equipment and start/stop equipment.
 - 2. Operators shall be able to navigate through the entire system and change the value or status of any point in any controller.
- J Dashboards: Provide built-in dashboards that enable customizable views of live data which can be public to all users or capable of making them specific to a user based on log in credentials. Dashboards shall have the following functionality:
 - 1. The user shall have the ability to create custom dashboards.
 - 2. The dashboards shall have a kiosk mode which allows for occupant level data display on monitors or tablets throughout the building.
- K Alarm Management:

1. No additional client software shall be required to be installed on a desktop workstation or handheld device in order to view alarms.
 2. Through the browser interface, a live alarm viewer identical to the alarm viewer on the Administration and Programming workstation shall be presented to the user.
- L Groups and Schedules:
1. Operators shall be able to view pre-defined groups of points, with their values updated automatically.
 2. Operators shall be able to change schedules and modify calendars.
- M User Accounts and Audit Trail:
1. The same user accounts shall be used for the browser interface and for the operator workstations.
 2. All commands and user activity through the browser interface shall be recorded in the BMCS activity log.
- N Web Services:
1. The installed system shall be able to use consume information via SOAP and REST web services within the Network Building Controllers (NBCs) with other products and systems

2.6 NETWORK BUILDING CONTROLLERS AND PANELS

- A Provide BMCS Network building Control and Panels as follows:
1. Minimum one (1) BMCS system Primary DDC panel and controller per floor. The application specific controllers installed for the terminal units on a floor will be connected to the BMCS panel on the same floor.
 2. Minimum one (1) BMCS system Primary DDC panel per each major mechanical system:
 - a. Rooftop Unit
 3. It shall be acceptable to combine up to three (3) of the following mechanical equipment into one (1) Primary DDC panel:
 - a. Exhaust Fans
 4. It is acceptable to wire the following systems into any of the Primary DDC panels:
 - a. Miscellaneous alarm monitoring (i.e. ATS, leak, temperature, light ...etc.)
 - b. Miscellaneous equipment (i.e. Unit Heater, Domestic Water Heater, Standalone Dampers ...etc.)
 5. Motors in motor control centers shall be controlled from the DDC controller associated with HVAC system. It shall not be acceptable to control all motors in a MCC from one DDC controller dedicated to the MCC. The intent of this specification is that the loss of any one DDC controller shall not affect the operation of other HVAC systems, only for the points connected to the DDC controller.
- B The Network Building Controllers (NBCs) shall support BACnet Secure Connect (SC) node, hub and router functions as defined in the Annex AB of ANSI/ASHRAE Standard 135-2020
- C Network Building Controllers shall combine network routing functions, control functions, and server functions into a single unit.

- D The BACnet NBC shall be classified as a native BACnet device, supporting the BACnet Network Building Controller (B-BC) profile. NBCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Network Building Controllers (B-BC).
- E The Network Building Controllers shall provide the interface between the LAN and the fieldbus control devices, and provide global supervisory control functions over the control devices connected to the NBC.
- F The NBCs shall be capable of whitelisting IPs to restrict access to a pre-defined list of hosts or devices, and whitelisting of the extensions for documents.
- G Encrypted and authenticated communication shall be configurable for non-open protocol communications using TLS 1.3.
- H The NBCs shall support Simple Network Management Protocol version 3 (SNMPv3) for monitoring of the NBCs using a Network Management Tool.
- I The NBCs shall support remote system logging for used by System Information and Event Monitoring (SIEM) software.
- J Network Building Controllers shall be responsible for monitoring and controlling their own connected HVAC equipment.
- K Each NBC shall contain graphics, trends, trend charts, alarm views, and other similar presentation objects that can be served to workstations or web-based interfaces. A sufficient number of NBCs shall be supplied to fully meet the requirements of this specification and the point list indicated in Specification Section 23 09 93.
- L NBCs shall be capable of executing application control programs to provide the following.
 - 1. Calendar functions
 - 2. Scheduling
 - 3. Trending
 - 4. Alarm monitoring and routing
 - 5. Time synchronization
 - 6. Native integration of controller data for BACnet, Modbus, and LonWorks
 - 7. Network Management functions for all LonWorks based devices
- M Hardware Specifications
 - 1. The operating system of the controller, application programs, and all other portions of the configuration database, shall be stored in non-volatile, FLASH memory. Network Building Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.
 - 2. Each NBC shall provide the following on-board hardware for communication:
 - a. Two 10/100b Ethernet for communication to Workstations, other NBCs, and IP field bus controllers.
 - 1) The two Ethernet ports shall support active switch and BACnet/IP communication protocols.
 - 2) Support IPv4 addressing

- 3) One of the Ethernet ports shall support static or DHCP client configuration for communication to Workstation or other NBCs
- 4) The other Ethernet port shall support switch mode or DHCP server to set addressing of DHCP client devices
- 5) Where a switch is needed, use a Cisco 9000 Catalyst or IE switch, EtherWAN EX63402-01B, or other equal and approved equivalent.
- 6) Two RS-485 ports for communication to BACnet MSTP bus or serial Modbus (software configurable).
- 7) One TP/FT port for communication to LonWorks devices.
- 8) One device USB port
- 9) One host USB port

N Hardware Override Switches:

1. All digital outputs shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall provide feedback to the controller so that the position of the override switch can be obtained through software. Each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

O Inputs and Outputs

1. Universal inputs directly connected to the NBC via I/O modules shall be capable of supporting the following input types.
 - a. Industry standard thermistor temperature sensors
 - b. Industry standard RTD temperature sensors
 - c. Analog sensing input devices utilizing varying voltage and/or current signals
 - d. Digital input devices
2. The NBC shall support analog and digital outputs directly connected to the Network Building Controller via I/O modules.

P Local Status Indicator Lamps:

1. The NBC shall have as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each input or output, provide LED indication of the value of the point (On/Off).

Q Real Time Clock (RTC):

1. Each NBC shall include a real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. Each NBC will allow for its own UTC offset, depending upon the time zone. When the time zone is set, the NBC will also store the appropriate times for daylight savings time.

R Power Supply:

1. The 24 VDC power supply for the NBCs shall provide ample available power for the NBC and associated IO modules.

S Automatic Restart After Power Failure:

1. Upon restoration of power after an outage, the NBC shall automatically and without human intervention update all monitored functions, resume operation based on current, synchronize time and status, and implement special start-up strategies as required.
- T Data Retention:
1. During a power failure, the NBC shall retain all programs, configuration data, historical data, and all other data that is configured to be retained. There shall be no time restriction for this retention.
- U Software Specifications
1. The operating system of the controller, application programs, and all other portions of the configuration database such as graphics, trends, alarms, views, etc., shall be stored in non-volatile, FLASH memory. Each NBC shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.
 2. Each NBC shall have adequate memory capacity to support application and historical data retention and backup storage.
- V User Programming Language:
1. The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be fully programmable by the user.
- W Control Software:
1. The NBC shall have the ability to perform the following pre-tested control algorithms:
 - a. Proportional, Integral plus Derivative Control (PID)
 - b. Two Position Control
 - c. Digital Filter
 - d. Ratio Calculator
 - e. Equipment Cycling Protection
- X Mathematical Functions:
1. Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc.
- Y NBCs shall have the ability to perform any or all of the following energy management routines.
1. Time of Day Scheduling
 2. Calendar Based Scheduling
 3. Holiday Scheduling
 4. Temporary Schedule Overrides
 5. Optimal Start
 6. Optimal Stop
 7. Night Setback Control
 8. Enthalpy Switchover (Economizer)

9. Peak Demand Limiting
10. Temperature Compensated Duty Cycling
11. CFM Tracking
12. Heating/Cooling Interlock

Z History Logging:

1. Each NBC controller shall be capable of locally logging any input, output, calculated value or other system variable either over user defined time intervals or based upon a user configurable change of value. A minimum of 2000 pieces of sampled data for each variable assigned to this feature. Recall of data shall be in either a tabular form or in a graphical form and shall be displayed at the OIW. It shall be possible to concurrently output data for a minimum of three variables. The time period to be covered by the data output shall be selected by the operator using an interactive procedure. When the storage capacity for a variable is full the newly sampled data shall over-write the data stored for that variable for the longest period of time. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logged data shall be downloadable to a higher level NBC long term archiving based upon user-defined time intervals, or manual command.
2. The operator shall be able to assign on-line, using an interactive procedure, any BMCS input or output point, calculated variable or setpoint to the historical data trend facility. It shall be possible to have data collection and storage concurrently, at minimum, for one thousand variables.
3. For extended trend logging a minimum of 1500 trends shall be capable, with a minimum number of 600,000 records within.
4. Storage shall be limited at the associated controller to 50 pieces of sampled data. All additional storage shall reside at the NDS.
5. Every hardware input and output point, hosted within the NBC and attached I/O modules, shall be trended automatically without the requirement for manual user creation, and each of these logs shall log values based upon a change of value and store at least 500 trend samples before replacing the oldest sample with new data.
6. Each variable shall be sampled at an operator-defined frequency using an interactive procedure. The sampling frequencies shall be in the following ranges at minimum:
 - a. For BMCS monitored points the sample rate shall range from one second to once per day.
7. The presentation of logged data can be in time stamped list formats or in a chart format with fully configurable pen colors, weights, scales and time spans.
 - a. For BMCS outputs the sample rate shall range from one second to once per day.
 - b. For calculated points the sample rate shall be in the range of the calculation rate to once per day.
 - c. Setpoints shall be sampled at the same rate as their associated variable.
8. Comments shall be visible whenever viewing the trend log list.
9. System shall give indication of memory usage and be able to alert the user if too many logs are allocated.
10. The BMCS software and Network Servers shall support recording of all historical data, independent of any limitation in its local memory, which will be readily available for reporting and analysis without additional configurations or actions.
11. All historical data shall be available for use by the operator to access in BMCS or a third-party reporting systems.

AA Alarm Management:

1. For each system point, alarms can be created based on high/low limits or in comparison to other point values. All alarms will be tested each scan of the NBC and can result in the display of one or more alarm messages or reports.
2. Alarms can be configured to be generated based upon a single system condition or multiple system conditions.
3. Alarms will be generated based on an evaluation of the alarm conditions and can be presented to the user in a fully configurable order, by priority, by time, by category, etc. These configurable alarm views will be presented to a user upon logging into the system regardless of whether the log in takes place at a WorkStation or a Webstation.
4. The alarm management system shall support the ability to create and select cause and action notes to be selected and associated with an alarm event. Checklists shall also be possible in order to present to an operator a suggested mode of troubleshooting. When acknowledging an alarm, it shall be possible to assign it to a user of the system such that the user is notified of the assignment and is made responsible for the alarm resolution.
5. Alarms must be capable of being routed to any BACnet workstation that conforms to the B-OWS device profile and uses the BACnet/IP protocol.

BB Embedded Web Server

1. Each NBC must have the ability to serve out web pages containing the same information that is available from the WorkStation without any additional engineering labor.
2. The NBC shall be configurable to logging all Embedded Web Server access attempts.
3. The NBC shall have the option to redirect HTTP based Embedded Web Server connections to secure, HTTPS connections.
4. The NBC shall authenticate and authorize all users connecting to the Embedded Web Server.
5. The NBC shall provide to ability to configure an automatic logoff for Embedded Web Server users that have not had any activity for an adjustable time period.

CC Network Building Controllers shall be certified for smoke control and smoke management within a fully IP control solution.**DD Building and Application Specific Controllers:**

1. Anticipated Environmental Ambient Conditions:
 - a. Outdoors and/or in Wet Ambient Conditions:
 - 1) Mount within waterproof enclosures.
 - 2) Rated for operation at -20 F to 150 F degrees F.
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F.

EE Fieldbus Controllers:

1. Fieldbus controllers shall reside on a Ethernet sub-network below the Network Building Controller communicating using BACnet/IP protocol. BMCS Contractor is responsible for the complete installation of Ethernet and associated switches for the fieldbus network.
2. All BACnet/IP Fieldbus controllers shall be BACnet Testing Laboratory listed (v12 or later) as specified BACnet Advanced Application Controller (B-AAC)
3. All BACnet/IP Fieldbus controllers shall use the following communication specifications and achieve performance as specified herein:

- a. All controllers shall be able to communicate peer-to-peer without the need for a NBC.
 - b. Any BACnet/IP Fieldbus controllers on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling.
4. The BACnet/IP Fieldbus controllers shall be equipped with 2x 10/100bT Ethernet communication ports with active switch and will support BACnet/IP communication protocols with the following configurations:
 - a. Supporting IPv4 addressing
 - b. Supporting Static IP setting, DHCP client and Auto-IP address acquisition
5. Topology
 - a. BACnet/IP Fieldbus Controller network shall be installed utilizing RSTP loop topology.
6. Performance
 - a. Each BACnet/IP Fieldbus Controllers shall have a 32-bit microprocessor operating at 500 MHz and support a BACnet protocol stack in accordance with the ANSI/ASHRAE Standard 135-2008 and the BACnet Device Profile supported.
 - b. They shall be multi-tasking, real-time digital control processors consisting of communication controllers, controls processing, power supplies with built-in inputs and outputs.
7. Programmability
 - a. The BACnet/IP Fieldbus controllers shall support programming language consistent with the NBC.
 - b. All control sequences programmed into the BACnet/IP Fieldbus Controllers shall be stored in non-volatile memory.
 - c. BACnet/IP Fieldbus controllers shall communicate with the Network Building Controller (NBC) via a BACnet/IP connection at a baud rate of not less than 100 Mbps.
 - d. Each BACnet/IP Fieldbus controller shall have sufficient memory, to support its own operating system and databases, including the following.
 - 1) Control processes
 - 2) Energy management applications
 - 3) Alarm management
 - 4) Historical/trend data
 - 5) Maintenance support applications
 - 6) Custom processes
 - 7) Manal override monitoring
8. Each BACnet/IP Fieldbus controller shall support local trend data up to 2x the built-in inputs/outputs (I/O) and at a minimum be capable of holding 5 days @ 15 min intervals locally.
9. Each BACnet/IP Fieldbus controller shall have adequate built-in configurable I/O to support the connected monitored and controlled I/O of the following types.
 - a. Industry standard thermistor temperature sensors
 - b. Current Input - 0-20 mA
 - c. Voltage Input 0-10 Vdc
 - d. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
 - e. Digital outputs
 - f. Analog outputs of 4-20 mA and/or 0-10 Vdc
10. BACnet Fieldbus Controllers (B-AAC) shall have internal clocks using BACnet time synchronization services.

- a. Automatically synchronize system clocks daily from an operator-designated controller.
- b. The system shall automatically adjust for daylight saving time.
- c. Each BACnet/IP Fieldbus controller shall include a real time clock, accurate to +/-1 minute per month.
- d. The RTC shall provide the following: time of day, day, month, year, and day of week.
11. The BACnet/IP Fieldbus controller for VAV applications shall include a built-in 'flow thru' differential pressure transducer.
 - a. The VAV differential pressure transducer shall have a measurement range of 0 to 1 in. W.C. and measurement accuracy of $\pm 5\%$ at 0.001 to 1 in. W.C. and a minimum resolution of 0.001 in. W.C., ensuring primary air flow conditions shall be controlled and maintained to within $\pm 5\%$ of setpoint at the specified minimum and maximum air flow parameters
 - b. The BACnet/IP FieldBus controller for VAV applications shall support a dedicated commissioning tool for air flow balancing.
 - c. The BACnet/IP Fieldbus controller for VAV applications shall be preprogrammed for an air balancing algorithm.
 - 1) All balancing parameters shall be synchronized in NBC.
12. Each BACnet/IP Fieldbus controller other than those for VAV applications shall have a minimum of 10% spare capacity for each point type represented on the controller for future point connection.
13. Each BACnet/IP Fieldbus controller shall be certified for smoke control and smoke management within a fully IP control solution.

FF Input/Output Interface

1. Hardwired inputs and outputs tie into the DDC system through building, custom application, or application specific controllers.
2. All Input/Output Points:
 - a. Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.
 - b. Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.
3. Binary Inputs:
 - a. Allow monitoring of On/Off signals from remote devices.
 - b. Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.
 - c. Sense dry contact closure with power provided only by the controller.
4. Pulse Accumulation Input Objects: Comply with all requirements of binary input objects and accept up to 10 pulses per second.
5. Analog Inputs:
 - a. Allow for monitoring of low voltage 0 to 10 VDC, 4 to 20 mA current, or resistance signals (thermistor, RTD).
 - b. Compatible with and field configurable to commonly available sensing devices.
6. Binary Outputs:
 - a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
 - b. Outputs provided with three position (On/Off/Auto) override switches.

- c. Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.
- 7. Analog Outputs:
 - a. Monitoring signal provides a 0 to 10 VDC or a 4 to 20 mA output signal for end device control.
 - b. Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
 - c. Drift to not exceed 0.4 percent of range per year.
- 8. Tri State Outputs:
 - a. Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
 - b. Limit the use of three point, floating devices to the following zone and terminal unit control applications:
 - 1) VAV terminal units.
 - 2) Duct mounted heating coils.
 - c. Control algorithms run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
- 9. System Object Capacity:
 - a. System size to be expandable to twice the number of input output objects required by providing additional controllers, including associated devices and wiring.
 - b. Hardware additions or software revisions for the installed operator interfaces are not to be required for future, system expansions.

2.7 POWER SUPPLIES AND LINE FILTERING

A Power Supplies:

- 1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
- 2. Limit connected loads to 80 percent of rated capacity.
- 3. Match DC power supply to current output and voltage requirements.
- 4. Unit to be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
- 5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
- 6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
- 7. Operational Ambient Conditions: 32 to 120 degrees F.
- 8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD-810 for shock and vibration.
- 9. Line voltage units UL recognized and CSA approved.

B Power Line Filtering:

- 1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
- 2. Minimum surge protection attributes:
 - a. Dielectric strength of 1000 volts minimum.
 - b. Response time of 10 nanoseconds or less.
 - c. Transverse mode noise attenuation of 65 dB or greater.

- d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

2.8 LOCAL AREA NETWORK (LAN)

- A Provide communication between control units over local area network (LAN).
- B LAN Capacity: Not less than 60 stations or nodes.
- C Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.
- D LAN Data Speed: Minimum 19.2 Kb.
- E Communication Techniques: Allow interface into network by multiple operation stations and by auto-answer/auto-dial modems. Support communication over telephone lines utilizing modems.
- F Transmission Median: Fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.
- G Network Support: Time for global point to be received by any station, shall be less than 3 seconds. Provide automatic reconfiguration if any station is added or lost. If transmission cable is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.

PART 3 EXECUTION

3.1 GENERAL

- A Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner's Representative and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
- B Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer-stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.
- C Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.
- D Install equipment in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.
- E Verify that conditioned power supply is available to the control units and all BMCS network devices and computers.
- F Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

- G At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract.
- H In addition to the requirements specified herein, execution shall be in accordance with the requirements of Specification Section 26 00 00 and Drawings.

3.2 INSTALLATION

- A Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
- B Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 230993.
- C Provide interfaces between all equipment/systems and BMCS as indicated and required.
- D The contractor shall be responsible for all electrical work associated with the BMCS.
 - 1. Perform all wiring in accordance with all local and national codes.
 - 2. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the division 26 specifications, NEC and local building code.
 - 3. The 120VAC 20 amp dedicated power wiring to each controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral and ground wire. The ground wire will terminate at the breaker panel ground. This circuit shall not feed any other circuit or device.
 - 4. Surge transient protection shall be incorporated in design of system to protect electrical components in all BMCS Controllers and operator's workstations.
 - 5. All low voltage electrical control wiring throughout the building in exposed areas shall be run in conduit in accordance with the division 26 specifications, local building code and the NEC.
 - 6. Provide all miscellaneous field device mounting and interconnecting wiring for all mechanical systems.
 - 7. All systems requiring interlock wiring shall be hardwired interlocked and shall not rely on the BMCS to operate. Interlock wiring shall be run in separate conduits from BMCS associated wiring.
 - 8. Provide the complete installation of Ethernet and associated switches for the BMCS LAN and sub-networks
- E All controllers are to be mounted vertically and per the manufacturer's installation documentation.
- F Controllers must be connected to a true earth ground.
- G Install control units and other hardware in position on permanent walls where not subject to excessive vibration.

3.3 SOFTWARE CONFIGURATION AND PROGRAMMING

- A The BMCS Contractor shall perform all system configuration and programming to provide a complete and operational Building Management Control System meeting the requirements of this specification.
- B Implement all features of programs to meet specified requirements and to control and monitor equipment and systems as detailed in the sequence of operation. Refer to Section 23 09 93.
- C Provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.
- D The BMCS Contractor shall work in conjunction with the Owner's Representative and Engineer during programming configuration to review potential approaches, data presentation, alarming, reporting, and information required to be available to operators. During development of the BMCS user interface Engineer reviews shall take place prior to the start of development, during development and after development completion to ensure that all information is presented in an acceptable method for the user. The BMCS Contractor shall make necessary modifications resulting from these reviews up until the time of final acceptance.
- E The BMCS Contractor shall provide BMCS configuration and programming including, but not limited to, the following:
 - 1. Programming to achieve system operation for all controlled and monitored systems as defined by the sequence of operation for each system in Specification Section 23 09 93.
 - 2. Configure those portions of the database that are required by the points list and sequence of operation.
 - 3. Configure and set up the BMCS local area network and subnetworks.
 - 4. Initial creation and configuration of the following:
 - a. User customized workspaces.
 - b. User access and permissions.
 - c. User groups.
 - d. Custom reporting.
 - e. Schedules.
 - f. Audit trail.
 - g. Alarm reporting, management, and delivery.
 - 5. Create and configure reports for each controlled and monitored system or equipment capable of including the following information.
 - a. Trend comparison data.
 - b. Alarm status and prevalence information.
 - c. System user data.
 - 6. Create and configure alarms for each system and all monitored and controlled I/O points.
 - 7. Creation of graphical displays and Dashboards for use on the Configuration and Programming Workstation, Web-based Operator Workstations, and Hand Held devices as detailed in this specification for a minimum of two user groups. Subgroups within the two user groups shall also be set up as needed. For example, a subgroup under Facility Operations and Engineering Staff for a particular Service Provider to limit access to only equipment necessary for that particular Service Provider. The primary user groups for this project shall be as follows:
 - a. Facility Operations and Engineering Staff.

- b. Facility Occupant/Owner.
- 8. The system shall be configured to offer each user group a unique set of graphics designed to provide the following functionality:
 - a. Facility Operations and Engineering Staff group: Graphics and dashboards shall be designed to provide the user with detailed information about all monitored points, controlled points, calculated points, variables and setpoints, systems, and subsystems connected to the BMCS to effectively operate the facility.
 - b. Facility Occupant/Owner group: Graphics and dashboards shall be designed to provide the user with the simplified information necessary to monitor and control the spaces from an occupant's perspective. Dashboards shall contain information pertinent to the occupant regarding the overall operation of the facility.
- 9. Graphical displays and Dashboards created for the Facility Operations and Engineering Staff user group shall include, but not be limited to, the following:
 - a. Navigation Tree providing, but not limited to, the following functionality:
 - 1) Navigation method to intuitively index between graphical screens, schedules, alarms, and reports, and other BMCS related information.
 - 2) Drop down menus logically grouped by building, areas, systems, and subsystems.
 - b. Graphical displays for each piece of equipment, system, and subsystem providing, but not limited to, the following functionality:
 - 1) 3D graphical representation of the controlled and/or monitored equipment, system, or subsystem.
 - 2) Equipment or system name and area served.
 - 3) All monitored and controlled I/O and system variables associated with the system including engineering units.
 - 4) All setpoints including engineering units with a methodology to easily adjust setpoints from the graphical screen.
 - 5) Pop-up menus to present all equipment or system related data in tabular form.
 - 6) Drill down functionality for pieces of equipment which have more related data than can be practically illustrated on a single graphic screen.
 - 7) Current alarm conditions associated with the piece of equipment or system.
 - 8) Links to schedules related to the equipment or system.
 - 9) Links to reports related to the equipment or system.
 - 10) Links to BMCS Control drawings and written sequence of operation for the equipment or system displayed on each graphical screen.
 - 11) Ability for the operator to enter notes regarding the equipment or system.
 - c. Graphical displays for each building and area of each building providing, but not limited to, the following functionality:
 - 1) 3D graphical representation of floor plans with color coded indication of temperature conditions as compared to setpoint and the ability to adjust setpoints for individual rooms and area.
 - 2) Building and area name.
 - 3) All monitored and controlled I/O and system variables associated with the area including engineering units.
 - 4) All setpoints associated with the area including engineering units with a methodology to easily adjust setpoints from the graphical screen.
 - 5) Links to graphical screens for equipment serving the area.

- 6) Drill down functionality for areas which have more related data than can be practically illustrated on a single graphic screen.
- 7) Current alarm conditions associated with the area.
- 8) Links to schedules related to the area.
- 9) Links to reports related to the area.
- 10) Ability for the operator to enter notes regarding the area.

3.4 FIELD QUALITY CONTROL

- A Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
- B Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BMCS will be tested against the appropriate sequence of operation. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.
- C The BMCS system supplier shall commission and set in operating condition all major equipment and systems, such as the chilled water and all air handling systems, in the presence of the equipment manufacturer's representatives.

3.5 SYSTEM ACCEPTANCE TESTING

- A All application software will be verified and compared against the sequences of operation.
- B Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to a Test Results Sheet.
- C Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations, printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, email notifications, etc.). Submit a Test Results Sheet.
- D Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet.
- E Perform an operational test of each third party interface that has been included as part of the building management control system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.
- F A performance verification test shall be completed for the operator interaction with the system. Test elements shall be written to require the verification of all operator interaction tasks including, but not limited to the following:

1. Graphics navigation.
2. Trend data collection and presentation.
3. Alarm handling, acknowledgement and routing.
4. Time schedule editing.
5. Application parameter adjustment.
6. Manual control.
7. Report execution.
8. Automatic backups.
9. Web Client access.

- G A Startup Testing Report and a Performance Verification Testing Report shall be provided upon test completion.

3.6 FIELD SERVICES

- A A field checkout of all controllers and front end equipment (computers, printers, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted prior to the completion of the project.
- B The BMCS system supplier shall provide a technician for engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BMCS Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.

3.7 DEMONSTRATION AND INSTRUCTIONS

- A Demonstrate complete and operating system to Owner.
- B Provide on-site training to the Owner's representative and maintenance personnel per the following description:
- C On-site training shall consist of a minimum of (8) hours of hands-on instruction geared at the operation and maintenance of the systems. The training shall be conducted in increments as follows:
1. Four (4) hours of training prior to completion of the project.
 2. Four (4) hours of training upon completion of the project at the time of turnover.
- D The training curriculum shall include the following.
1. System Overview.
 2. System Software and Operation.
 3. System access.
 4. Software features overview.
 5. Changing setpoints and other attributes.
 6. Scheduling.
 7. Editing programmed variables.
 8. Displaying color graphics.
 9. Running reports.

10. Workstation maintenance.
11. Viewing application programming.
12. Operational sequences including start-up, shutdown, adjusting and balancing.
13. Equipment maintenance.

END OF SECTION

SECTION 230993**SEQUENCE OF OPERATIONS FOR BUILDING MANAGEMENT CONTROL SYSTEM****PART 1 GENERAL****1.1 SECTION INCLUDES**

- A This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.
- B Sequence of operation for:
 - 1. Air terminal units.
 - 2. Single zone air handling unit.
 - 3. Variable air volume terminal units.
 - 4. Exhaust fans.
 - 5. Plumbing Circulation pumps, sump pumps and water heaters
 - 6. Unit heaters.
 - 7. Energy Management Strategies
 - a. Cascade Temperature Control
 - b. Critical zone reset: AHU Duct Static Pressure
 - c. Critical zone reset: AHU Discharge air setpoint reset
 - d. AHU DAT Reset: Linear OAT
 - e. Zone space temperature offset
 - f. Zone space temperature offset: Unoccupied weekend temperature control

1.2 SYSTEM DESCRIPTION

- A This Section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other Sections.

1.3 SUBMITTALS

- A Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.
 - 1. Preface: 1 or 2 paragraph overview narrative of the system describing its purpose, components and function.
 - 2. State each sequence in small segments and give each segment a unique number for referencing in Functional Test procedures; provide a complete description regardless of the completeness and clarity of the sequences specified in Contract Documents.
 - 3. Include at least the following sequences:
 - a. System off.
 - b. Start-up.
 - c. Warm-up mode.

- d. Normal operating mode.
 - e. Unoccupied mode.
 - f. Shutdown.
 - g. Capacity control sequences and equipment staging.
 - h. Temperature and pressure control, such as setbacks, setups, resets, etc.
 - i. Detailed sequences for all control strategies, such as economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
 - j. Effects of power or equipment failure with all standby component functions.
 - k. Sequences for all alarms and emergency shut downs.
 - l. Seasonal operational differences and recommendations.
 - m. Interactions and interlocks with other systems.
- 4. Include initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
 - 5. For packaged controlled equipment, include manufacturer's furnished sequence of operation amplified as required to describe the relationship between the packaged controls and the control system, indicating which points are adjustable control points and which points are only monitored.
 - 6. Include schedules, if known.
- B Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.
- 1. Label with settings, adjustable range of control and limits.
 - 2. Include flow diagrams for each control system, graphically depicting control logic.
 - 3. Include the system and component layout of all equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
 - 4. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
 - 5. Include all monitoring, control and virtual points specified in elsewhere.
 - 6. Include a key to all abbreviations.
- C Points List: Submit list of all control and monitor points indicating at least the following for each point.
- 1. Name of controlled system.
 - 2. Point abbreviation.
 - 3. Point description; such as dry bulb temperature, airflow, etc.
 - 4. Display unit.
 - 5. Control point or setpoint (Yes / No); i.e. a point that controls equipment and can have its setpoint changed.
 - 6. Monitoring point (Yes / No); i.e. a point that does not control or contribute to the control of equipment but is used for operation, maintenance, or performance verification.
 - 7. Intermediate point (Yes / No); i.e. a point whose value is used to make a calculation which then controls equipment, such as space temperatures that are averaged to a virtual point to control reset.

- 8. Calculated point (Yes / No); i.e. a “virtual” point generated from calculations of other point values.
- D Project Record Documents: Record actual locations of components and setpoints of controls, including changes to sequences made after submission of shop drawings.

1.4 CONTROL SYSTEM INTERFACES

- A System shall fully support a multi-vendor environment and be able to interface and integrate third party systems and sequences via vendor protocols including, as a minimum, BACnet, LonTalk and Modbus.
- B System and Equipment to BMCS Interfaces shall be provided for, but not limited to:
 - 1. Manufacturer's packaged system control panels.
 - 2. Packaged Unitary Equipment.
 - 3. Roof-Top Units.
 - 4. Plumbing Circulation pumps, sump pumps and water heaters
 - 5. Packaged Equipment Controls
 - 6. Unit Heaters
 - 7. Temperature sensors where noted on plans
- C A watchdog procedure must be implemented that enables the identification of the point of failure, i.e., where in the communications chain between the two systems did the failure occur. The watchdog function must operate at a frequency that detects a failure within 60 seconds.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 OPERATING SEQUENCES - GENERAL

- A Sequence of Control indicated illustrates basic control function only. Provide all control devices required for controlling air handling units, exhaust fans, physical plant equipment, terminal equipment, and all related items. Provide monitoring only devices as indicated.
- B Perform the initial input of all required operational data for each point that is to be used based on information supplied by the Owner. Assist the Owner's staff in developing the schedule and shall demonstrate the operation of the system using the data.
- C Provide adequate English language notation in the software to assist the operator in understanding the intent of the programmed sequences.
- D Provide stable operation of all control loops. If the Contractor has not provided self-tuning PID control algorithms then the Contractor shall manually tune all control loops. Verify all control loops are stable whether or not they are self-tuning.

- E Provide any modifications to the operating sequence programs as requested by the Owner without additional costs until the final acceptance of the entire control system.
- F All outputs using PID control shall be adjusted to the actual range of end device. Example: If VFC range is from 20% to 100%, output PID loop shall run from 20%-100% to eliminate spooling of PID outside actual operating range of end device.
- G Graphics shall represent actual range of outputs.

3.2 EQUIPMENT RUN TIME TOTALIZATION

- A Incorporate run time totalization techniques into the programming logic that will accumulate the operating times for motors as selected by the operator using an interactive procedure. Any piece of equipment that has its status monitored by the building management control system (BMCS) shall be selectable for inclusion in this feature. It shall be possible to concurrently monitor the accumulated operating time for every item of equipment monitored and/or controlled by the BMCS.
- B The operator shall be able to establish on-line, using an interactive procedure, a value for the accumulated operating time at which a suitably worded message shall be output to the operator advising that the reporting limit has been reached for a specific motor. The message shall be output at the designated device.
- C The operator shall be able to change the accumulated total for any motor to any value.
- D The accumulated operating times shall be updated at least every 15 minutes.
- E The operator shall be able to obtain on demand or on a scheduled basis a report detailing the accumulated operating times.
- F Operating time software shall be used as the basis for equipment operating selection and standby status. Changeover of units based on operating times shall not take place more than an operator-defined period, initially set at once per week.

3.3 NIGHT (UNOCCUPIED) SETBACK - SETUP

- A Incorporate unoccupied setback-setup techniques into the programming logic to provide the following:
 - 1. Start HVAC equipment after normal hours of scheduled operation to maintain building after-hour setpoints, while reducing energy consumption.
 - 2. Night setback temperatures for heating shall be initially set at 55 degrees F to activate the heating equipment and 60 degrees F to stop the heating equipment. Once activated, the units involved shall operate as specified in the respective sequence of operation. Coordinate the operation of this program with the requirements for terminal unit controls.
 - 3. Night setup temperatures for cooling shall be initially set at 90 degrees F to activate the cooling equipment and 85 degrees F to stop the cooling equipment. Once activated, the

units involved shall operate as specified in the respective sequence of operation.
Coordinate the operation of this program with the requirements for terminal unit controls.

- B The operator shall be able to implement this function for all HVAC equipment using an interactive procedure on an individual or group-controlled basis.
- C The operator shall be able to assign minimum run times for each piece of equipment.
- D The operation of this program shall be disabled when the outside air temperature is outside operator defined limits, initially set at 35 degrees F and 95 degrees F.
- E A report shall be available on demand and on a scheduled basis, which provides the following information:
 - 1. Night setback/setup setpoints and associated equipment.
- F This feature shall only be implemented for equipment in the BMCS software control mode.
- G Setpoints for each associated piece of equipment shall be displayed on the associated system display graphics. Setpoints shall be changeable via the graphical display.
- H The current status of night setback - setup modes shall be indicated on the associated system graphic.

3.4 OPTIMIZED SCHEDULING

- A Provide an adaptive software program that shall:
 - 1. Start HVAC equipment at the latest possible time while ensuring that space in the building reaches setpoint conditions by the time occupancy commences.
 - 2. Stop HVAC equipment at the earliest possible time while ensuring that space in the building shall still be within the setpoint deadband at the scheduled end of occupancy.
- B The operator shall be able to implement this function for each group of terminal units and other HVAC equipment using an interactive procedure. A group of terminal units shall comprise all the terminal units on the same floor of the tower served by the same air handling unit. The operator shall be able to assign start of occupancy and end of occupancy times for each day of the week and for holidays. A separate Monday schedule should be provided for earlier start times.
- C This program shall base the determined equipment start and stop times on monitored data such as space temperatures within the area served by the equipment and ambient conditions. If the BMCS subcontractor requires information other than that provided by the monitoring detailed in the Field Termination Schedules, then the necessary additional instrumentation shall be provided within the base bid price.
- D The operator shall be able to assign limits to the start and stop times. Initially these limits shall be set as follows:
 - 1. BMCS determined start times shall not be more than three hours before the scheduled occupancy.

2. BMCS determined stop times shall not be more than one hour before the scheduled end of occupancy.
- E A report shall be available on demand and on a scheduled basis, which provides the following information:
1. Occupancy schedules.
 2. Time of last equipment start and space conditions at scheduled occupancy time.
 3. Time of last equipment stop and space conditions at scheduled end of occupancy time.
- F This feature shall only be implemented for equipment in the BMCS software control mode.

3.5 ENERGY MANAGEMENT STRATEGIES

- A Apply additional emergency management strategies listed below to the applicable systems.

3.6 TYPICAL SYSTEMS START-UP AND SHUT-DOWN INITIATION

- A Air Terminal Units:
1. Initiation of System Start-Up - The system shall be started:
 - a. Manual:
 - 1) BMCS single entry operator command.
 - b. Automatic:
 - 1) Based on BMCS occupancy schedule.
 - 2) As required during night setback/setup mode of operation.
 2. System Shutdown - Shall be initiated as follows:
 - a. Manual:
 - 1) BMCS single entry operator command.
 - b. Automatic:
 - 1) Based on BMCS occupancy schedule.
 - 2) At the conclusion of setback/setup operation during unoccupied periods.
 - 3) In the event of component failure.
 - 4) On any building fire alarm activation. (Fan powered units)
- B Rooftop Units:
1. Initiation of System Start-Up - The system shall be started by one of the following methods as selected by the operator:
 - a. Manual:
 - 1) BMCS single entry operator command.
 - b. Automatic:
 - 1) Based on BMCS occupancy schedule.
 - 2) Initiated by the BMCS whenever a space requires unoccupied cooling or heating based on setback/setup operation.
 2. Initiation of System Shutdown - System shutdown shall be initiated as follows:
 - a. Manual:
 - 1) BMCS single entry operator command.
 - b. Automatic:
 - 1) Based on BMCS occupancy schedule.

- 2) In the event of component failure.
- 3) High/low static pressure switch trip
- 4) In the event of a building power failure.
- 5) In the event of fire alarm shutdown.
- 6) Freezestat trip.
- 7) When there are no associated terminal unit requiring Occupied cooling, Unoccupied cooling, Occupied heating, or Unoccupied heating.

3.7 AIR TERMINAL UNITS

A Single-Duct Variable Volume with Heat:

1. System Off - When the system is off:
 - a. The primary air damper shall be closed.
 - b. The heating shall be closed or off.
2. Initiation of System Start-Up - The system shall be started:
 - a. Manual:
 - 1) BMCS single entry operator command.
 - b. Automatic:
 - 1) Based on BMCS occupancy schedule.
 - 2) As required during night setback/setup mode of operation.
3. System Operation - After system start-up has been initiated the following shall occur:
 - a. The primary air damper shall modulate to the maximum primary airflow rate indicated to maintain the space cooling temperature setpoint.
 - b. When the space temperature falls below the space heating temperature setpoint the following shall occur:
 - 1) The primary air damper shall be set to the minimum primary air flow rate indicated.
 - 2) The heating water valve or electric coil controller shall modulate to maintain the space heating temperature setpoint.
 - 3) The discharge air temperature sensor shall limit discharge air temperature to no more than 20 degrees above space setpoint.
 - 4) Upon further call for heating, the primary air damper shall modulate to the maximum heating air flow rate indicated.
4. System Shutdown - Shall be initiated as follows:
 - a. Manual:
 - 1) BMCS single entry operator command.
 - b. Automatic:
 - 1) Based on BMCS occupancy schedule.
 - 2) At the conclusion of setback/setup operation during unoccupied periods.
 - 3) In the event of component failure.
5. System Setpoints - The setpoints shall be operator changeable and initially set as follows:
 - a. Space cooling temperature setpoint shall be 74 degrees F.
 - b. Space heating temperature setpoint shall be 70 degrees F.
 - c. The minimum and maximum primary air flow setpoints shall be set to the design airflow setpoints as indicated in the contract documents.
 - d. The high and low temperature setpoints shall be set initially at 2 degrees F above/below the temperature setpoints.

- e. The occupant shall have the capability to adjust the space temperature setpoint through the space temperature sensor.
- f. The programming shall limit user adjustment to + or - 2 degrees F of the base setpoint.
- 6. Alarms - The BMCS shall generate an alarm for the following conditions:
 - a. High temperature.
 - b. Low temperature.
- 7. Points List:
 - a. Analog Inputs:
 - 1) Primary air flow.
 - 2) Space temperature.
 - 3) Space temperature setpoint adjust.
 - 4) Discharge air temperature.
 - b. Analog Outputs:
 - 1) Primary air damper.
 - 2) electric coil controller.

3.8 SINGLE ZONE ROOFTOP UNIT (VARIABLE VOLUME)

- A System Off - When the system is off:
 - 1. The relief air dampers shall be closed.
 - 2. The outside air dampers shall be closed.
 - 3. The return air dampers shall be open.
 - 4. Supply and return fan shall be off.
- B Initiation of System Start-Up - The system shall be started:
 - 1. Manually initiated by operator through BMCS.
 - 2. Automatically by BMCS through occupancy schedule.
- C System Operation - After system start-up has been initiated the following shall occur:
 - 1. Differential pressure safety switches shall be provided on inlet and outlet sides of supply fans and inlet of return fans, or on supply fan outlet and return fan inlet where fans are in a common housing. Switches shall stop fans and require manual reset.
 - 2. The supply and return fans shall be started at minimum speed. After an operator defined period of time, the fans shall be enabled for automatic speed control.
 - 3. The supply fan speed shall modulate to maintain the supply static pressure setpoint. Pressure sensor shall be located 2/3 of the distance down the system ductwork.
 - 4. The relief air damper shall modulate to maintain the building static pressure setpoint. The building pressure sensor shall compare the pressure difference between the inside and outside. Outside pressure shall be taken near the front door, low on the building, preferably south, or alternatively east or west sides of the building.
 - 5. The return fan speed shall modulate to maintain the return air plenum static pressure setpoint. This sensor shall be located in the discharge plenum of the return fan before the return air damper.
 - 6. Economizer Control:
 - a. Outside and return air dampers shall be modulated inversely proportionate to maintain a mixed air temperature set point 2 deg. (adj.) less than the discharge air set point.
 - b. If local control is being used the economizer shall be enable whenever:

- 1) Outside air temperature is less than 65 deg (adj.)
 - 2) And outside air enthalpy is less than return enthalpy.
 - 3) Supply fan status is on.
 - c. If "global" economizer enable is to be used the economizer shall be enabled whenever:
 - 1) Outside air temperature is less than 65 deg (adj.).
 - 2) Outside air enthalpy is below 25 btu/lb of dry air with a dead band of 3 btu/lb.
 - d. The economizer shall not be used whenever:
 - 1) Morning warm-up is enabled.
 - 2) If return air temperature is below 65 degrees (adj.) unless a "pre-cool" sequence is being used.
 7. Minimum outside air damper shall modulate to maintain the minimum outdoor air flow setpoint.
- D System Shutdown - Shall be initiated as follows:
1. Manually initiated by operator through BMCS.
 2. Automatically through occupancy schedule.
 3. Freezestat trip.
 4. High/low static pressure switch trip.
 5. Automatically in the event of building power failure or fire alarm.
- E System Setpoints - The setpoints shall be operator changeable and initially set as follows:
1. Supply air temperature setpoint shall be 55 degrees F.
 2. Mixed air temperature setpoint shall be 54 degrees F.
 3. Space humidity setpoint shall be 20% RH.
 4. Supply air pressure setpoint shall be 2 inches w.g.
 5. Return fan return air plenum pressure setpoint shall be set by the balancing contractor, but initially set at 0.1 inches w.g.
 6. Freezestat setpoint shall be 35 degrees F.
 7. Supply air duct static pressure high limit set at 3.5 inches w.g.
 8. Return air duct static pressure low limit device set at -3.5 inches w.g.
 9. The minimum and maximum speed signal positions shall be set by the Balancing Contractor within the fan manufacturer's limitations.
 10. The time delay for outside air damper control upon AHU startup shall be set at five minutes.
 11. The minimum outside air flowrate setpoint shall be as scheduled on the Mechanical Drawings.
 12. The space pressure setpoint shall be 0.05 inches w.g.
- F Alarms - The BMCS shall generate an alarm for the following conditions:
1. Fan failure,
 2. If the supply air temperature is more than 2 degrees F above/below setpoint.
 3. If the supply air static pressure is more than 0.5 inches w.g. above/below setpoint for a period of more than 5 minutes.
 4. Freezestat trip.
 5. Duct high/low static pressure limit device trip.
 6. Heating failure.

7. All alarms shall be inhibited if the supply/return fans are not in operation. The alarms, except the fan failure to start, shall remain inhibited following start up of the unit for an operator determined period of time initially set at two minutes.
- G Failure Positions - The following shall occur upon component failure or loss of power:
1. Failure Positions - The following shall occur upon component failure or loss of power:
 2. Relief air dampers shall close.
 3. Outside air dampers shall close.
 4. Return air dampers shall open.
 5. The supply and return fan shall remain in the last commanded state and the speed signal shall go to the minimum speed.
- H Points List:
1. Analog Inputs:
 - a. Return air temperature.
 - b. Return air CO2.
 - c. Return air humidity.
 - d. Return air fan flow.
 - e. Return fan VFC speed reference feedback.
 - f. Return plenum static pressure.
 - g. Relief air damper position feedback.
 - h. Return air damper position feedback.
 - i. Outside air damper position feedback.
 - j. Minimum outside air flow.
 - k. Outside air flow.
 - l. Outside air temperature.
 - m. Outside air humidity.
 - n. Outside air CO2.
 - o. Mixed air temperature.
 - p. Preheat coil discharge temperature.
 - q. Supply air fan flow.
 - r. Supply fan VFC speed reference feedback.
 - s. Supply air temperature.
 - t. Supply duct static pressure.
 - u. Space humidity.
 2. Digital Inputs:
 - a. Return fan status.
 - b. Supply fan status.
 - c. Freezestat.
 - d. Return fan high suction static pressure .
 - e. Return fan high discharge static pressure.
 - f. Return fan VFC fault.
 - g. Supply fan high suction static pressure .
 - h. Supply fan high discharge static pressure.
 - i. Supply fan VFC fault.
 3. Analog Outputs:

- a. Relief air damper.
- b. Return air damper.
- c. Outside air damper.
- d. Minimum outside air damper.
- e. Return fan VFC speed.
- f. Supply fan VFC speed.
- 4. Digital Outputs:
 - a. Return fan VFC enable.
 - b. Supply fan VFC enable.
- 5. Set points
 - a. Supply air set point
 - b. Mixed air set point
 - c. Enthalpy set point
 - d. Minimum outside air position
- 6. Hardwired Interlocks - The following shall disable the supply and return fans upon activation:
 - a. Supply fan high suction static pressure.
 - b. Supply fan high discharge static pressure.
 - c. Return fan high suction static pressure.
 - d. Return fan high discharge static pressure.
 - e. Freezestat.
- 7. Software Interface - The following points shall be provided through the BACnet interface.
 - a. Supply fan VFC speed reference feedback.
 - b. Supply fan VFC fault.
 - c. Supply fan runtime in hours.
 - d. Return fan VFC speed reference feedback.
 - e. Return fan VFC fault.
 - f. Return fan runtime in hours.

3.9 EXHAUST FANS

- A System Description: Fans provide exhaust for areas including, but not limited to, restrooms, break/print rooms, and janitor closet.
- B Exhaust fans shall operate continuously to provide Code-required bathroom and dryer exhaust. Fan shall not be disabled based on a schedule.
- C System off - when system is off:
 - 1. The exhaust fan shall be off.
- D Initiation of System Startup:
 - 1. Manually initiated by BMCS operator workstation.
 - 2. Automatically by the BMCS based on a time schedule.
- E System operation - after startup has been initiated, the following shall occur:
 - 1. Exhaust fan shall start.
- F System shutdown - shall be initiated as follows:

1. Manually initiated by operator at BMCS workstation.
- G Alarms - the BMCS shall generate an alarm for the following:
1. Fan failure.
- H Failure position - the following shall occur upon BMCS communication failure.
1. Fan shall remain in last commanded state.
- I Field Termination Schedule:
1. Digital input:
 - a. Fan status.
 2. Digital output:
 - a. Fan start/stop.

3.10 WATER HEATER

- A Points List:
1. Status
 2. Start/Stop
 3. Change temperature set points
 4. Fault mode

3.11 DOMESTIC HOT WATER CIRCULATION PUMP

- A Points List:
1. Speed Control 0-10V analog
 2. Start/Stop
 3. Fault Mode
 4. Run indication
 5. Operating mode

3.12 ELEVATOR SUMP PUMP WITH OIL MINDER SYSTEM

- A Points List:
1. Pump Failure to Flow
 2. Oil Fault
 3. High Water Alarm
 4. Pump Run Status
 5. Pump Overload
 6. Pump Failure to start
 7. Floar Failures

3.13 UNIT HEATER CONTROL - STAND ALONE

- A System Off - When the system is off:
1. The fan shall be off.

- B Initiation of System Start-Up - The system shall be started:
 - 1. Automatically whenever the space temperature falls below the space temperature heating setpoint.
- C System Operation - After system start-up has been initiated the following shall occur:
 - 1. The fan shall start.
- D System Shutdown - Shall be initiated as follows:
 - 1. Automatically whenever the space temperature rises above the space temperature heating setpoint.
- E System Setpoints - The setpoints shall be operator changeable and initially set as follows:
 - 1. Space heating temperature setpoint shall be 70 degrees F.

3.14 ADDITIONAL ENERGY MANAGEMENT STRATEGIES

- A Energy management strategies shall be applied to specific equipment control sequences as indicated.
- B Cascade Temperature Control:
 - 1. This sequence change shall apply to any piece of equipment that satisfies a space temperature directly e.g. terminal units, single zone air handlers, etc. Although this sequence can apply to staged equipment such as dx and electric heat, it is primarily suited to fully modulating heating and cooling e.g. chilled and hot water, scr heat, etc.
 - 2. Cascade Temperature Control - A PID loop shall be used to determine an active "discharge air temperature set point". Other programs or control systems can then make use of this calculated set point. This will result in a tighter control of space temperature.
 - 3. Calculating the active "discharge air temperature set point" is the first step to this sequence. The calculated "discharge air temperature set point" is changed based on the difference between the space temperature set point and the space temperature.
 - 4. Two sensors are required, space temperature and discharge air temperature. Since two sensors are required for this logic, a failure of one of these sensors should be anticipated. The second stage in this sequence is to modulate a heating/cooling valve to maintain the calculated "discharge air temperature set point" with a separate PID control loop.
 - 5. Alarms shall then be derived from this sequence such as deviation from discharge air set point as well as deviation from space set point.
 - 6. Using this methodology, equipment deviations can be monitored and corrective actions applied before the space temperature deviates from set point appreciably. With the data set of valve positions, space temperature, space temperature set point, discharge air temperature, discharge air temperature set point, along with other inputs can give the user ability to track equipment performance e.g. valve position, vs. discharge air temperature, vs. outside air temperature.
 - a. Points required
 - 1) Space temperature
 - 2) Space temperature set point
 - 3) Discharge air temperature
 - 4) Active discharge air temperature set point

- b. Failure sequences
 - 1) If space temperature fails, the “discharge air temperature set point” should be equal to the space temperature set point and alarm is issued.
 - 2) If the discharge air temperature sensor fails, control the hot or chilled water valve as appropriate based on space requirement. Default to a PID directly controlling the space with the heating/cooling source and disregard the discharge air sensor.
- C Critical zone reset: AHU Duct Static Pressure:
 - 1. Simple strategy - Vary the duct static pressure based on the demand in the VAV system.
 - 2. Detailed explanation - Upon start up the duct static pressure will be 1.0 “wc (adj.).
 - a. When a terminal unit damper position is 95% (adj.) or greater, the duct static pressure will be increased by 0.1 “ wc (adj.) every 15 min. (adj.) until terminal units are below 95% or the maximum static pressure set point of 2.0 “wc (adj.) is reached.
 - b. If no boxes are above 65% (adj.) the duct static pressure setpoint will decreased by 0.1 “ wc (adj.) every 15 min or until the minimum static pressure set point of 0.8 “wc (adj.) is reached.
 - 3. Points List:
 - a. Analog inputs
 - 1) AHU supply static pressure
 - b. Set points
 - 1) Start-up static pressure set point 1.0” wc (adj.).
 - 2) Minimum static pressure set point 0.8” wc (adj.).
 - 3) Maximum static pressure set point 2.0” wc (adj.).
 - 4) Static pressure increment set point 0.1” wc (adj.).
 - 5) Reset time increment set point 15 minutes (adj.).
 - c. Calculated points
 - 1) Active static pressure set point
 - 2) Maximum vav position
 - 3) Minimum vav position
 - 4) Time until next reset.
- D Critical zone reset: AHU Discharge air setpoint reset:
 - 1. Simple strategy - Vary the discharge air setpoint based on VAV demand.
 - 2. Detailed explanation - Upon start up the supply set point will be 57 deg (adj.).
 - a. When a terminal unit damper position is 95% (adj.) or greater, the supply air temperature set point will be decreased by 0.5 deg(adj.) every 15 min. (adj.) until terminal units are below 95% or the minimum supply set point of 53 deg (adj.) is reached.
 - b. If no boxes are above 65% (adj.) the supply setpoint will decreased by 0.5 deg (adj.) every 15 min or until the maximum supply set point of 62 deg (adj.) is reached.
 - c. The maximum set point is subject to environment and may need to be lower with respect to humidity. An override set point based on return humidity is an option.
 - 3. Points List:
 - a. Analog inputs
 - 1) AHU supply temperature
 - b. Set points
 - 1) Start-up supply temperature set point 57 deg (adj.).

- 2) Minimum supply temperature set point 53 deg (adj.).
- 3) Maximum supply temperature set point 62 deg (adj.).
- 4) Supply temperature increment set point 0.5 deg (adj.).
- 5) Reset time increment set point 15 minutes (adj.).
- c. Calculated points
 - 1) Active supply air temperature set point
 - 2) Maximum vav position
 - 3) Minimum vav position
 - 4) Average vav position
 - 5) Maximum space temperature deviation
 - 6) Maximum space temperature deviation VAV tag
 - 7) Maximum VAV tag (VAV-1, example)
 - 8) Minimum VAV tag
 - 9) Time until next reset.
- E Zone space temperature offset:
 1. Unoccupied seasonal temperature control.
 - a. Simple strategy - While setting back temperatures during unoccupied periods can save money, setting back too far can cause greater recovery costs during some conditions.
 - 1) Detailed explanation - By raising/lowering unoccupied temperature setpoints in increments the building impact can be less than trying to recover the building all at once in an optimal or regular start sequence.
- F Zone space temperature offset:
 1. Unoccupied weekend temperature control.
 - a. Simple strategy - Changing setback amount when unoccupied for longer periods.
 - 1) Detailed explanation - During the weekend period the unoccupied heating/cooling setpoints can be more significant because of prolonged unoccupied periods.
 - (a) Day before full occupancy unoccupied set points can be incremented to lessen occupancy impact.

END OF SECTION

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SECTION 232300
REFRIGERANT PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Piping.
- B Refrigerant.
- C Moisture and liquid indicators.
- D Valves.
- E Strainers.
- F Check valves.
- G Pressure regulators.
- H Pressure relief valves.
- I Filter-driers.
- J Solenoid valves.
- K Receivers.
- L Flexible connections.
- M Engineered wall seals and insulation protection.

1.2 CODE AND PERMIT COMPLIANCE

- A Work shall be in accordance with all applicable codes. Where the codes and drawings do not agree, the code shall take precedence; however, code shall take precedence over what is shown only when it is more stringent than that indicated. Items that are allowed by codes which are less stringent than that shown on the Drawings shall not be substituted.
- B Contractors shall familiarize themselves with all requirements as to permits, fees, etc., and shall comply. All permits, licenses, inspections, and arrangements required for the work shall be provided by the Contractors at their expense.
- C All utilities shall be installed in accordance with utility company rules and regulations.
- D Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of piping systems. Wherever practical, install piping as indicated.

1.3 REFERENCE STANDARDS

- A AHRI 495 - Performance Rating of Refrigerant Liquid Receivers.
- B AHRI 730 (I-P) - Flow Capacity Rating of Suction Line Filters and Suction Line Filter Driers.
- C AHRI 760 (I-P) - Performance Rating of Solenoid Valves for Use with Volatile Refrigerants.
- D ASHRAE Std 15 - Safety Standard for Refrigeration Systems.
- E ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- F ASME B31.9 - Building Services Piping.
- G ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.
- H ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels.
- I ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- J ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- K ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.
- L ASTM E283/E283M - Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.
- M ASTM E331 - Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.
- N ASTM E2178 - Standard Test Method for Determining Air Leakage Rate and Calculation of Air Permeance of Building Materials.
- O ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.
- P ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- Q ASTM G153 - Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials.
- R MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

- S MSS SP-69 - Pipe Hangers and Supports - Selection and Application; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2003.
- T MSS SP-89 - Pipe Hangers and Supports - Fabrication and Installation Practices; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2003.
- U UL 429 - Electrically Operated Valves.
- V UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS

- A See Section 013000 - Administrative Requirements for submittal procedures.
- B Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.
- C Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.
- D Design Data: Submit design data indicating pipe sizing. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- E Test Reports: Indicate results of leak test, acid test.
- F Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.
- G Project Record Documents: Record exact locations of equipment and refrigeration accessories on record drawings.
- H Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts lists.
- I Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.
 - 2. Extra Filter-Dryer Cartridges: One of each type and size.

1.5 QUALITY ASSURANCE

- A Designer Qualifications: Design piping system under direct supervision of a Professional Engineer experienced in design of this type of work.
- B Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Deliver and store piping and specialties in shipping containers with labeling in place.

- B Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- C Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A Comply with ASME B31.9 for installation of piping system.
- B Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.
- C Welders Certification: In accordance with ASME BPVC-IX.
- D Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

2.2 PIPING

- A Copper Tube: ASTM B280, H58 hard drawn or O60 soft annealed.
 - 1. Alternate Fittings: ASTM-B75 or B743, Flame-Free, copper-to-copper fittings for connecting copper-to-copper refrigerant piping.
 - a. 700 psi rated at 250 degrees F.
 - b. HNBR O-Ring.
 - c. ETL tested to UL 207 and ETL listed.
 - d. UL Listed: 207, SA#33958, SDTW(7) (Except where noted)
 - e. ASHRAE-15, ANSI 15, ASME B31.5, ANSI 31.5 approved.
- B Preinsulated Refrigerant Piping Linesets:
 - 1. Copper Tube: ASTM B280 seamless, anticorrosion pipe; lineset is precoupled to include two joined pipes.
 - a. Maximum Operating Pressure: 700 psi at 250 degrees F.
 - b. Joints: Flared or Braze, BCuP silver/phosphorus/copper alloy.
 - 2. General:
 - a. 1" minimum thickness, provide applicable code required thickness.
 - b. K Value: 0.25 at 75 degrees F.
 - c. Moisture Vapor Permeability: 0.05 perm inch.
 - d. Maximum Service Temperature: 220 degrees F.
 - e. Minimum Service Temperature: Minus 40 degrees F.
 - f. Use molded tubular material wherever possible.
 - 3. Insulation: Polyethelene closed-cell foam; preapplied to entire length of lineset. Weather- and UV-resistant for outdoor installation. Maximum flame spread index of 25 and maximum smoke developed index of 50, when tested in accordance with ASTM E84 or UL 723.
 - a. Connection: Contact adhesive.
 - 4. Flexible Elastomeric:

- a. Insulation: UV coated, preformed flexible elastomeric cellular rubber insulation, Grade 1;
 - 1) Connection: Waterproof vapor barrier adhesive.
- C Pipe Supports and Anchors:
 - 1. Provide hangers and supports complying with MSS SP-58.
 - a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 - 2. Conform to ASME B31.5.
 - 3. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron adjustable swivel, split ring.
 - 4. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
 - 5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - 6. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
 - 7. Vertical Support: Steel riser clamp.
 - 8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - 9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 - 10. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
 - 11. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.3 REFRIGERANT

- A Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 700.

2.4 MOISTURE AND LIQUID INDICATORS

- A Indicators: Single port type, UL listed, with copper or brass body, flared or solder ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum temperature of 200 degrees F and maximum working pressure of 500 psi.

2.5 VALVES

- A Diaphragm Packless Valves:
 - 1. UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, soldered or flared ends, with positive backseating; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.
- B Packed Angle Valves:
 - 1. Forged brass or nickel plated forged steel, forged brass seal caps with copper gasket, rising stem and seat with backseating, molded stem packing, soldered or flared ends; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.
- C Ball Valves:

1. Two piece bolted forged brass body with teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of 500 psi and maximum temperature of 300 degrees F.

D Service Valves:

1. Forged brass body with copper stubs, brass caps, removable valve core, integral ball check valve, flared or soldered ends, for maximum pressure of 500 psi.

2.6 STRAINERS

A Straight Line or Angle Line Type:

1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi.

2.7 CHECK VALVES

A Globe Type:

1. Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor-bronze or stainless steel spring, teflon seat disc; for maximum temperature of 300 degrees F and maximum working pressure of 500 psi.

B Straight Through Type:

1. Brass body and disc, phosphor-bronze or stainless steel spring, neoprene seat; for maximum working pressure of 500 psi and maximum temperature of 250 degrees F.

2.8 PRESSURE REGULATORS

- A Brass body, stainless steel diaphragm, direct acting, adjustable over 0 to 80 psi range, for maximum working pressure of 450 psi.

2.9 PRESSURE RELIEF VALVES

- A Straight Through or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB, selected to ASHRAE Std 15, with standard setting of 450 psi.

2.10 FILTER-DRIERS

A Performance:

1. Flow Capacity - Liquid Line: Rated in accordance with ARI 710.
2. Flow Capacity - Suction Line: Rated in accordance with ARI 730.
3. Pressure Drop: 2 psi, maximum, when operating at full connected evaporator capacity.
4. Design Working Pressure: 350 psi, minimum.

- B Cores: Molded or loose-fill molecular sieve desiccant compatible with refrigerant, activated alumina, activated charcoal, and filtration to 40 microns, with secondary filtration to 20 microns; of construction that will not pass into refrigerant lines.

C Construction: UL listed.

1. Connections: As specified for applicable pipe type.

2.11 SOLENOID VALVES

- A Valve: AHRI 760 (I-P), pilot operated, copper, brass or steel body and internal parts, synthetic seat, stainless steel stem and plunger assembly (permitting manual operation in case of coil failure), integral strainer, with flared, soldered, or threaded ends; for maximum working pressure of 500 psi.
- B Coil Assembly: UL 429 UL listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with surge protector and color coded lead wires, integral junction box with pilot light.

2.12 RECEIVERS

- A Internal Diameter 6 inch and Smaller:
 - 1. AHRI 495, UL listed, steel, brazed; 400 psi maximum pressure rating, with tappings for inlet, outlet, and pressure relief valve.
- B Internal Diameter Over 6 inch:
 - 1. AHRI 495, welded steel, tested and stamped in accordance with ASME BPVC-VIII-1; 400 psi with tappings for liquid inlet and outlet valves, pressure relief valve, and magnetic liquid level indicator.

2.13 FLEXIBLE CONNECTORS

- A Corrugated stainless steel hose with single layer of stainless steel exterior braiding, minimum 9 inches long with copper tube ends; for maximum working pressure of 500 psi.

2.14 ENGINEERED WALL SEALS AND INSULATION PROTECTION

- A Pipe Penetration Wall Seal: Seals HVAC piping wall penetrations with compression gasket wall mounted rigid plastic outlet cover.
 - 1. Outlet Cover Color: Gray.
 - 2. Water Penetration: Comply with ASTM E331.
 - 3. Air Leakage: Comply with ASTM E283/E283M.
 - 4. Air Permeance: Comply with ASTM E2178.
- B Insulation Protection System: Mechanical line insulation and PVC cover.
 - 1. PVC Insulation Cover Color: Black with full-length velcro fastener.
 - 2. Weatherization and Ultraviolet Exposure Protection: Comply with ASTM G153.
 - 3. Water/Vapor Permeability: Comply with ASTM E96/E96M.
 - 4. Anti-Fungal and Anti-Microbial Resistance: Comply with ASTM G21.
 - 5. Flame Spread and Smoke Development Rating of 25/450: Comply with ASTM E84.
 - 6. Adhesive free.

PART 3 EXECUTION

3.1 PREPARATION

- A Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B Remove scale and dirt on inside and outside before assembly.

- C Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

- A Install refrigeration specialties in accordance with manufacturer's instructions.
- B Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C Install piping to conserve building space and avoid interference with use of space.
- D Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
- E Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F Pipe Hangers and Supports:
1. Install in accordance with ASME B31.5.
 2. Support horizontal piping as indicated.
 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 4. Place hangers within 12 inches of each horizontal elbow.
 5. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - a. Where trapeze hangers are constructed, the threaded rods supporting the trapeze member shall not extend more than 1" below assembly.
 7. Provide copper plated hangers and supports for copper piping.
- G Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- H Provide clearance for installation of insulation and access to valves and fittings.
- I Flood piping system with nitrogen when brazing.
- J Where pipe support members are welded to structural building frame, brush clean, and apply one coat of zinc rich primer to welding.
- K
- L Insulate piping matching insulation thickness and values shown for preinsulated line sets in this section. Thickness shall be minimum as shown for pre-insulated line sets and shall be greater than or equal to thicknesses recommended by manufacturer.
- M Insulate piping_____; refer to Section 230719 and Section 230716.
- N Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.

- O Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.
- P Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.
- Q Fully charge completed system with refrigerant after testing.
- R Provide electrical connection to solenoid valves. See Section 260583.
- S Route and size piping per manufacturer's requirements. Submit piping diagrams for review prior to installation.
- T Install permanent liquid line filter drier on systems up to 15 tons.

3.3 FIELD QUALITY CONTROL

- A Test refrigeration system in accordance with ASME B31.5.

3.4 SCHEDULES

- A Hanger Spacing for Copper Tubing.
 - 1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 - 2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 - 3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.
 - 4. 1-5/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 5. 2-1/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 6. 2-5/8 inch OD: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 - 7. 3-1/8 inch OD: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 8. 3-5/8 inch OD: Maximum span, 11 feet; minimum rod size, 1/2 inch.
 - 9. 4-1/8 inch OD: Maximum span, 12 feet; minimum rod size, 1/2 inch.
- B Hanger Spacing for Steel Piping.
 - 1. 1/2 inch, 3/4 inch, and 1 inch: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 - 2. 1-1/4 inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 3. 1-1/2 inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 - 4. 2 inches: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 5. 2-1/2 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 - 6. 3 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
 - 7. 4 inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.

3.5 ADJUSTING

- A Adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.
- B Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C Adjust set-point temperature of the conditioned air or chilled-water controllers to the system design temperature.

- D Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Open shutoff valves in condenser water circuit.
 - 2. Check compressor oil level above center of sight glass.
 - 3. Open compressor suction and discharge valves.
 - 4. Open refrigerant valves, except bypass valves that are used for other purposes.
 - 5. Check compressor-motor alignment, and lubricate motors and bearings.
- E Replace core of filter-dryer after system has been adjusted and design flow rates and pressures are established.

3.6 SYSTEM CHARGING

- A Charge system using the following procedures:
 - 1. Install core in filter-dryer after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

END OF SECTION

SECTION 233100
HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Metal ducts.
- B Flexible ducts.

1.2 DEFINITIONS

- A Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C168. In this Section, these values are the result of the formula $\text{Btu} \times \text{in./h} \times \text{sq. ft.} \times \text{deg F}$ or $\text{W/m} \times \text{K}$ at the temperature differences specified. Values are expressed as Btu or W.
 - 1. Example: Apparent Thermal Conductivity (k-Value): 0.25 or 0.037.
- B Pressure - Velocity Classification for Ductwork: As defined by SMACNA Duct Construction Standards - Metal and Flexible (latest edition), and applicable codes. Pressure classification for this specification:
 - 1. Low Pressure: Maximum 2500 FPM velocity; maximum 2.0 inches WG positive or -2.0 inches WG negative static pressure class.
 - 2. Medium Pressure: Maximum 4000 FPM velocity; maximum 4 inches WG positive or -3.0 inches WG or greater negative static pressure class.
 - 3. High Pressure: Velocity over 4000 FPM, pressure over 4 inches WG.
- C Gauge:
 - 1. Steel Sheet: U.S. Standard gauge.
 - 2. Aluminum Sheet: Brown & Sharpe schedule.
 - 3. Steel Wire: Washburn & Moen gauge.
- D Concealed Insulated Surfaces: Ductwork and equipment located in walls, partitions, floors, chases, shafts, and above ceilings.
- E Exposed Insulated Surfaces: Ductwork and equipment located in mechanical rooms, tunnels and rooms without suspended ceilings.

1.3 REFERENCE STANDARDS

- A 29 CFR 1910.146 - Permit-Required Confined Spaces.
- B ASHRAE (FUND) - ASHRAE Handbook - Fundamentals.
- C ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

- D ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Required Hardness, Solution Hardened, and Bake Hardenable.
- E ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- F ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- G NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- H NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- I NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- J SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
- K SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual.
- L UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.

1.4 PERFORMANCE REQUIREMENTS

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

1.5 SUBMITTALS

- A Product Data: Provide data for all duct materials and duct connections.
- B Shop Drawings: Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration prior to start of work for 2" pressure class and higher systems.
 - 1. CAD-generated and drawn to 1/4 inch equals 1 foot (1:50) scale.
 - a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - b. Duct layout indicating sizes and pressure classes.
 - c. Elevations of top and bottom of ducts.
 - d. Dimensions of main duct runs from building grid lines.
 - e. Fittings.
 - f. Reinforcement and spacing.
 - g. Seam and joint construction.
 - h. Penetrations through fire-rated and other partitions.
 - i. Equipment installation based on equipment being used on Project.
 - j. Duct accessories, including access doors and panels.

- k. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.
- C Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Other systems installed in same space as ducts.
 - 3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
 - 4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- D Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate per appropriate seal class, following SMACNA (LEAK).
- E Manufacturer's Installation Instructions: Indicate special procedures for glass fiber ducts.
- F Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.6 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section.
- B Installer Qualifications: Company specializing in performing the type of work specified in this section.
- C Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members, and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- D Comply with ASHRAE and SMACNA Design Handbooks.

1.7 FIELD CONDITIONS

- A Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B Maintain temperatures within acceptable range during and after installation of duct sealants.

1.8 DELIVERY, STORAGE AND HANDLING

- A Ductwork shall not be stored directly on the ground. Watermarked ductwork will not be accepted for installation.
- B Lined ductwork shall have all open ends sealed during delivery and storage periods.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A Provide UL Class 1 ductwork, fittings, hangers, supports, and appurtenances in accordance with NFPA 90A and SMACNA (DCS) guidelines unless stated otherwise.
- B Acoustical Treatment: Provide sound-absorbing liners and sectional silencers for metal-based ducts in compliance with Section 233319.
- C Duct Shape and Material in accordance with Allowed Static Pressure Range:
 - 1. Round: Plus or minus 3 in-wc of galvanized steel.
 - 2. Rectangular: Plus or minus 3 in-wc of galvanized steel.
 - 3. Flat Oval: Plus 3 in-wc of galvanized steel.
- D Duct Sealing and Leakage in accordance with Static Pressure Class:
 - 1. Duct Pressure Class and Material for Common Mechanical Ventilation Applications:
 - a. Low Pressure Supply: 1 inch w.g. pressure class, galvanized steel.
 - b. Medium Pressure Supply: 3 inch w.g. pressure class, galvanized steel.
 - c. Supply Air: 1 in-wc pressure class, galvanized steel.
 - d. Return and Relief Air: 1 in-wc pressure class, galvanized steel.
 - e. General Exhaust Air: 1 in-wc pressure class, galvanized steel.
 - f. Combustion Air: 1 inch w.g. pressure class, galvanized steel.
- E Duct Fabrication Requirements:
 - 1. Duct and Fitting Fabrication and Support: SMACNA (DCS) including specifics for continuously welded round and oval duct fittings.
 - 2. No variation of duct configuration or size permitted except by written permission. Size round duct installed in place of rectangular ducts in accordance with ASHRAE (FUND) Handbook - Fundamentals.
 - 3. Use reinforced and sealed sheet-metal materials at recommended gauges for indicated operating pressures or pressure class.
 - 4. Construct tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide airfoil turning vanes of perforated metal with glass fiber insulation.
 - 5. Provide turning vanes of perforated metal with glass fiber insulation when acoustical lining is indicated.
 - 6. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
 - 7. Provide turning vanes of perforated metal with glass fiber insulation when an acoustical lining is required.
 - 8. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

2.2 MATERIALS

- A Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, FS Type B, with G90/Z275 coating.
 - 1. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- B Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.
- C Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
 - 1. Type: Water based, non-fibrated, heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
 - 2. Joint and Seam Tape: 2 inches wide; glass-fiber-reinforced fabric.
 - 3. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 4. Duct Sealing Rolled Sealant:
 - a. Pressure sensitive, 40-year cycle, duct joint and general purpose rolled sealant. rated for use with sheet metal, duct board, flex board, PVC coated duct, and duct wrap vapor barriers.
 - b. 100 percent solid elastomeric modified butyl with aluminum foil backing.
 - c. Thickness: 17 Mils.
 - 5. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
 - 6. Flange and Joint Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.
- D Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 HANGERS AND SUPPORTS

- A Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- B Hanger Materials: Galvanized sheet steel, threaded steel rod or steel cable with adjustable and removable locking mechanism.
 - 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 - 2. Strap, Rod and Cable Sizes: Comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible" for steel sheet width and thickness and steel rod diameters. Comply with SMACNA and manufacturer's recommendations for cable and locking mechanism sizes.
 - 3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

- C Cable Hanger System:
1. Basis of Design: Gripple and Ductmate Clincher
 2. Products shall carry a 5:1 safety factor.
 3. SMACNA compliance - Tested and verified to be an acceptable hanger per the SMACNA, HVAC Duct Construction Standards.
 4. UL Listing - UL 1598 luminaire fitting sizes 1 - 5, UL 2289 Conduit and Cable Hardware sizes 2, 3 and 4.
 5. Housing: Type ZA2 Zinc.
 6. Wedge: Sintered steel hardened to min. 56 Rockwell C.
 7. Spring: 302 Stainless Steel.
 8. End Cap: UV stabilised homopolymer propylene.
 9. Wire Rope: Grade galvanized high tensile steel wire rope to EN12385.
 10. Toggle Plate and End Stop: Zinc plated steel.
 11. Stud Eyelet and Barrel End: Zinc plated steel.
- D Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- E Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
 3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.
- F Flexible Duct Elbow Supports:
1. Universal-mount, 1-piece, fully adjustable, radius-forming brace to support 4-inch through 16-inch diameter flexible air ducts.
 2. Classified: UL 2043.
 3. Material: 100 percent recycled copolymer polypropylene.
 4. Support Frame Radius: 8 inches.
 5. Compliance for Flexible Duct Radius:
 - a. SMACNA HVAC Duct Construction Standards.
 - b. ASHRAE Advanced Energy Design Guides.
 - c. ADC Flexible Duct Performance and Installation Standards.
 6. Basis of Design: FlexRight (Durable Elbow Support)

2.4 DUCTWORK FABRICATION

- A Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation. Radius T's, bends and elbows less than 1-1/2 times width of duct on centerline are not allowed.
- B Low Pressure Ductwork: Construct all ductwork using galvanized steel except as indicated.
1. Seams and Joints: Longitudinal seams shall be grooved seams, button punch snap lock or Pittsburgh lock. Transverse joints shall be drive slip. Joints 36-inch size and larger shall be manufactured duct joining system with downset corners, no-bolt design, or SMACNA T-25 formed on flanges with corner and cleat. Contractor option on smaller sizes.

- C Medium and High Pressure Duct: Construct all ductwork using galvanized steel except as indicated.
 - 1. Seams and Joints: Longitudinal seams shall be grooved seam type with sealant or gasket and center punched at 12-inch maximum intervals or Pittsburgh lock with sealant or gasket. Transverse joints shall be flanged and gasketed manufactured duct joining system with downset, bolted corner.
- D Branch ducts to air devices shall be bell-mouth, conical or 45 degrees to round boot type fitting as a basis. Straight tap-ins, splitter dampers, and air extractors shall not be used.
- E Duct connections to fans/air-handling units shall be designed for proper entering and leaving conditions at the fan to avoid any adverse system effect fan losses.

2.5 MANUFACTURED DUCTWORK, FITTINGS AND CONNECTORS

- A Manufacturers:
 - 1. Ductmate Industries, Inc.:
 - 2. Eastern Sheet Metal.
 - 3. KB Duct
 - 4. LaPine Metal Products
 - 5. Lewis and Lambert
 - 6. Linx Industries
 - 7. Metal-Fab, Inc.: www.mtlfab.com.
 - 8. MKT Metal Manufacturing: www.mktduct.com.
 - 9. Nexus Inc.
 - 10. Norlock
 - 11. SEMCO Incorporated: www.semcoinc.com.
 - 12. S.E.T. Duct Manufacturing
 - 13. Sheet Metal Connectors.
 - 14. United McGill Corp.: www.unitedmcgill.com.
 - 15. Ward Industries, Inc.
 - 16. Or pre-approved equivalent.
- B Material Requirements:
 - 1. Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.
 - 2. Ungalvanized Steel: ASTM A1008/A1008M Designation CS (commercial steel), cold-rolled.
 - 3. Aluminum: ASTM B209/B209M, aluminum sheet, alloy 3003-H14.
- C Flat-Oval Metal Ducts:
 - 1. Flat-Oval Single Wall Duct: Machine made from a round spiral lock seam duct.
 - a. Fittings: Manufacture at least two gauges heavier metal than the duct.
 - b. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- D Round Metal Ducts:
 - 1. Round Single Wall Duct: Round lock seam duct with galvanized steel outer wall.
 - 2. Round Double Wall Insulated Duct: Round spiral lock seam duct with galvanized steel outer wall, perforated galvanized steel inner wall; fitting with the solid inner wall.

- a. Insulation:
 - 1) Thickness: 1 inch.
 - 2) Material: Air.
 - 3. Round Connection System: Interlocking duct connection system in accordance with SMACNA (DCS).
- E Round Spiral Duct:
- 1. Round spiral lock seam duct with galvanized steel outer wall.
- F Connectors, Fittings, Sealants, and Miscellaneous:
- 1. Fittings: Manufacture with solid inner wall of perforated galvanized steel.
 - 2. Transverse Duct Connection System: SMACNA "E" rated rigid class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips in accordance with SMACNA (DCS).
 - 3. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
 - a. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
 - b. VOC Content: Not more than 250 g/L, excluding water.
 - c. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
 - d. For Use with Flexible Ducts: UL labeled.
 - 4. Gasket Tape:
 - a. Provide butyl rubber gasket tape for a flexible seal between transfer duct connector (TDC), transverse duct flange (TDF), applied flange connections, and angle ring connections.

2.6 FLEXIBLE DUCTS

- A Flexible Air Ducts:
- 1. UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound spring steel wire.
 - 2. Insulation: Fiberglass insulation with polyethylene vapor barrier film.
 - 3. Pressure Rating: From 10 in-wc positive to 1 in-wc negative.
 - 4. Maximum Velocity: 4,000 fpm.
 - 5. Temperature Range: Minus 20 to 210 degrees F.
- B Vapor Barrier Insulated Flexible Air Ducts:
- 1. UL 181, Class 1, two-ply polyester or vinyl film supported by helically wound spring steel wire.
 - 2. Insulation: Fiberglass insulation with polyethylene vapor barrier core.
 - 3. Pressure Rating: From 10 in-wc positive to 1 in-wc negative.
 - 4. Maximum Velocity: 4,000 fpm.
 - 5. Temperature Range: Minus 10 to 160 degrees F.

2.7 DUCT LINER

- A Refer to Section 23 0713 - Duct Insulation.

PART 3 EXECUTION

3.1 PRE-INSTALLATION

- A Field measure to determine exact conditions.
- B Provide duct opening closure film on all ductwork until final connections are completed.
- C Verify location of air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Refer to reflected ceiling plans, finish schedule, material finish specification, and shop drawings.
- D Openings required for ductwork through structural elements in new construction shall be coordinated with all contractors. Shop drawings locating such openings shall be prepared in ample time to meet the construction schedule.
- E Coordinate and install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install ducts with a clearance of 2 inches, plus allowance for insulation thickness.
- F Coordination Process and Drawings:
 - 1. Provide coordination in determining adequate clearance and space requirements for mechanical equipment and electrical equipment and other items/equipment in the project. The Design Professional reserves the right to determine space priority of equipment in the event of interference between pieces of equipment, piping, conduit, ducts and equipment of the trades. The Design Professional will only review conflicts and given an opinion but will not perform as a coordinator.
 - a. The coordination process shall utilize the actual equipment being provided. Refer to manufacturer's data for physical size, access and maintenance requirements. Provide all code required clearances.
 - 2. Provide coordination drawings indicating structural components, reflected ceiling layout, mechanical items, electrical items, and pneumatic tube systems. Indicate on the coordination drawings where components will be installed and how the service access area to such items shall be maintained, Illustrate items requiring access for maintenance or adjustment.
 - 3. The Contractor will not be allowed any time extensions for participation in the coordination drawing process. The Contractor will not be allowed any contract cost extra for any additional fittings, rerouting or changes of duct size to equivalent sizes to those shown on the drawings that may be determined necessary through the coordination drawing process.
 - 4. Equipment layout and all system layouts shall confirm adequate clearances for installation, operation, maintenance, and code-required clearances from the structure or other equipment and systems. Provide offsets and elevation changes in piping, conduit and ductwork as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.
 - 5. Deviations from the contract documents that are necessary for overall system installation and coordination shall be brought to the attention of the Design Professional.
 - 6. Access panels shall occur only in gypsum wallboard or plaster ceilings where indicated on the drawings. Access to mechanical and electrical items shall be through accessible

acoustical ceiling areas. Additional access panels will not be allowed without written approval from the Design Professional at the coordination drawing stage and only after alternatives are reviewed. Layout changes shall be made to avoid additional access panels. If additional access panels are required, they shall be provided at no additional cost to the Owner.

7. Soffit penetrations and light alcoves shall be fully coordinated with hanging devices, studs, fire/smoke ratings, and structural support requirements.
8. Drawings shall be prepared at 1/4 inch = 1 foot, 0 inches (minimum).
 - a. Coordination participants shall provide equipment installation and clearance requirements. This information shall be indicated on the coordination drawings.
 - b. Coordination drawings shall indicate the following major system components (including insulation, hub or connection widths with verification of turning radius):
 - 1) All general construction components
 - 2) Roof drain leaders
 - 3) Large waste piping
 - 4) Sprinkler mains
 - 5) Equipment located above the ceiling
 - 6) Conduit runs 2 inches and larger
 - 7) Cable tray
 - 8) Bus duct
 - 9) Recessed light fixtures
 - 10) Building wiring or cable trays
 - 11) Ceiling heights as shown in contract documents and thickness of system
 - 12) Soffits (including framing of supports)
 - 13) Access points and clearances required
 - 14) Access panels
 - 15) Valves
 - 16) Dampers
 - 17) Coils
 - 18) Ductwork
 - 19) Fire-rated wall, partition, and floor penetrations
 - 20) condensate piping
 - 21) Space allotted for future utilities
 - 22) Equipment in mechanical and electrical spaces
 - c. Information shall be delineated to indicate distances from column centerlines, pipe/equipment size, and distance from finished floor to bottom of pipe/equipment and hangers.
9. The Contractor and subcontractors responsible for items of work located in or above ceilings shall participate in the coordination drawing process. Participation is mandatory. If the Contractor or subcontractor fails to participate in the coordination drawing process, the Owner reserves the right to do the following:
 - a. Stop construction progress payments for work performed by the Contractor. Payments will be reinstated only after the Contractor or subcontractor resumes participation in the coordination drawing process.
 - b. Require the relocation and resizing of components as necessary to ensure components will be installed as intended. In the event the Contractor did not participate in the coordination process, the Contractor will not be entitled to contract cost increases or time extensions due to Owner-initiated changes in the work.

- c. The Contractor shall be held responsible for unnecessary rework that is attributable to failure to participate in the coordination process.
- 10. The coordination drawings shall be submitted to the Design Professional and Owner's representative for review. The submitted coordination drawings shall indicate which contractors participated in the process and where conflicts appear to occur even after the priority ranking of utility routing has been utilized. In the event that conflicts require input from the Design Professional, recommended solutions will be provided with the coordination drawings for review by the Design Professional. The Design Professional will review and return an opinion to the contractors for implementation. All contractors shall agree to the final coordinated layout by signing off on the coordination drawings before any construction can begin.
- 11. Maintain an updated set of coordination drawings at the job site reflecting changes, modifications and adjustments. Changes shall be reflected and sets or new sheets reissued to the Design Professional and the Owner for review on a monthly basis with changes "clouded" and brought to the attention of the Design Professional and the Owner.
- 12. When a change order request is issued, the affected subcontractors shall review the coordination drawings and bring to the attention of the Contractor and the Design Professional revisions necessary to the work of others not directly affected by the change order.
- 13. Contractors that fail to cooperate in the coordination drawing effort shall be responsible for all costs incurred for adjustments to the work made necessary to accommodate installations. Provide adequate clearance and access through accessible ceilings. Conflicts that result after the coordination drawings are signed off will be the responsibility of the Contractor or subcontractor who did not properly identify their work or installed the work improperly.

3.2 INSTALLATION

- A Install, support, and seal ducts in accordance with SMACNA (DCS).
 - 1. Hanging, Sealing and Supporting:
 - a. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
 - b. Support vertical ducts at a maximum interval of 16 feet and at each floor.
 - c. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
 - d. Install concrete inserts before placing concrete.
 - e. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 1) Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 - f. Seal ducts before external insulation is applied.
- B Install products following the manufacturer's instructions.
- C Comply with safety standards NFPA 90A and NFPA 90B.
- D During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system. Keep openings covered until ready

for continuing duct run or final connections. Clean all unlined supply air ductwork during installation by swabbing with a non-toxic, non-flammable cleaning agent.

- E Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- F Provide volume dampers in all branch take-offs connecting to diffusers, registers and grilles, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
 - 1. Provide access door or remote damper operator to adjust dampers.
 - 2. Registers and diffusers with dampers shall be used only if devices are installed directly on the trunk duct.
- G Provide volume dampers in all duct systems where indicated and as required to perform complete system test and balance. Coordinate all volume damper locations with the test and balance contractor.
 - 1. Provide access door or remote damper operator to adjust dampers.
- H Flexible Ducts: Connect to metal ducts with draw bands.
 - 1. Flexible ductwork shall be attached to metal collars or sleeves with draw bands. Duct adhesive shall be added to connections as required per duct system sealing class. Metal collars or sleeves 12 inches and larger shall contain draw band holding beads.
 - 2. Low Pressure Ductwork: Peel back vapor barrier and fold back insulation; then secure to duct collar or sleeve with metal or nylon clamps or draw bands; then fold over insulation and vapor barrier and secure with two stretched wraps of approved cut tape.
 - 3. Medium Pressure Ductwork: Peel back vapor barrier and fold back insulation; then secure to duct collar or sleeve with approved duct adhesive; then secure with metal draw bands or clamps; then fold over insulation and vapor barrier and secure with two stretched wraps of approved duct tape. Take two or three tucks in vapor barrier while taping.
 - 4. Support flexible ductwork following manufacturer's recommendations and SMACNA HVAC Duct Construction Standards.
 - 5. Final connections to air inlets and outlets may be made with flexible ductwork. Expanded length of flexible ductwork shall not exceed 36 inches. Path of flexible ductwork shall not exceed 45 degrees unless flexible duct elbow supports are provided.
 - 6. Flexible Duct Elbow Supports:
 - a. Install flexible duct elbow supports in accordance with manufacturer's instructions.
 - b. Install flexible duct elbow supports over outer jacket of flexible ducts to form smooth, 90-degree bends to eliminate flexible duct kinks and airflow restrictions.
 - c. Install flexible duct elbow supports at flexible duct 90-degree bends at following locations:
 - 1) Diffusers.
 - 2) Grilles.
 - 3) Registers.
 - 4) Duct take-offs and taps.
 - 5) Air devices with round inlets and outlets.
 - 6) HVAC equipment with round inlets and outlets.
 - 7) As indicated.
- I Duct sizes indicated are precise inside dimensions. For lined ducts, maintain sizes inside lining.

- J Provide openings in ductwork as indicated to accommodate thermometers and controllers. Provide pilot tube openings as indicated for testing of systems, complete with metal can with spring device or screw to insure against air leakage. For openings, insulate ductwork and install insulation material inside a metal ring.
- K Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- L Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with a crimp in the direction of airflow.
- M Use double nuts and flat washer on threaded rod supports.
- N Connect terminal unit inlets to supply ducts directly or with one foot maximum length of straight run of flexible duct. Do not use flexible duct to change direction.
- O Set plenum doors at 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
- P Plenums and Casings:
1. Mount floor-mounted casings on 4 inch high concrete curbs.
 2. Where floors are acoustically insulated, provide liner of galvanized 18-gauge, 0.052-inch expanded metal mesh supported at 12-inch centers, turned up 12 inches at sides with sheet metal shields.
- Q Fire Partitions: Provide firestopping sealing.
- R Penetrations:
1. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.
 2. Provide sleeves at all duct penetrations through walls, floors and roofs. Openings through sound-rated partitions shall have annular space stuffed with fiberglass insulation for full thickness of wall.
 3. Provide closure flanges around exposed ductwork at wall and ceiling penetrations, 1-1/4 inches wide minimum.
- S Provide 2-inch deep bitumastic coated drip pans on all non-ducted hoods, fans or penthouses used for relief or exhaust air service. Pans shall be 12 inches larger all around than roof opening with clear vertical openings between pan and structure as indicated. Insulate pan where indicated.
- T Install round and flat-oval ducts in lengths not less than 12 feet, unless interrupted by fittings.
- U Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

- V Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.
- W Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- X Prevent passage of unfiltered air around filters with felt, rubber, neoprene gaskets, or other approved safing material.
- Y Paint ductwork visible behind wall-mounted air outlets and inlets matte black.
- Z Provide flexible connect between ductwork and all moving equipment.

END OF SECTION

SECTION 233300
AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Air turning devices.
- B Backdraft dampers - metal.
- C Duct access doors.
- D Duct test holes.
- E Flexible duct connectors.
- F Volume control dampers.
- G Miscellaneous Products:
 - 1. Internal strut end plugs.
 - 2. Duct opening closure film.
- H Pipe flashing hood.
- I Duct accessory hardware.
- J Filter gauges.

1.2 REFERENCE STANDARDS

- A NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- B SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
- C UL 555 - Standard for Fire Dampers.
- D UL 555S - Standard for Smoke Dampers.

1.3 SUBMITTALS

- A Product Data: Provide for shop-fabricated assemblies including volume control dampers, duct access doors, duct test holes, and hardware used. Include electrical characteristics and connection requirements.
- B Shop Drawings: Indicate for shop and field fabricated assemblies including volume control dampers and duct access doors.
 - 1. Special fittings.
 - 2. Motorized-control damper installations.

- 3. Wiring Diagrams: Power, signal, and control wiring.
- C Project Record Drawings: Record actual locations of access doors and test holes.
- D Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.4 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section.
- B Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

- A Access Doors, Devices and Accessories:
 - 1. Acudor Products Inc: www.acudor.com.
 - 2. Carlisle HVAC Products: www.carlislehvac.com/sle.
 - 3. Ductmate Industries, Inc.
 - 4. Elgen Manufacturing: www.elgenmfg.com.
 - 5. Flexmaster U.S.A., Inc.
 - 6. Greenheck: www.greenheck.com
 - 7. Krueger: www.krueger-hvac.com.
 - 8. Lloyd Industries, Inc.: www.firedamper.com.
 - 9. Nailor Industries Inc: www.nailor.com.
 - 10. PCI Industries, Inc; Pottorff Brand [<>]: www.portorff.com.
 - 11. Ruskin Company: www.ruskin.com.
 - 12. SEMCO Incorporated: www.semcohvac.com.
 - 13. Titus: www.titus-hvac.com.
 - 14. United Enertech
 - 15. Ventfabrics, Inc.
 - 16. Vent Products Company, Inc.
 - 17. Young Regulator Co
 - 18. CL Ward Industries, Inc: www.clward.com/.
 - 19. Or pre-approved equivalent.
- B Dampers:
 - 1. Air Balance, Inc.
 - 2. Greenheck: www.greenheck.com
 - 3. Louvers & Dampers, Inc: www.louvers-dampers.com.
 - 4. Lloyd Industries, Inc.[<>]: www.firedamper.com.
 - 5. Nailor Industries Inc[<>]: www.nailor.com.
 - 6. NCA Manufacturing, Inc.: www.ncamfg.com
 - 7. Pottorff/PCI Industries, Inc; Pottorff Brand : www.portorff.com.

8. Rossi: www.rossihardware.com
9. Ruskin Company: www.ruskin.com.
10. Tamco
11. United Enertech: www.unitedenertech.com/#sle.
12. Vent Products Company, Inc.
13. CL Ward Industries, Inc: www.clward.com/.
14. Or pre-approved equivalent.

C See paragraphs below for additional manufacturers.

2.2 SHEET METAL MATERIALS

- A Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- B Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- C Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.
- D Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- E Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 AIR TURNING DEVICES

- A Multi-blade device with blades aligned in short dimension; steel construction; with individually and mounting straps.
- B Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.4 BACKDRAFT DAMPERS - METAL

- A Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.
- B Frame: 0.052-inch-thick, galvanized sheet steel, with welded corners and mounting flange.
- C Blades: 0.025-inch-thick, roll-formed aluminum.
- D Blade Seals: Vinyl.
- E Blade Axles: Nonferrous.
- F Bearings: Synthetic.

- G Tie Bars and Brackets: Galvanized steel.
- H Spring Assisst: Adjustable tension for use in vertical up air flow or low pressure relief applications.
- I Counter-Balanced: Adjustable for use in vertical down air flow applications.

2.5 DUCT ACCESS DOORS

- A Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick-fastening locking devices. For insulated ducts, install minimum 1-inch thick insulation with sheet metal cover.
 - 1. Less Than 12 inches Square: Secure with sash locks.
 - 2. Up to 18 inches Square: Provide two hinges and two sash locks.
 - 3. Up to 24 by 48 inches: Three hinges and two compression latches with outside and inside handles.
 - 4. Larger Sizes: Provide an additional hinge.
 - 5. Access doors shall be provided with sash locks only when clearance space does not allow a door swing.
- B Access doors with sheet metal screw fasteners are not acceptable.
- C Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with foam insulation fill and 1-inch thickness.
 - 1. Frame: Galvanized sheet steel, with spin-in notched frame.
- D Pressure Relief Access Door: Double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.
 - 1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
- E Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

2.6 DUCT TEST HOLES

- A Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- B Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.7 FLEXIBLE DUCT CONNECTORS

- A Fabricate in accordance with SMACNA (DCS) and as indicated.
- B Flexible Duct Connections: Fabric crimped into metal edging strip.
 - 1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz/sq yd.
 - a. Net Fabric Width: Approximately 2 inches wide.
 - 2. Metal: 3 inches wide, 24 gauge, 0.0239 inch thick galvanized steel.

- C Leaded Vinyl Sheet: Minimum 0.55 inch thick, 0.87 lbs per sq ft, 10 dB attenuation in 10 to 10,000 Hz range.
- D Maximum Installed Length: 14 inch.
- E Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 degrees F.
- F Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd.
 - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 degrees F.
- G High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd.
 - 2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 degrees F.

2.8 VOLUME CONTROL/BALANCING DAMPERS

- A Fabricate in accordance with SMACNA (DCS) and as indicated.
- B Single Blade Dampers:
 - 1. Fabricate for duct sizes up to 6 by 30 inch.
 - 2. Blade: 24 gauge, 0.0239 inch, minimum.
- C Multi-Blade Damper: Fabricate consisting of opposed blades with maximum blade sizes 8 by 72 inches. Assemble center- and edge-crimped blades in prime-coated or galvanized-channel frame with suitable hardware.
 - 1. Blade: 18 gauge, 0.0478 inch, minimum.
- D End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.
- E Quadrants:
 - 1. Provide positive-locking, indicating quadrant regulators on single and multi-blade dampers.
 - 2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
 - 3. Where rod lengths exceed 30 inches provide regulator at both ends.

2.9 MISCELLANEOUS PRODUCTS

- A Internal Strut End Plugs: Combination end-mounting and sealing plugs for metal conduit used as internal reinforcement struts for metal ducts; plug crimped inside conduit with outside gasketed washer seal.

- B Duct Opening Closure Film: Mold-resistant, self-adhesive film to keep debris out of ducts during construction.
 - 1. Thickness: 2 mils.
 - 2. High tack water based adhesive.
 - 3. UV stable light blue color.
 - 4. Elongation Before Break: 325 percent, minimum.
- C Jackshaft: 1-inch-diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 - 1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
- D Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.10 REMOTE VOLUME DAMPER BALANCING POSITION CONTROL (MANUAL ACTUATOR)

- A Young Regulator, Bowden Cable Controls Model No. 270-275 or 896 C, concealed ceiling damper regulator with 7/8-inch cap and #030 wrench adjustable with #030 wrench.
- B Volume damper shaft mounting hardware as required for installation of controls.

2.11 PIPE OR CONDUIT PENetration HOUSING & HOODS

- A Manufacturer:
 - 1. Pate
 - 2. RPH; www.RoofPenetrationHousings.com
 - 3. Or pre-approved equivalent.
- B Lid and housing lined with insulation to a minimum value of R-19.
- C Warranty: 20 years.
- D Roof Mounted: Engineered penetration housing, accommodating up to 18 pipes/conduits-- cables, water, refrigeration, and power in one roof penetration with high rain tight integrity.
- E Roof penetration system is constructed of 14 gauge powder coated, welded, galvanized steel or aluminum with stainless steel hardware.
 - 1. Removable, gasketed, pitched cover.
 - 2. Exit seals shall be schedule 80 PVC with UV protection.
 - 3. All seals must be protected from UV with an aluminum or stainless steel jacket.
- F Coordinate size of housing and hoods with all trades utilizing the penetration.
- G Furnish with 18-inch tall curb for roof applications.

2.12 FILTER GAGES

- A Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
 - 1. Diameter: 4-1/2 inches.
 - 2. Range: 0- to 0.5-inch wg.

PART 3 EXECUTION

3.1 PREPARATION

- A Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

- A Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). See Section 233100 for duct construction and pressure class.
- B Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- D Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96. Provide minimum 12 x 12 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated. Provide 4 x 4 inch for balancing dampers only. Review locations prior to fabrication.
- E Provide duct access doors to all internal devices requiring inspection for maintenance. Coordinate location devices in access door to allow proper access to equipment once project has been completed. Duct access doors shall be square and sized 2 inches less than the width of the duct. Maximum door size shall be 18 inches. If required, provide multiple doors for adequate access to equipment.
- F Provide duct test holes where indicated and required for testing and balancing purposes.
- G At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- H At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.
- I Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum two duct widths from duct take-off.

- J Provide volume control (balancing) dampers on duct take-off to all air inlets and outlets, diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
 - 1. Provide access door or remote damper operator to adjust dampers. Registers and diffusers with dampers shall be used only if devices are installed directly on the trunk duct.
- K Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.
- L Label all duct access doors.
- M Provide flexible connections to motor driven air moving equipment. Secure fabric to duct or fan collar with 3/16-inch rivets spaced not more than 5 inches o.c. Provide thrust restraints and other devices so that connections are not in tension with equipment running or off. Air handling units with internally isolated fans need not have flexible connections.
- N Volume dampers located above inaccessible ceilings shall be controlled by remote volume damper position controls.
- O Provide turning vanes in all mitered duct turns.
- P Provide filter gage for each filter bank.

3.3 REMOTE VOLUME DAMPER POSITION CONTROLS

- A Provide at all volume dampers that are not accessible from access panels.
- B Extend cable and locate adjuster to an area that is accessible by an access panel or removal of an accessible ceiling component.
- C Submit locations of ceiling- or wall-mounted adjusters to Architect/Engineer for review prior to installation.

3.4 ADJUSTING

- A Adjust duct accessories for proper settings.

3.5 DEMONSTRATION

- A Demonstrate the following to the owner's representative and maintenance personnel:
 - 1. Access to all volume damper position controls.
 - 2. Access to control damper actuators.

END OF SECTION

SECTION 233423
HVAC POWER VENTILATORS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Roof exhausters.
- B Cabinet exhaust fans.

1.2 REFERENCE STANDARDS

- A AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program.
- B AMCA 99 - Standards Handbook.
- C AMCA 204 - Balance Quality and Vibration Levels for Fans.
- D AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
- E AMCA 300 - Reverberation Room Methods of Sound Testing of Fans.
- F AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- G NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- H UL 705 - Power Ventilators.

1.3 SUBMITTALS

- A Product Data: Provide data on fans and accessories, including fan curves with specified operating point plotted, power, rpm, sound power levels at rated capacity, and electrical characteristics and connection requirements.
 - 1. Operating weights.
 - 2. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 3. Material thickness and finishes, including color charts.
 - 4. Dampers, including housings, linkages, and operators.
 - 5. Fan speed controllers.
 - 6. Wiring Diagrams: Power, signal, and control wiring.
 - 7. Roof curbs.
- B Manufacturer's Instructions: Indicate installation instructions.
- C Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

D Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. Extra Fan Belts: One set for each individual fan.

1.4 QUALITY ASSURANCE

A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section.

1.5 FIELD CONDITIONS

A Request Owner permission to use permanent ventilator(s) for ventilation during construction.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A ACME Engineering and Manufacturing Corporation; : www.acmefan.com.

B Carnes, a division of Carnes Company Inc: www.carnes.com//.

C Greenheck: www.greenheck.com.

D JencoFan; Div.

E Loren Cook Company: www.lorencook.com.

F PennBarry: www.pennbarry.com.

G Soler & Palau Ventilation Group

H Twin City Fan & Blower: www.tcf.com//.

I Or pre-approved equivalent.

2.2 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A See Drawings for Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.3 POWER VENTILATORS - GENERAL

A Fan systems shall incorporate integral lifting lugs for ease of installation.

B Fan shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure, and maximum fan RPM.

C Static and Dynamically Balanced: Comply with AMCA 204.

D Performance Ratings: Comply with AMCA 210, bearing certified rating seal.

- E Sound Ratings: Comply with AMCA 301, tested to AMCA 300, bearing certified sound ratings seal.
- F Fabrication: Comply with AMCA 99.
- G UL Compliance: UL 705, listed, labeled, designed, manufactured, and tested.
- H Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- I Motor:
 - 1. Refer to Section 230513.
 - 2. Motor shaft grounding kit for VFC applications.
- J Belt Drive Assembly:
 - 1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
 - 2. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - 3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
 - 4. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position.
 - 5. Automatic belt tensioner to maintain proper belt tension.
 - 6. Motor pulley adjustable for final system balancing.
 - 7. Readily accessible for maintenance.
- K Enclosed Safety Switches: Comply with NEMA EN 10250.

2.4 ROOF EXHAUSTERS

- A Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.
- B Roof Curb: 16 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips.
- C Disconnect Switch: Factory wired, nonfusible, in housing for thermal overload protected motor.
- D Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked.
- E Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.

2.5 CABINET EXHAUST FANS

- A Centrifugal Fan Unit: V-belt or direct driven with galvanized steel housing lined with acoustic insulation, resiliently mounted motor, gravity backdraft damper in discharge.

- B Disconnect Switch: Cord and plug-in housing for thermal overload protected motor and wall mounted switch.
- C Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
- D Grille: Aluminum with baked white enamel finish.

PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Secure roof exhausters with cadmium plated steel lag screws to roof curb.
- C Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.
- D Provide sheaves required for final air balance.
- E Install backdraft dampers on inlet to roof and wall exhausters.
- F Provide backdraft dampers on outlet from cabinet and ceiling exhaust fan and as indicated.
- G Install power ventilators level and plumb.
- H Ceiling Units: Suspend units from structure.
- I Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch.
- J Install units with clearances for service and maintenance.

3.2 CONNECTIONS

- A Install ducts adjacent to power ventilators to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

- A Perform the following field tests and inspections and prepare test reports:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 5. Adjust belt tension.
 - 6. Adjust damper linkages for proper damper operation.
 - 7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- B Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

- A Adjust damper linkages for proper damper operation.
- B Adjust belt tension.
- C Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.
- D Replace fan and motor pulleys as required to achieve design airflow.
- E Lubricate bearings.

END OF SECTION

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SECTION 233600
AIR TERMINAL UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Single-duct terminal units.
 - 1. Variable-volume units.

1.2 REFERENCE STANDARDS

- A AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
- B AHRI 880 (I-P) - Performance Rating of Air Terminals.
- C ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality.
- D ASHRAE Std 130 - Laboratory Methods of Testing Air Terminal Units.
- E ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- F NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- G NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.3 SUBMITTALS

- A Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate airflow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
- B Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
 - 1. Include schedules listing discharge and radiated sound power level for each of the second through sixth-octave bands at inlet static pressures of 1 to 4 in-wc.
- C Certificates: Certify that coils are tested and rated in accordance with AHRI 410.
- D Manufacturer's Installation Instructions: Indicate support and hanging details, installation instructions, recommendations, and service clearances required.
- E Project Record Documents: Record actual locations of units and locations of access doors required for access of valving.
- F Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant-volume regulators.

G Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

H Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1.4 QUALITY ASSURANCE

A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section.

B Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

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

1.5 WARRANTY

A Provide one year manufacturer warranty for air terminal units.

1.6 COORDINATION

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

1. Coordinate maintenance clearance requirements of all terminal unit controls components prior to ordering and submitting units for review.

PART 2 PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A See Drawings for Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 MANUFACTURERS

A Anemostat.

B Carnes Company: www.carnes.com.

C Carrier Corp.

D Environmental Technologies, Inc.; Enviro-Air Div.

E Greenheck; www.greenheck.com.

F Johnson Controls, Inc: www.johnsoncontrols.com.

G Krueger; www.krueger-hvac.com

- H Metalaire Inc.; Metal Industries Inc.
- I Nailor Industries Inc.: www.nailor.com.
- J Price Industries.; www.priceindustries.com.
- K Titus; www.titus-hvac.com.
- L Trane Inc: www.trane.com.
- M Tuttle & Bailey.
- N Siemens.
- O Or pre-approved equivalent.

2.3 SOURCE QUALITY CONTROL

- A Identification: Label each air terminal unit with plan number, room number served, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

2.4 GENERAL

- A Basic Assembly:
 - 1. Factory insulated casing, reheat coil, access door and sound attenuating sections.
 - 2. Plenum Air Inlets: Round stub connections for duct attachment.
 - 3. Plenum Air Outlets: S slip and drive connections.
 - 4. Access: Insulated, removable panels or doors for access to heating coils, dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.
 - 5. Heating coil access doors located upstream of heating coil for coil cleaning purposes.
- B Basic Unit:
 - 1. Configuration: Air volume damper assembly inside unit casing.
 - 2. Locate control components inside protective metal enclosure.

2.5 SINGLE-DUCT, VARIABLE-VOLUME UNITS

- A Acoustic Performance Requirements:
 - 1. Sound ratings of air distribution assemblies: Not to exceed 30 NC at a .50" static pressure drop across the unit, and the downstream static pressure of .25".
- B General:
 - 1. Factory-assembled, AHRI 880 (I-P) rated and bearing the AHRI seal, air volume control terminal with damper assembly, flow sensor, externally mounted volume controller, duct collars, and all required features.
 - 2. Control box bearing identification, including but not necessarily limited to nominal cfm, maximum and minimum factory-set airflow limits, coil type and coil (right or left hand) connection, where applicable.
 - 3. Basic Unit:
 - a. Mount damper operator to position damper normally open.

C Unit Casing:

1. Minimum 22 gauge, 0.0299 inch galvanized steel.
 - a. Casing leakage to meet ASHRAE Std 130.
2. Air Inlet Collar: Provide round, suitable for standard flexible duct sizes.
3. Unit Discharge: Rectangular, with slip-and-drive connections.
4. Acceptable Liners:
 - a. 3/4 inch thick adhesive of polyurethane or neoprene foam complying with UL 181 erosion requirements in accordance with ASHRAE Std 62.1, and having a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84.
 - b. Liner not to contain pentabrominated diphenyl ether (CAS #32534-81-9) or octabrominated diphenyl ether.

D Damper Assembly:

1. Heavy-gauge, galvanized steel, or extruded aluminum construction with solid steel, nickel-plated shaft pivoting on HDPE, self-lubricating bearings.
2. Provide integral position indicator or alternative method for indicating damper position over full range of 90 degrees.
3. Incorporate low leak damper blades for tight airflow shutoff.

E Electric Heating Coil:

1. Listed and provided by the terminal unit manufacturer.
2. Coil Casing: 20 gauge, 0.0359 inch galvanized steel.
3. Heating Elements: Nickel chrome, supported by ceramic insulators.
4. Integral Control Panel: NEMA EN 10250, Type 2 enclosure with hinged access door for access to all controls and safety devices.
5. Furnish a primary automatic reset thermal cutout and differential pressure airflow switch for proof of airflow.
6. Provide the following additional components, mounted and/or wired within the control enclosure:
 - a. Fused or non-fused door interlocking disconnect switch.
 - b. Mercury contactors.
 - c. Fuse block.
7. Factory wired, including all limit switches and steps of control as indicated on the equipment schedule, with the SSR (solid-state relay) proportional heat control.

F Controls:

1. DDC (Direct-Digital Controls):
 - a. See Section 23 0923.
2. Airflow Sensor: Differential pressure airflow device measuring total, static, and wake pressures.
 - a. Signal accuracy: Plus/minus five percent throughout terminal operating range.

PART 3 EXECUTION**3.1 EXAMINATION**

- A Verify that conditions are suitable for installation.

- B Verify that field measurements are as indicated on drawings.

3.2 INSTALLATION

- A Install in accordance with manufacturer's instructions. Provide a minimum of 18" clearance to all servicable components.
- B Provide all code required service clearances.
- C Provide code required access clearances, 36" minimum, to all electrical components and panels.
- D Install the inlets of air terminal units and air flow sensors a minimum of four duct diameters from elbows, transitions, and duct takeoffs.
- E Coordinate locations of control components, heating coil piping and access door or panels with installation space available. Adjusting indicated location of terminal unit and heating coil piping is acceptable if necessary to acheive required service clearances.
- F Provide 24" x 24" ceiling access doors at each unit or locate units above easily removable ceiling components.
- G Support units individually from structure with wire rope complying with SMACNA (SRM).
- H Embed anchors in concrete in accordance with ASTM E488/E488M.
- I Do not support units from adjacent ductwork.
- J Connect to ductwork in accordance with Section 233100.
- K Verify that electric power is available and of the correct characteristics.
- L Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- M Provide 10" x 8" (min.) access doors upstream of reheat coils, as indicated, for cleaning and service.

3.3 CONNECTIONS

- A Provide straight run of inlet supply ductwork as required by manufacturer.
- B Provide flexible duct connection on discharge (supply) air connection to fan powered terminal units as indicated.
- C Connect ductwork according to 23 3100 - HVAC Ducts and Casings. Prvide inlet and outlet duct connections as recommended by air terminal unit manufacturer to achieve proper performance.

3.4 DEMONSTRATION

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

3.5 ADJUSTING

- A Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to zero percent full flow.

3.6 FIELD QUALITY CONTROL

- A Provide manufacturer's field representative to inspect and instruct field-assembled components and equipment installation, including connections. Report results in writing.
 - 1. Complete installation and startup checks according to manufacturer's written instructions and do the following:
 - a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - b. Verify that controls and control enclosure are accessible.
 - c. Verify that control connections are complete.
 - d. Verify that nameplate and identification tag are visible.
 - e. Verify that controls respond to inputs as specified.
 - 2. Leak Test:
 - a. After installation, fill water coils and test for leaks.
 - b. Repair leaks and retest until no leaks exist.
 - 3. Operational Test:
 - a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Test and adjust controls and safeties.
 - c. Replace damaged and malfunctioning controls and other equipment.
 - d. Remove and replace malfunctioning units and retest as specified above.

3.7 CLEANING

- A Vacuum clean coils and inside of units.

END OF SECTION

SECTION 233700
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Diffusers
- B Registers/grilles
- C Goosenecks.

1.2 REFERENCE STANDARDS

- A AMCA 500-L - Laboratory Methods of Testing Louvers for Rating.
- B ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Air Inlets.
- C SMACNA (ASMM) - Architectural Sheet Metal Manual.
- D SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

1.3 SUBMITTALS

- A Specification Compliance Review.
- B Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.
- C Product Data: For each model indicated, include the following:
 - 1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
 - 2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
 - 3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished.
 - 4. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.
- D Coordination Drawings: Reflected ceiling plans and wall elevations drawn to scale to show locations and coordination of diffusers, registers, and grilles with other items installed in ceilings and walls.
- E Samples for Verification: Of diffusers, registers, and grilles, in manufacturer's standard sizes, showing the full range of colors. Prepare Samples from the same material to be used for the Work.

- F Project Record Documents: Record actual locations of air outlets and inlets.

1.4 QUALITY ASSURANCE

- A Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- B Test and rate louver performance in accordance with AMCA 500-L.
- C Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section.
- D Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- E Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers' products with equal performance characteristics may be considered.
- F Product Options: Drawings indicate size, profiles, and dimensional requirements of intake and relief ventilators and are based on the specific equipment indicated.
1. Do not modify intended aesthetic effects, as judged solely by Design Professional, except with Design Professional's approval. If modifications are proposed, submit comprehensive explanatory data to Design Professional for review.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A American Louver Company: www.americanlouver.com.
- B Carnes, a division of Carnes Company Inc: www.carnes.com/sle.
- C Dadanco: www.dadanco.com
- D Krueger: www.krueger-hvac.com.
- E Metalaire, a brand of Metal Industries Inc: www.metalaire.com/#sle.
- F NCA
- G Nailor Industries.
- H Price Industries: www.price-hvac.com.
- I Ruskin Company[<>]: www.ruskin.com/#sle.
- J Titus: www.titus-hvac.com.
- K Tuttle and Bailey: www.tuttleandbailey.com/sle.

- L Trox Technik.
- M Or pre-approved equivalent.

2.2 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

- A See Drawings for Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.3 MANUFACTURED UNITS

- A General: Sizes, types and capacities shall be as indicated.
- B Ceiling and wall frame types and dimensions shall be verified from architectural drawings.
- C Verify ceiling frame and panel style and dimension with reflected ceiling plan, room finish schedule and material type.
- D If final diffusers or registers have a higher sound level than those specified or if dimensions are not compatible with finished walls, ceilings, floors or architectural air cabinets (millwork), installed diffusers and registers shall be replaced at the Contractor's expense.
- E Outlets and inlets shall be factory baked enamel finished with color selected by Design Professional unless indicated.

2.4 GOOSENECKS

- A Fabricate in accordance with of minimum 18 gauge, 0.0598 inch galvanized steel.
- B Mount on minimum 12 inch high curb base where size exceeds 9 by 9 inch.
- C Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
 - 1. Configuration: Built-in cant and mounting flange.
 - 2. Overall Height: 18 inches.
- D Bird Screening: Galvanized-steel, 1/2-inch-square mesh, 0.041-inch wire.
- E Galvanized-Steel Sheet Finish:
 - 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
 - 2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
- F Color: To be selected by Design Professional from manufacturer's custom range.

PART 3 EXECUTION**3.1 EXAMINATION**

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

3.2 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.
- C Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement.
- D Install diffusers to ductwork with air tight connection.
- E Provide volume control (balancing) dampers on duct take-off to all air inlets and outlets, diffusers, grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly. Provide volume dampers in all duct systems where indicated and required to perform complete system test and balance. Coordinate all volume damper locations with the test and balance contractor.
 - 1. Provide access door or remote damper operator to adjust dampers. Registers and diffusers with dampers shall be used only if devices are installed directly on the trunk duct.
- F Paint ductwork visible behind air outlets and inlets matte black, see Section 099123.
- G Install diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.
- H Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of the panel. Where architectural features or other items conflict with installation, notify Design Professional for a determination of final location.
- I Install diffusers, registers, and grilles with airtight connection to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.
- J Install goosenecks on curb base where throat size exceeds 9 by 9 inches.
- K Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

- L Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.3 ADJUSTING

- A After installation, adjust diffusers, registers, and grilles to air patterns indicated, as directed and as required to prevent drafts before starting air balancing.
- B Adjust air patterns per manufactures recommendations based on installed conditions.

3.4 CLEANING

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

END OF SECTION

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SECTION 237413

PACKAGED OUTDOOR ROOFTOP UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Packaged roof top unit.
- B Unit controls.
- C Roof mounting curb and base.

1.2 REFERENCE STANDARDS

- A AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- B AHRI 270 (SI/I-P) - Sound Performance Rating of Outdoor Unitary Equipment.
- C NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.3 SUBMITTALS

- A Product Data: Provide capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
- B Shop Drawings: Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
- C Manufacturer's Instructions: Indicate assembly, support details, connection requirements, and include start-up instructions.
- D Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- E Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.
- F Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Filters: One set for each unit.

1.4 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section.

- B Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- C Where the National Electrical Code or applicable codes require controllers to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment.

1.5 DELIVERY, STORAGE, AND HANDLING

- A Protect units from physical damage by storing off site until roof mounting curbs are in place, ready for immediate installation of units.

1.6 WARRANTY

- A See the Closeout Submittal Section for additional warranty requirements.
- B Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in materials or workmanship within specified warranty period. Warranty period for:
 - 1. Compressors and Refrigerant: Five years.
 - 2. Heat Exchangers: Ten years.
 - 3. Solid-State Ignition Modules: Three years.
 - 4. Control Boards: Three years.
 - 5. Variable-Speed Fan Motors: Three years.
 - 6. Electronic Thermostats: Three years.
 - 7. Energy Recovery Modules: Two years.
- C Provide a five year warranty to include coverage for refrigeration compressors.
- D See the Common Requirements for HVAC specification Section for requirements.

PART 2 PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

- A See Drawings for Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 MANUFACTURERS

- A Addison
- B AAON: www.aaon.com.
- C Carrier, a part of UTC Building and Industrial Systems, a unit of United Technologies Corp: www.carrier.com.
- D Daikin Applied: www.daikinapplied.com.
- E Trane, a brand of Ingersoll Rand: www.trane.com.

F York International Corporation/Johnson Controls Inc: www.johnsoncontrols.com.

G Or pre-approved equivalent.

2.3 MANUFACTURED UNITS

A General: Roof mounted units having gas burner and electric refrigeration.

B Description: Self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, return fan, heat exchanger and burner, controls, air filters, refrigerant cooling coil and compressor, condenser coil and condenser fan. 100% economizer with enthalpy control and powered exhaust relief.

C Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 700.

D Disconnect Switch: Factory mount disconnect switch in control panel.

E Where the National Electrical Code or applicable codes require controllers to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment.

2.4 FABRICATION

A Cabinet: Steel with baked enamel finish, including access panels with screwdriver operated flush cam type fasteners. Structural members shall be minimum 18 gauge, 0.0478 inch, with access doors or panels of minimum 20 gauge, 0.0359 inch.

B Insulation: 2 inch thick neoprene coated glass fiber with edges protected from erosion.

C Heat Exchangers: Stainless steel, of welded construction.

D Supply and Return Fan: Centrifugal type, resiliently mounted with V-belt drive, adjustable variable pitch motor pulley, and rubber isolated hinge mounted high efficiency motor or direct drive as indicated. Isolate complete fan assembly.

E Air Filters: 2" and 4" filter racks. MERV 8 prefilters, MERV 13 final filters.

2.5 CURBS

- A Roof Mounting Curb: 18 inches high galvanized steel, channel frame with gaskets, nailer strips.
1. Units without internal spring isolation shall be provided with vibration isolation roof curbs, refer to 230548.
 2. Unit is installed on sloped roof, roof curb shall be sloped to match roof and keep unit level. Refer to structural and architectural.

2.6 BURNER

- A Gas Burner: Forced draft type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shut-off, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shut-off pilot.
- B Gas Burner Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after airflow proven and slight delay, allow gas valve to open.
- C High Limit Control: Temperature sensor with fixed stop at maximum permissible setting, de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.
- D Supply Fan Control: Temperature sensor sensing bonnet temperatures and independent of burner controls, with provisions for continuous fan operation.
- E Modulating control providing 20% to 100% burner modulation

2.7 EVAPORATOR COIL

- A Provide copper tube aluminum fin coil assembly with galvanized drain pan and connection.
- B Provide capillary tubes or thermostatic expansion valves for units of 6 Tons of refrigeration capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 Tons of refrigeration cooling capacity and larger.

2.8 COMPRESSOR

- A Provide hermetic digital scroll compressors, 3600 rpm maximum, resiliently mounted with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gage ports, and filter drier.
 - 1. Provide compressor sound isolation covering.
- B Five minute timed off circuit to delay compressor start.
- C Outdoor thermostat to energize compressor above 35 degrees F ambient.
- D Provide step capacity control by cycling multi-speed compressors.

2.9 CONDENSER COIL

- A Provide copper tube aluminum fin coil assembly with subcooling rows and coil guard.
- B Provide direct drive propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor. Provide high efficiency fan motors.
- C Provide refrigerant pressure switches to cycle condenser fans.

2.10 MIXED AIR CASING

- A Dampers: Provide outside, return, and relief dampers with damper operator and control package to automatically vary outside air quantity. Outside air damper to fall to closed position.
- B Gaskets: Provide tight fitting outdoor dampers with edge gaskets maximum leakage 5 percent at 2 inches pressure differential.
- C Damper Operator: 24 volt with gear train sealed in oil.
- D Mixed Air Controls: Maintain selected supply air temperature and return dampers to minimum position on call for heating and above 75 degrees F ambient, or when ambient air temperature exceeds return air temperature.

2.11 CONDENSER COIL COTTONWOOD HAIL GUARD/INTAKE FILTER SCREENING:

- A Engineered HVAC Mesh
- B Non-porous, UV resistant, vinyl coated polyester media w/non-stick surface.
 - 1. Flame resistant (self-extinguishing)
 - 2. Low debris adhesion
 - 3. Mold and mildew resistant.
- C 1.125" heavy duty fiber reinforced outer binding.
 - 1. Quick release nylon twist-lock fasteners.
- D Low air resistance and static pressure impact
- E 10 year Warranty
- F Basis of design: Air Solution Company, Heavy Duty Commercial Grade. Or pre-approved equivalent.

2.12 POWER AND CONTROLS

- A Equipment and controls shall to interface and integrate to BMCS systems and sequences via vendor protocols including, as a minimum, BACnet, LonTalk and Modbus.
- B Motor Control Panels: UL listed.
- C Include necessary motor starters, fuses, transformers and overload protection according to NFPA 70.
- D Provide single-point field connection to power supply.
- E Provide non fused main disconnect integral to control panel.
- F Install wiring in accordance with NFPA 70.
- G Wiring: Enclosed in flexible, liquid tight steel conduit.

2.13 OPERATING CONTROLS - VARIABLE VOLUME UNITS

- A Temperature transmitter located in supply air shall signal electronic logic panel to control mixing dampers and cooling in sequence. Mixing section shall operate as first stage of cooling and revert to minimum outside air above approximately 75 degrees F as determined by enthalpy of return and outdoor air.
- B Control cooling by cycling compressors, cylinder unloading, and hot gas bypass.
- C Control logic shall allow supply air reset under low load or airflow conditions.
- D BMS interface shall control unit on occupied/un-occupied schedule. At night, unit shall be off. Locate clock in remote control panel with status lights.
- E Provide two stage morning warm-up sequence via BMS to hold outdoor dampers closed and energize heat until return air temperature reaches set point. Building temperature input shall be polled average of thermostats in building served by unit.
- F Duct mounted static pressure sensor to adjust supply fan speed to maintain supply duct static at its adjustable setpoint.
- G Unit mounted static pressure sensor, located at the return fan discharge, to adjust return fan speed to maintain plenum pressure at its adjustable setpoint.
- H Refer to 230993.

PART 3 EXECUTION**3.1 EXAMINATION**

- A Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings.
- B Verify that proper power supply is available.

3.2 CONNECTIONS

- A Coordinate installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.
- B Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- C Install piping adjacent to machine to allow service and maintenance.
 - 1. Gas Piping: Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

- D Coordinate duct installation requirements with schematics on Drawings and with requirements specified for duct systems. If Drawings are explicit enough, these requirements may be reduced or omitted.
- E Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Install ducts to termination in roof curb.
 - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 - 3. Connect supply ducts to rooftop unit with flexible duct connectors.
 - 4. Terminate return-air duct through roof structure and insulate space between roof and bottom of unit with 2-inch thick, acoustic duct liner.
 - 5. Provide flexible connection between ductwork and rooftop unit.
- F Electrical System Connections: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.
- G Ground equipment according to Division 26 Section "Grounding and Bonding."
- H Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B Perform the following field quality-control tests and inspections and prepare test reports:
 - 1. After installing rooftop air conditioners and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C Remove malfunctioning units, replace with new units, and retest as specified above.

3.4 ADJUSTING

- A Adjust initial temperature and humidity set points.
- B Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

3.5 DEMONSTRATION

- A Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain rooftop air conditioners.

3.6 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install in accordance with NFPA 90A.
- C Vibration isolation devices and installation requirements are specified in Vibration and Seismic Controls for HVAC Piping and Equipment. Install roof mounting curb level.
- D Vibration Isolation: Mount condensing units on rubber pads with a minimum deflection of 1/4 inch. Install roof mounting curb level.
- E Provide filter gage on each filter bank. Refer to AIR DUCT ACCESSORIES.

3.7 SYSTEM STARTUP

- A Prepare and start equipment. Adjust for proper operation.
- B Engage a factory-authorized service representative to perform startup service.
- C Complete installation and startup checks according to manufacturer's written instructions and do the following:
 - 1. Clean outside coil and inspect for construction debris.
 - 2. Clean furnace flue and inspect for construction debris.
 - 3. Connect and purge gas line.
 - 4. Adjust vibration isolators.
 - 5. Inspect operation of barometric dampers.
 - 6. Lubricate bearings on fan.
 - 7. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 8. Adjust fan belts to proper alignment and tension.
 - 9. Start unit according to manufacturer's written instructions.
 - a. Start refrigeration system in summer only.
 - b. Complete startup sheets and attach copy with Contractor's startup report.
 - 10. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 11. Operate unit for an initial period as recommended or required by manufacturer.
 - 12. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency. Adjust pilot to stable flame.
 - a. Measure gas pressure on manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure flue-gas temperature at furnace discharge.
 - d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

13. Calibrate thermostats.
14. Adjust and inspect high-temperature limits.
15. Inspect outside-air dampers for proper stroke and interlock with return-air dampers.
16. Start refrigeration system and measure and record the following:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
17. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
18. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through outside coil or from outside coil to outside-air intake.
19. Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:
 - a. High-limit heat exchanger.
 - b. Warm-up for morning cycle.
 - c. Freezestat operation.
 - d. Economizer to limited outside-air changeover.
 - e. Alarms.
20. After startup and performance testing, change filters, vacuum heat exchanger and cooling and outside coils, lubricate bearings, adjust belt tension, and inspect operation of power vents.

3.8 CLOSEOUT ACTIVITIES

- A Demonstrate operation to Owner's maintenance personnel.

END OF SECTION

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SECTION 238126.13**SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS****PART 1 GENERAL****1.1 SECTION INCLUDES**

- A Air cooled condensing units.
- B Indoor air handling (fan and coil) units for ductless systems.
- C Controls.

1.2 REFERENCE STANDARDS

- A AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- B AHRI 270 (SI/I-P) - Sound Performance Rating of Outdoor Unitary Equipment.
- C AHRI 520 - Performance Rating of Positive Displacement Condensing Units.
- D ASHRAE Std 15 - Safety Standard for Refrigeration Systems.
- E ASHRAE Std 23 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Compressor Units.
- F ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- G ASHRAE Std 90.2 - High-Performance Energy Design of Residential Buildings.
- H ASHRAE Std 103 - Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers.
- I NEMA MG 00001 - Motors and Generators.
- J NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- K UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical.
- L Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

1.3 SUBMITTALS

- A Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

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Council Bluffs, IA

SMALL-CAPACITY SPLIT-SYSTEM AIR
CONDITIONERS
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- B Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- C Design Data: Indicate refrigerant pipe sizing.
- D Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- E Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- F Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.
- G Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Filters: One for each unit.

1.4 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section.
- B Installer Qualifications: Company specializing in performing the work of this section and approved by manufacturer.

1.5 COORDINATION

- A Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases.
- B Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations.

1.6 WARRANTY

- A Provide five year manufacturers warranty for compressors.

PART 2 PRODUCTS

2.1 MANUFACTURERS - COOLING ONLY

- A Carrier Corporation: www.carrier.com/#sle.
- B Rheem Manufacturing Company Inc: www.rheem.com/#sle.
- C Daikin Comfort
- D Goodman
- E Lennox.

- F LG
- G Mitsubishi
- H Panasonic
- I Toshiba
- J Trane Technologies, PLC: www.trane.com/#sle.
- K York International Corporation / Johnson Controls: www.york.com/#sle.
- L Or pre-approved equivalent.

2.2 SYSTEM DESIGN

- A Split-System Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
 - 1. Cooling: Outdoor electric condensing unit with evaporator coil in ductless indoor units..
 - 2. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
 - 3. Provide trapped coil condensate piping between indoor unit evaporator drain pan and terminate over nearest floor drain.
- B Performance Requirements: See Drawings for Equipment Schedule.
- C Electrical Characteristics:
 - 1. Disconnect Switch: Factory mount disconnect switch on equipment under provisions of Section 260583.

2.3 INDOOR AIR HANDLING UNITS FOR DUCTLESS SYSTEMS

- A Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.
 - 1. Location: High-wall.
 - 2. Cabinet: Galvanized steel.
 - a. Finish: White.
- B Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
 - 1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
 - 2. Manufacturer: System manufacturer.

2.4 OUTDOOR UNITS

- A Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.

1. Comply with AHRI 210/240.
 2. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 700.
 3. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
 4. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23 and UL 207.
 5. Sound Rating: 69 dBA, when measured in accordance with AHRI 270 (SI/I-P).
- B Compressor: Hermetic, two speed 1800 and 3600 rpm, AHRI 520 resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high-pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.
- C Air Cooled Condenser: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
1. Condenser Fans: Direct-drive propeller type.
 2. Condenser Fan Motor: Enclosed, 1-phase type, permanently lubricated.
 3. Cottonwood/Hail Guard Coil Filter Screening:
 - a. Engineered HVAC Mesh
 - b. Non-porous, UV resistant, vinyl coated polyester media w/non-stick surface.
 - 1) Flame resistant (self-extinguishing)
 - 2) Low debris adhesion
 - 3) Mold and mildew resistant.
 - c. 1.125" heavy duty fiber reinforced outer binding.
 - 1) Quick release nylon twist-lock fasteners.
 - d. Low air resistance and static pressure impact
 - e. Provide with Hail-Proof backing mesh w/aluminum mounting track.
 - f. 10 year Warranty
 - g. Basis of design: Air Solution Company, Heavy Duty Commercial Grade. Or pre-approved equivalent.
- D Coil: Air-cooled, aluminum fins bonded to copper tubes.
- E Accessories: Filter drier, high-pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).
1. Provide thermostatic expansion valves.
- F Operating Controls:
1. Control by room thermostat to maintain room temperature setting.
 2. Low Ambient Kit: Provide refrigerant pressure switch to cycle condenser fan on when condenser refrigerant pressure is above 285 psig and off when pressure drops below 140 psig for operation to 0 degrees F.
- G Condenser Stand/Riser: 12" high, UV resistant plastic, rated for -20F to 120F outdoor temperature, anti-vibration pads

2.5 PRE-INSULATED PIPING LINE SETS

- A Copper Tube: Seamless, H58 hard drawn or O60 soft annealed.
 - 1. Maximum Operating Pressure: 700 psi at 250 degrees F.
 - 2. Joints: Flared or Braze, BCuP silver/phosphorus/copper alloy.
- B Insulation:
 - 1. General:
 - a. 1" minimum thickness, provide applicable code required thickness.
 - b. ASTM E84 25/50 flame/smoke index.
 - c. K Value: 0.25 at 75 degrees F.
 - d. Moisture Vapor Permeability: 0.05 perm inch.
 - e. Maximum Service Temperature: 220 degrees F.
 - f. Minimum Service Temperature: Minus 40 degrees F.
 - g. Use molded tubular material wherever possible.
 - 2. Flexible Elastomeric:
 - a. Insulation: UV coated, preformed flexible elastomeric cellular rubber insulation, Grade 1;
 - 1) Connection: Waterproof vapor barrier adhesive.
 - 3. Polyethylene:
 - a. Insulation: Flexible closed-cell polyethylene tubing.
 - 1) Connection: Contact adhesive.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- B Verify that proper power supply is available and in correct location.
- C Verify that proper fuel supply is available for connection.

3.2 INSTALLATION

- A Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.
- B Install in accordance with NFPA 90A.
- C Install refrigeration systems in accordance with ASHRAE Std 15.
- D Install units level and plumb.
- E Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- F Install outdoor heat pump compressor-condenser unit on 12" tall heat pump stand/riser.

- G Install roof-mounting compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.
- H Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.
- I Provide trapped coil condensate piping between indoor unit evaporator drain pan and terminate over nearest floor drain.

3.3 CONNECTIONS

- A Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangements of piping, fittings, and specialties.
- B Refrigerant Piping: Comply with applicable requirements in Section 232300 - Refrigerant Piping. Connect to supply and return coil tapings with shutoff valve and union or flange at each connection.
- C Install piping adjacent to unit to allow service and maintenance.
- D Provide trapped coil condensate piping between indoor unit evaporator drain pan and terminate over nearest floor drain.
- E Ground equipment according to Division 26 Sections.
- F Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.4 FIELD QUALITY CONTROL

- A Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

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

1. Complete installation and startup checks according to manufacturer's written instructions.

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SECTION 260400
COMMON REQUIREMENTS FOR ELECTRICAL

PART 1 GENERAL

1.1 SUMMARY

- A This section describes the general requirements of these specifications and shall apply to all phases of the work specified, shown on the drawings, or required to provide for complete installation of all systems for this project.
- B This Section includes basic materials and methods to complement other Division 26 Sections.
- C This Section includes basic materials and methods to complement Section 284600 - Fire Detection and Alarm.

1.2 WARRANTIES

- A Warrant materials, workmanship and equipment against defects for a period of one year after the date of substantial completion.
- B Certain equipment shall be warranted beginning at the time of final acceptance or for longer periods of time as specified in those divisions of the Project Manual.
- C Repair or replace, at no additional cost to the Owner, any item which may become defective within the warranty period.
- D Any manufacturers' warranties concerning any item installed will run to the benefit of the Owner.
- E The Contractor agrees not to void or impair, or to allow Sub-Contractors to void or impair, any warranties regarding products or items installed as part of this project.
- F The repair of faulty workmanship shall be considered to be included in the contract.

1.3 ALTERNATES

- A Alternates, if required, shall be as described in the "Alternates" section of this Project Manual, as described on the proposal form, or as indicated on the drawings.

1.4 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

- A If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Architect for clarification.
- B Any definitive interpretation or clarification of the contract documents will be published by addenda, properly issued to each person holding documents, prior to the bid date.

- C Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents.
- D When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.
- E The Architect shall be the sole judge regarding interpretations of conflicts within contract documents.

1.5 CONTRACT DOCUMENT DISCREPANCIES

- A If any ambiguities should appear in the contract documents, request clarification from the Architect before proceeding with the work.
- B If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Architect.
- C Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work unless a written clarification from the Architect was requested and obtained before submission of proposed methods or materials.
- D The Architect shall be the sole judge regarding interpretations of conflicts within contract documents.

1.6 DEFINITIONS

- A The following definitions shall apply throughout the contract documents:
 - 1. Architect: Architect or Engineer
 - 2. Code: Applicable national, state and local codes
 - 3. Mechanical: Plumbing, HVAC, and Fire Protection work required by the Contract Documents
 - 4. Electrical: Electrical and Fire Alarm work required by the Contract Documents
 - 5. Contractor: Any Contractor performing work required by the Contract Documents
 - 6. Indicated: Noted, scheduled or specified
 - 7. Selected: Selected by the Architect.
 - 8. Provide: Furnish, install, connect and tested complete and ready for use
 - 9. Furnish: Supply and deliver to the site ready for installation
 - 10. Install: Install complete, per Contract Documents and manufacturer's requirements.
 - 11. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
 - 12. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
 - 13. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
 - 14. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

15. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
16. Dry Locations: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.
17. Damp Locations: Locations protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture.
 - a. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold storage warehouses.
18. Wet Locations: Installations underground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather.

1.7 SYMBOLS

- A Items of equipment and materials are indicated on the drawings in accordance with the symbols on the plans.

1.8 ABBREVIATIONS

- A Refer to abbreviations list on the Drawings.
- B The following abbreviations apply throughout the Contract Documents:
 1. ADA: Americans with Disabilities Act
 2. ANSI: American National Standards Institute
 3. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers
 4. ASME: American Society of Mechanical Engineers
 5. ASTM Specification: Standard specifications of the American Society for Testing Materials
 6. FM: Factory Mutual Engineering Corporation
 7. IRI: Industrial Risk Insurers
 8. NEC: National Electrical Code, latest edition
 9. NEMA: National Electrical Manufacturers Association
 10. NFPA: National Fire Protection Association
 11. UL or Underwriters: Underwriters Laboratories, Inc.

1.9 CODES

- A The work shall be performed by persons skilled in the trade involved and shall be done in a manner consistent with normal industry standards.
- B The work shall conform to all applicable sections of currently adopted editions of the following codes, standards, and specifications:
 1. International Building Code (IBC)
 2. International Fire Code (IFC)
 3. International Energy Conservation Code (IECC)

4. Safety and Health Regulations for Construction
5. Occupational Safety and Health Standards (OSHA), National Consensus Standards and Established Federal Standards
6. National Electrical Code (NEC)
7. National Electrical Safety Code (NESC)
8. National Fire Protection Association (NFPA)
9. Life Safety Code (NFPA 101)
10. Factory Mutual Global Engineering (FMG)
11. Underwriters' Laboratories, Inc. (UL)
12. National Electrical Manufacturers Association (NEMA)
13. Institute of Electrical and Electronics Engineers (IEEE)
14. Insulated Power Cable Engineers Association (IPCEA)
15. Telecommunications Industry Association (TIA)
16. Building Industry Consulting Service International (BICSI)
17. Applicable national, state and local codes

- C Where there is a conflict between the code and the Contract Documents, the code shall have precedence only when it is more stringent than the Contract Documents.
1. Items that are allowed by the code but are less stringent than those specified shall not be substituted.

1.10 PERMITS

- A The Contractors shall familiarize themselves with requirements regarding permits, fees, etc., and shall comply with them.
- B Permits, licenses, inspections and arrangements required for the work shall be obtained by the Contractor at his expense.
- C Utilities shall be installed in accordance with the local rules and regulations.

1.11 MATERIALS AND EQUIPMENT MANUFACTURERS

- A Options in selecting materials and equipment are limited by requirements of the contract documents and governing regulations. They are not controlled by industry traditions or procedures experienced on previous construction projects.
- B Materials and equipment shall be provided in accordance with the following:
1. Primary Design Products: Primary design products are those products around which the project was designed in terms of capacity, performance, physical size and quality.
 2. Primary design products are indicated by use of a single manufacturer's name, model number or similar data on drawings or schedules or within the specifications.
 3. Provide primary design products unless substitutions are made in accordance with the following paragraphs.
 4. Acceptable Equivalent Substitutions: Acceptable equivalent substitutions are products of manufacturers other than those listed for the primary design products. Equivalent acceptable substitutions shall meet each of the following requirements:

- a. The product shall be manufactured by one of the acceptable manufacturers listed in the Project Manual, drawings, or addenda.
 - b. The product shall meet or exceed the requirements of the contract documents in terms of quality, performance, suitability, appearance, and physical characteristics.
 - c. The Contractor providing the substitution shall bear the total cost of changes due to substitutions. These costs may include additional compensation to the Architect for redesign and evaluation services, increased cost of work by the Owner or other Contractors, and similar considerations.
5. Performance Requirements: Where the contract documents list performance requirements or describe a product or assembly generically, provide products that comply with the specific requirements indicated and that are recommended by the manufacturer for the respective application.
6. Compliance with Standards, Codes and Regulations: Where the specifications require only compliance with an imposed standard, code or regulation, the Contractor has the option of selecting a product that complies with specification requirements, including the standards, codes and regulations.
- C Proposed substitutions will be judged on the basis of quality, performance, appearance and on the governing space limitations. The reputation of the manufacturer, delivery time requirements, and the availability of repair or replacement parts may also be considered.
- D The Architect shall be the sole and final judge as to the suitability of substitution items.

1.12 SUBMITTALS

- A Shop Drawings, Product Data and Samples:
1. Other sections in the Project Manual shall be adhered to if more stringent than the following paragraphs.
 2. When required by other sections of this Project Manual, submit shop drawings, product data or samples to the Architect for review.
 3. Submittals deemed unnecessary by the Architect shall be returned indicating "No Action Taken".
 4. A completed copy of the transmittal form included with the Project Manual shall accompany each submittal.
 5. Submittals shall be numbered consecutively.
 6. Unless otherwise noted, submit one copy electronically of shop drawings and product data for review. Review comments will be returned electronically. A hard copy of the electronic submittal will be returned if requested.
 7. Where samples are required, submit one (1) sample of each required item.
 8. Shop drawings are drawings, diagrams, schedules and other data specifically prepared for this project by the Contractor, Manufacturer, Supplier, or Distributor to illustrate some portion of the work. Shop Drawings shall also detail fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment.
 - a. Shop drawings shall be drawn to accurate scale and of adequate size to illustrate required details.
 9. Product data are illustrations, standard schedules, performance charts, instruction brochures, diagrams and other information furnished by the Contractor, Manufacturer,

- Supplier, or Distributor to illustrate a material, product or system for some portion of the work.
10. Samples are physical examples furnished by the Contractor, Manufacturer, Supplier, or Distributor to illustrate materials, equipment or workmanship and to establish the standards by which the work will be performed.
 11. Each submittal shall clearly indicate proposed items, capacities, characteristics and details in conformance with contract documents. Equipment items shall be marked with the same item number as used on drawings or schedules. Capacities, dimensions and special features required shall be certified by the manufacturer.
 12. Submittals shall indicate manufacturer's delivery time for the item after review by the Architect.
 13. When required by other sections of this Project Manual, the Contractor shall submit a Specification Compliance Review consisting of a paragraph-by-paragraph review of the specifications and addenda with the following marked for each paragraph. Markings may be made in the margins of the original specification or addenda. Unless a deviation or exception is specifically noted in the Specification Compliance Review, it is assumed that the equipment, product, or material is in complete compliance with the contract documents. Submit Specification Compliance Review with shop drawings and product data.
 - a. "C": Comply with no exceptions.
 - b. "D": Comply with minor deviations. For each deviation, provide the reasons for the deviation and how the intent of the specification can be satisfied.
 - c. "E": Exception. Equipment, product, or material does not comply. For each exception, provide reasons for the exception, and suggest possible alternatives for the Owner's consideration.
 - d. "N/A": The paragraph does not apply to the proposed equipment, product, or material.
 14. The Architect shall review or take other appropriate action upon the Contractor's submittals such as shop drawings, product data and samples, but only to determine conformance with the design concept of the work and the information given in the contract documents.
 15. Contractor shall not be relieved of responsibility for any deviation from the requirements of the contract documents by the Architect's review of shop drawings, product data or samples.
 16. Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data or samples by the Architect's review of those drawings.
 17. No portion of the work requiring submission of a shop drawing, product data or sample shall be commenced until the submittal has been reviewed by the Architect. Such portions of the work shall be in accordance with reviewed submittals.
 18. The successful Contractor/Supplier may, at their option, obtain DXF or AutoCad DWG electronic drawing files for use in preparation of shop drawings.
 - a. This information is available from Alvine upon written request.
 - b. A non-refundable handling charge of \$10.00 per drawing file requested will be required at the time of receipt of the electronic files.
 - c. The use of these drawing files is intended solely for the preparation of drawings as required by these contract documents.
 - d. Any other use is strictly prohibited by copyright laws.
 - e. The user of these electronic drawing files assumes full responsibility for their accuracy and scale.

B Operation and Maintenance Manuals:

1. Prepare three (3) operation and maintenance manuals for the equipment furnished. Manuals shall be submitted to the Architect for review and distribution to the Owner not less than 30 days prior to substantial completion of the project. Manuals not meeting the following requirements may be rejected by the Architect.
2. Each manual shall be assembled in a three-ring binder with hard cover and plastic finish. Binders shall not exceed a 3-inch thickness. Where more than one binder is required, the manuals shall be separated into a logical grouping, i.e., "Mechanical", "Electrical", "Maintenance", "Operation", "Parts", Shop Drawings", etc. Each binder shall have the following information clearly printed on its front cover:
 - a. Project name and address.
 - b. Portion of the work covered by each volume (if more than one volume in the set). Where more than one volume is required, label each volume as "Volume ____ of ____".
 - c. Name, address and telephone number of Contractor and Sub-Contractors including night or emergency number.
3. Manual shall include, but shall not be limited to, the following:
 - a. A Complete Index. Contractor may submit the index to the Architect for review prior to submittal of complete manuals if desired.
 - b. Names, Addresses and Telephone Numbers. This list shall include the manufacturer and local representative who stocks or furnishes repair parts for all items of equipment and shall be typed on a single page in front of the binder.
 - c. Startup, Operation and Shutdown Procedures. Provide a written description of procedures for startup, operation and shutdown of each electrical item or system. This description shall include switches to operate, buttons to push, etc., in proper sequence, and the location of switches, starters, and pushbuttons. Description shall include item references or labels used in the contract documents unless otherwise instructed in advance by the Owner.
 - d. Equipment Accessory Schedule. Upon completion of the work, furnish the Owner with a complete equipment accessory schedule listing each piece of equipment and the related size, type, number required and the manufacturer of renewable items.
 - e. Manufacturer's Operation and Maintenance Manuals and Parts Lists.
 - f. Emergency Procedures. Provide a written description of emergency operating procedures or a list of service organizations (including addresses and telephone numbers) capable of rendering emergency services to the various parts of the system.
 - g. One copy of shop drawings and product data, clearly marked for each item furnished using the designation label specified or indicated on Drawings.
 - h. Manufacturers' warranty information.
 - i. Normal Maintenance Schedule. Include a listing of work to be performed at various time intervals; i.e., 30, 90, 180 days and yearly.

1.13 OPERATING TRAINING

- A Complete operating instructions for each system and item of equipment shall be provided to the Owner's designated personnel.
- B Operation and Maintenance Manuals must be reviewed and accepted by the Architect and provided to the Owner prior to operating training.

- C Training shall be scheduled at the convenience of the Owner. A minimum of 4 hours of training shall be provided.
- D Training shall include instructions on the following:
 - 1. Startup and shutdown procedures
 - 2. Periodic maintenance
 - 3. Emergency operation
 - 4. Safety
- E In addition to the instructions required above, wherever possible perform the operations being described in order to fully illustrate system operation.
- F At the completion of training, turn over to the Owner required keys and special tools for installed equipment. Each key or tool shall be labeled with its use.

1.14 QUALITY ASSURANCE

- A Conform to the requirements of NFPA 70.
- B Products: Listed and classified by Underwriters Laboratories Inc. or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.15 COORDINATION

- A Coordinate arrangement, mounting, and support of electrical equipment.
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
 - 1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
- C Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- D Coordinate electrical service connections to components furnished by utility companies.
 - 1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
 - 2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

- E Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces.
- F Coordinate electrical testing of electrical, mechanical, or architectural items so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.
- G Provide offsets and elevation changes in conduit and cable tray as required to complete the Layout and Coordination Process.

1.16 STRUCTURAL COORDINATION

- A In cases where the Contractor determines that superimposed loads such as suspended or floor mounted electrical system or equipment exist which exceed design loads indicated on structural contract documents, Contractor shall submit load data to Architect for review prior to proceeding with work.
- B Distribute the maximum load hung from any structural member for mechanical, electrical, plumbing, ductwork, piping, etc. over the member's tributary area in a way that the design superimposed dead loads listed in structural contract documents are not exceeded. The Contractor shall coordinate the loads and provide additional support or distribution framing as required achieving the allowable load distribution.
- C Connections of systems designed by Contractor's engineer such as, but not limited to mechanical, electrical, plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

PART 2 PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

- A See Drawings for Equipment Schedules for Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 EQUIPMENT SHORT CIRCUIT CURRENT RATING

- A Where the National Electrical Code or applicable codes require equipment to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment. Acceptable methods of complying with this requirement are as follows:
 - 1. Provide SCCR rating at the equipment that meets or exceeds the available short circuit current at the switchboard or panelboard where the equipment circuit originates.
 - 2. Provide calculations, based on the available short circuit current at the switchboard or panelboard where the equipment circuit originates, that document the actual short circuit current available at the equipment. The SCCR rating of the equipment shall meet or exceed this calculated value.

2.3 MATERIALS

- A Unless otherwise specified, all materials and equipment shall be new, unused and undamaged. Materials and equipment shall be the current and standard designs of manufacturers regularly engaged in their production.

2.4 MATERIALS AND EQUIPMENT FURNISHED BY OTHERS

- A Where materials and equipment are indicated as furnished by others and installed or connected under this contract, it shall be the Contractor's responsibility to verify installation details and requirements.

2.5 QUANTITY OF SPECIFIED ITEMS REQUIRED

- A Wherever in these specifications an article, device or piece of equipment is referred to in the singular number; such reference shall apply to as many such articles as are shown on the drawings or required to complete the installation.

2.6 SLEEVES

- A Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.

2.7 ACCESS DOORS

- A Manufacturers:
 - 1. Access Doors:
 - a. J. L. Industries
 - b. Karp Associates, Inc.
 - c. Larsons Mfg. Co.
 - d. Milcor, Inc.
 - e. Miller Limited Partnership
 - f. Nystrom, Inc.
 - g. Or pre-approved equivalent
- B Prime coated 14 gauge steel, flush, with screwdriver operated cam lock, frame to accommodate construction type; size as indicated.

2.8 EQUIPMENT FOR UTILITY COMPANY METERING

- A Current Transformer Cabinets: As required by the utility company.
- B Meter Sockets: As required by the utility company.

2.9 CONCRETE

- A Refer to the structural engineering drawings for pad concrete strength, typically 3500-psi minimum, 28-day compressive strength.
- B Equipment pads:

1. Forms: 3-1/2 inch minimum height, 3/4 inch chamfered edge at top of form.
2. Reinforcement: 6 x 6 x 10/10 welded wire fabric.

2.10 BACKFILL MATERIAL AND MIXES

- A Earth Fill: Approved type of soil classified, in accordance with ASTM D2487, as GW, GP, GM, GC, SW, SP, SM, SC, ML or CL, and free of foreign substances, obtained from excavation on this project or other approved source, and having a plasticity index between 7.5 and 17.
- B Granular Fill: Granular fill shall include clean, natural or prepared gravels, gravel-sand mixtures, sands or gravelly sands with little or no fines. A minimum of 95% shall be retained on a No. 200 sieve.
- C Pea Gravel: Pea gravel shall consist of clean, hard, round particles of crushed stone, crushed or uncrushed gravel with the following gradation:

Sieve Size	Percent Passing
3/8 inch	85 - 95
#4	55 - 15
#8	0 - 2

- D Crushed Rock: Crushed rock shall consist of clean, hard, particles of crushed limestone, dolomite, granite, quartzite, or other approved rock. It shall have a percentage of wear of not more than 45 and a percent loss of not more than 30 at the end of 16 cycles of the freezing and thawing test. Gradation for crushed rock shall be as follows:

Sieve Size	Percent Retained
1-1/2 inch	0
3/4 inch	5 - 35
3/8 inch	30 - 64
#10	70 - 90
#200	90 - 100

PART 3 EXECUTION

3.1 GENERAL

- A Fabrication, erection, and installation of the complete electrical system shall be done by qualified personnel experienced in such work and shall proceed in an orderly manner so as not to hold up the progress of the project.
- B Check areas and surfaces where electrical equipment or materials are to be installed and report any unsatisfactory conditions before starting work.
- C Commencement of work signifies the Contractor's acceptance of the conditions as fit and proper for the execution of the electrical work.
- D Install equipment and systems in accordance with manufacturer's instructions, requirements, or recommendations.
- E Comply with NECA 1.

- F Unless otherwise noted, measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- G Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- H Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- I Right of Way: Give to raceways and piping systems installed at a required slope.
- J Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

3.2 DELIVERY AND STORAGE OF MATERIALS

- A Make provisions for the delivery and safe storage of materials. Make the required arrangements with other contractors for the introduction into the building of equipment too large to pass through finished openings.
- B Materials shall be delivered at such stages of the work as will expedite the work as a whole and shall be marked and stored in such a way as to be easily checked and inspected.
- C Adequately protect supplies and equipment during cold weather.
- D Protect items subject to cold weather damage by covering, insulating, or storing in a heated space.

3.3 COOPERATION WITH OTHER CONTRACTORS

- A Perform the electrical work in conformance with the construction called for by other trades and afford other contractors reasonable opportunity for the execution of their work.
- B Properly connect and coordinate the electrical work with the work of other contractors at such time and in such a manner as not to delay or interfere with their work.
- C Examine the contract documents for the General, Mechanical, and Electrical work and the work of other trades. Coordinate work accordingly.
- D Promptly report to the Architect any delay or difficulties encountered in the installation of the electrical work which might prevent prompt and proper installation of work required from other trades.

3.4 COORDINATION OF WORK

- A Plan work so it proceeds with a minimum of interference with other trades.

- B Inform the General Contractor of all openings required in the building construction for the installation of the electrical work.
- C Cooperate with other contractors in furnishing material and information, in proper sequence, for the correct location of sleeves, inserts, foundations, wiring, etc.
- D Make provisions for special frames, openings, and sleeves as required.
- E The Electrical Contractor shall pay for extra cutting and patching made necessary by his failure to properly direct such work at the correct time.

3.5 LAYING OUT WORK

- A Carefully lay out work in advance of installation using data and measurements from the site, the appropriate civil, architectural, and structural drawings, and shop drawings.
- B Confirm code required clearances.
- C Do not infringe upon space required for operation, maintenance, or clearance for items installed by other contractors.
- D Prior to installation of any work, make certain the location does not conflict with other items in or near the same location.
- E If the layouts so prepared indicate that the required conditions cannot be met in the space provided, inform the Architect prior to installation and request clarification.
- F Failure to properly coordinate and lay out work will require correction by the Contractor at the Contractor's expense

3.6 DATA AND MEASUREMENTS

- A Mechanical and Electrical drawings are diagrammatic or schematic. Do not scale drawings.
- B The data given herein and on the drawings is as accurate as could be secured; absolute accuracy is not guaranteed.
- C Obtain exact locations, measurements, levels, etc., at the site and adapt their work to actual conditions.
- D Examine the General Construction, Mechanical, Electrical, and other applicable drawings and the Specifications.
- E Utilize only Architectural drawings, Structural drawings, and site measurements in calculations.
- F Layout and coordinate work prior to installation to provide clearances for operation, maintenance and codes. Verify non-interference with other work.

- G Locate outlets and devices mounted on finished surfaces with regard to paneling, furring, trim, etc.
- H Install outlets and devices with vertical edges of plates plumb.
- I Install boxes or plaster rings such that the front edge extends to the finished surface of the wall, ceiling or floor without projecting beyond the surface.
- J Install receptacles, switches, etc., on wood trim, cases, or other fixtures symmetrically and, where necessary, install with the long dimension of the plate horizontal.
- K Coordinate locations of outlets and devices with other contractors so as not to destroy the aesthetic effect of the surface in which the outlets and devices are mounted. Coordinate the locations of electrical items with work furnished by other trades to avoid interference.
- L Heights of outlets are measured from finished floor to centerline of device.
- M Adjust heights as necessary to clear wall-mounted cabinets, fin tube convectors, unit heaters, etc.
- N Mounting heights shall be in compliance with ADA requirements.
- O Install outlets at the heights indicated below unless otherwise noted.
 - 1. Wall switches: 46 inches.
 - 2. Receptacle outlets (general): 18 inches.
 - 3. Receptacle outlets (kitchen, utility room, workbenches, etc.): 46 inches.
 - 4. Communications outlets: 18 inches.
 - 5. Communications outlets (wall phones): 46 inches.
 - 6. TV outlets: 18 inches.
 - 7. Pushbuttons: 46 inches.
 - 8. Bells, buzzers, chimes: 8 inches below ceiling (field verify with Architect unless noted otherwise).
 - 9. Fire alarm station: 46 inches.
 - 10. Fire alarm visual signals and audible/visual signals, wall-mounted: 80 inches to the bottom of the lens unless local code or ADA requirement mandates a lower mounting height.
 - 11. Fire alarm audible signals, wall-mounted: Match height of audible/visual signals.
 - 12. Exit lights: 4 inches between top of nearest door frame and bottom of exit sign where possible.
- P The mounting heights of disconnect switches, circuit breakers, motor controllers, pushbutton stations and other similar devices and equipment may vary depending upon location and whether individually or group mounted.
- Q For convenience and safety, mount equipment with the center of operating levers, handles or buttons no more than 72 inches above the finished floor.
- R Locate individual devices or pieces of equipment, unless otherwise specified, so the operating handle, lever or button is located approximately 5 feet above finished floor. Coordinate heights of electrical items with work furnished by other trades to avoid interferences.

- S Improperly located devices or outlets shall be relocated by the Contractor at the Contractor's expense including necessary patching.

3.7 PROTECTION OF APPARATUS

- A Take necessary precautions to properly protect apparatus, fixtures, appliances, material, equipment, and installations from damage.
- B Failure to provide such protection to the satisfaction of the Architect shall be sufficient cause for the rejection of any particular piece(s) of material, apparatus, equipment, etc., concerned.

3.8 SLEEVE INSTALLATION

- A Coordinate sleeve selection and application with selection and application of firestopping.
- B Concrete Slabs and Walls: Install sleeves during erection of slabs and walls. Space sleeves a minimum of three sleeve diameters on center, unless otherwise noted. Sleeves are not required for core-drilled penetrations.
- C Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D Sleeves through walls: Install flush with both surfaces of wall.
- E Sleeves through floors: Extend 2 inches above finished floor.
- F Sleeves through roofs: Seal with flexible boot-type flashing units applied in coordination with roofing work
- G Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceways or cable unless sleeve seal is to be installed.
- H Seal space outside of sleeves with grout for penetrations of concrete and masonry.
- I Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
- J Underground, Exterior-Wall Penetrations: Size sleeves to allow for appropriate clear space between raceway and sleeve for sleeve seals.

3.9 FIRESTOPPING

- A Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to maintain fire-resistance rating of assembly.

3.10 UTILITY COMPANY ELECTRICITY-METERING EQUIPMENT

- A Install equipment according to utility company's written requirements. Provide grounding and empty conduits as required by utility company.

3.11 CONCRETE EQUIPMENT PADS

- A Construct concrete equipment pads of dimensions indicated, but not less than 4 inches larger, in both directions, than supported unit.
- B Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated.
- C Dowel to structural slab.
- D Provide a reinforced concrete pad for the utility company transformer.
 - 1. Size as required by the power company or as indicated on the drawings.
 - 2. Power company requirements shall take precedence over transformer pad details indicated on the drawings.
 - 3. Pour pad flat and level with all required conduit openings.

3.12 EXCAVATION

- A Perform excavation of every description and of whatever substances encountered, to the depths required or indicated on the drawings, in accordance with OSHA.
- B During excavation, deposit material suitable for backfill in an orderly manner a sufficient distance from the excavation banks to avoid overloading and to prevent slides or cave-ins.
- C Dispose of material unsuitable for backfill as directed by the Architect.
- D Grade as necessary to prevent surface water from flowing into trenches or other excavations, and remove any water accumulating therein by pumping or by other acceptable method.
- E Fill any excess excavation below the levels indicated for structures or raceways with sand, gravel or concrete.
- F Unsuitable Material:
 - 1. Where the bottom of the trench is found to be unstable or to include ashes, cinders, any types of refuse, vegetable or other organic material, or large pieces or fragments of inorganic material, which in the judgment of the Architect should be removed, excavate and remove such unsuitable material to a minimum depth of 12 inches below the conduit.
 - 2. Backfill the trench with selected bedding material and compact to provide uniform and continuous bearing for the conduit.
 - 3. Dispose of the unsuitable material.
- G Shoring Requirements:
 - 1. Perform shoring and sheeting that is required to protect the excavation and to safeguard employees in accordance with OSHA.
 - 2. Widen excavation to provide for space occupied by shoring and sheeting.
 - 3. Shoring shall meet the requirements of applicable codes and regulations.
- H Dewatering:

1. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.
2. Do not allow water to accumulate in excavations.
3. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations.
4. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.
5. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or runoff areas.
6. Do not use trench excavations as temporary drainage ditches.

3.13 BACKFILL

- A Do not backfill until required inspections are made and tests are performed for the specific utility.
- B Backfill with the excavated materials specified for backfilling, consisting of earth, loam, sandy clay, sand and gravel or other materials, free from large clods of earth or stones.
- C Do not use broken concrete as backfill materials.
- D Do not backfill in freezing weather or with frozen material.
- E Adjust the moisture content of the backfill material if required for proper compaction.
- F Reopen any trenches improperly backfilled, or where settlement occurs, to the depth required for proper compaction, refill and compact to specified density.
- G Compact backfill for structures to the specified density.
- H During the backfilling of each exterior underground conduit system, install continuous underground type plastic line markers.
 1. Locate markers directly over the buried conduit at 12 inches to 18 inches below finished grade.
 2. Where multiple small conduits are buried in common trenches and do not exceed an overall trench width of 16 inches, install a single line marker.
- I Deposit suitable backfill material around the conduit in 6-inch layers and thoroughly compact by hand, machine tamper, or other suitable equipment.
- J Backfill to at least 90 percent of maximum density at optimum moisture content determined by ASTM D698 until the conduit has a minimum cover of 2 feet.
- K The moisture content of the soil at time of compaction shall be not more than 3 percent above or 3 percent below the optimum.
- L Be careful not to disturb the conduit.
- M Carry backfilling on simultaneously on both sides of the conduit to eliminate the possibility of lateral displacement.

- N Return surface to original condition.

3.14 UTILITY COMPANY SERVICE

- A Verify details related to the electrical service and metering with the utility company.
- B The utility company will provide and install the primary cables and transformer and will connect the secondary cables to the transformer.
- C The primary conduit(s), secondary cables and conduits, and the transformer pad are the responsibility of the Electrical Contractor.

3.15 CUTTING AND PATCHING

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

3.16 FIELD QUALITY CONTROL

- A Inspect installed components for damage and faulty work. Repair as necessary.

3.17 CLEANING AND PROTECTION

- A Remove burrs, dirt, paint spots, and construction debris from electrical items.
- B Protect electrical items so that finishes are without damage or deterioration at time of Substantial Completion.
- C All cables and wiring shall be protected from paint. This includes but is not limited to power conductors and feeders, lighting control wiring, and fire alarm cabling. Painted cables shall be replaced in their entirety.

3.18 TEMPORARY POWER AND LIGHTING

- A Provide temporary power and lighting throughout the construction period for the use by all trades, Contractors and Sub-Contractors.
- B Temporary facilities shall be installed in compliance with applicable codes and in compliance with OSHA requirements.

- C Cost of temporary power used during construction, including the cost of setting and removing temporary service, shall be paid by the Contractor.

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SECTION 260519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Single conductor building wire.
- B Wiring connectors.
- C Electrical tape.
- D Heat shrink tubing.

1.2 REFERENCE STANDARDS

- A ASTM B3 - Standard Specification for Soft or Annealed Copper Wire.
- B ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
- D ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation.
- E ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- F NECA 1 - Standard for Good Workmanship in Electrical Construction.
- G NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
- H NFPA 70 - National Electrical Code.
- I UL 44 - Thermoset-Insulated Wires and Cables.
- J UL 83 - Thermoplastic-Insulated Wires and Cables.
- K UL 486A-486B - Wire Connectors.
- L UL 486C - Splicing Wire Connectors.
- M UL 486D - Sealed Wire Connector Systems.
- N UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
 - 3. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

- A Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

1.6 FIELD CONDITIONS

- A Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify Architect and obtain direction before proceeding with work.

PART 2 PRODUCTS

2.1 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A Provide products that comply with requirements of NFPA 70.
- B Provide products listed, classified, and labeled as suitable for the purpose intended.
- C Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- D Comply with NEMA WC 70.
- E Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- F Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- G Conductor Material:
 - 1. Provide copper conductors only. Aluminum conductors are not acceptable for this project. Conductor sizes indicated are based on copper.
 - 2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.

3. Tinned Copper Conductors: Comply with ASTM B33.
- H Minimum Conductor Size:
1. Branch Circuits: 12 AWG.
 2. Control Circuits: 14 AWG.
- I Conductor Color Coding:
1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
 2. Color Coding Method: Integrally colored insulation.
 - a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
 3. Color Code:
 - a. 480Y/277 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - 4) Neutral/Grounded: Gray.
 - b. 208Y/120 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - 4) Neutral/Grounded: White.
 - c. Equipment Ground, All Systems: Green.
 - d. For control circuits, comply with manufacturer's recommended color code.

2.2 SINGLE CONDUCTOR BUILDING WIRE

- A Description: Single conductor insulated wire.
- B Conductor Stranding:
1. Feeders and Branch Circuits:
 - a. Size 10 AWG and Smaller: Solid or Stranded.
 - b. Size 8 AWG and Larger: Stranded.
- C Insulation Voltage Rating: 600 V.
- D Insulation:
1. Copper Building Wire: Type THHN/THWN, THHN/THWN-2, or XHHW-2, except as indicated below.
 - a. Installed Underground: Type XHHW-2 or THHN/THWN-2.

2.3 WIRING CONNECTORS

- A Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.
- B Wiring Connectors for Splices and Taps:

1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
 2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.
- C Wiring Connectors for Terminations:
1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
 2. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
- D Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.
- E Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.
- F Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.
- G Mechanical Connectors: Provide bolted type or set-screw type.
- H Compression Connectors: Provide circumferential type or hex type crimp configuration.

2.4 ACCESSORIES

- A Electrical Tape:
1. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
 2. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.
- B Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that interior of building has been protected from weather.
- B Verify that work likely to damage wire and cable has been completed.
- C Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.

- D Verify that field measurements are as indicated.
- E Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.3 INSTALLATION

- A Circuiting Requirements:
 - 1. When circuit destination is indicated without specific routing, determine exact routing required.
 - 2. Install service and feeder conductors unspliced unless otherwise indicated.
 - 3. Arrange branch circuiting to minimize splices.
 - 4. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
 - 5. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
 - 6. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is permitted, under the following conditions:
 - a. Provide no more than 6 #12 AWG current-carrying conductors in 1/2 inch conduit; 9 #12 AWG current-carrying conductors in 3/4 inch conduit.
 - b. Provide no more than 6 #10 AWG current-carrying conductors in 3/4 inch conduit; 9 #10 AWG current-carrying conductors in 1 inch conduit.
 - c. Provide no more than 4 #8 AWG current-carrying conductors in 3/4 inch conduit; 6 #8 AWG current-carrying conductors in 1 inch conduit; 9 #8 AWG current-carrying conductors in 1-1/4 inch conduit.
 - 7. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.
- B Install products in accordance with manufacturer's instructions.
- C Perform work in accordance with NECA 1 (general workmanship).
- D Installation in Raceway:
 - 1. Pull all conductors and cables together into raceway at same time.
 - 2. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
 - 3. Use suitable wire pulling lubricant where necessary, except as below:
 - a. Do not use when lubricant is not recommended by the conductor manufacturer.
- E Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- F Install conductors with a minimum of 6 inches of slack at each outlet.

- G Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.
- H Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
- I Make wiring connections using specified wiring connectors.
 - 1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies.
 - 2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
 - 3. Do not remove conductor strands to facilitate insertion into connector.
 - 4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminants. Do not use wire brush on plated connector surfaces.
 - 5. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
 - 6. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- J Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
 - 1. Dry Locations: Use insulating covers specifically designed for the connectors or heat shrink tubing.
 - 2. Damp Locations: Use insulating covers specifically designed for the connectors or heat shrink tubing.
 - a. For connections with insulating covers, apply outer covering of moisture sealing electrical tape.
 - 3. Wet Locations: Use heat shrink tubing.
- K Insulate ends of spare conductors using vinyl insulating electrical tape.
- L Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.
- M Identify conductors and cables in accordance with Section 260553.
- N Install firestopping to preserve fire resistance rating of partitions and other elements.
- O Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

END OF SECTION

SECTION 260526
GROUNDING AND BONDING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Grounding and bonding requirements.
- B Conductors for grounding and bonding.
- C Connectors for grounding and bonding.
- D Ground bars.
- E Ground rod electrodes.

1.2 REFERENCE STANDARDS

- A NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B NEMA GR 1 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings.
- C NFPA 70 - National Electrical Code.
- D UL 467 - Grounding and Bonding Equipment.
- E TIA/EIA-607 - Commercial Building Grounding and Bonding Requirements for Telecommunications

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Verify exact locations of underground metal water service pipe entrances to building.
 - 2. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B Sequencing:
 - 1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.4 DEFINITIONS

- A ACEG: Alternating Current Equipment Ground
- B BCT: Bonding Conductor for Telecommunications (formerly Telecommunications Bonding Conductor)
- C BBC: Backbone Bonding Conductor (formerly Grounding Equalizer)

D PBB: Primary Bonding Busbar (formerly Telecommunications Main Grounding Busbar)

E TBB: Telecommunications Bonding Backbone

1.5 SUBMITTALS

A Product Data: Provide for ground bars.

B Telecommunications Grounding Test Reports.

1.6 QUALITY ASSURANCE

A Comply with requirements of NFPA 70.

B Comply with TIA/EIA-607 for telecommunications grounding.

1.7 DELIVERY, STORAGE, AND HANDLING

A Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 GROUNDING AND BONDING REQUIREMENTS

A Do not use products for applications other than as permitted by NFPA 70 and product listing.

B Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.

C Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

D Grounding Electrode System:

1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
 - a. Provide continuous grounding electrode conductors without splice or joint.
 - b. Install grounding electrode conductors in raceway. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
2. Metal Underground Water Pipe(s):
 - a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
 - b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
 - c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
3. Metal In-Ground Support Structure:
 - a. Provide connection to metal in-ground structure that is connected to the earth in accordance with NFPA 70.

4. Concrete-Encased Electrode:
 - a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of bare copper conductor sized as indicated on drawings embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
 5. Ground Rod Electrode(s):
 - a. Provide single electrode unless otherwise indicated or required.
 - b. Space electrodes not less than 10 feet from each other and any other ground electrode.
 6. Ground Bar: Provide ground bar, separate from service equipment enclosure, for common connection point of grounding electrode system bonding jumpers as permitted in NFPA 70. Connect grounding electrode conductor provided for service-supplied system grounding to this ground bar.
 - a. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.
- E Service-Supplied System Grounding:
1. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.
- F Separately Derived System Grounding:
1. Separately derived systems include, but are not limited to:
 - a. Transformers (except autotransformers such as buck-boost transformers).
 2. Provide grounding electrode conductor to connect derived system grounded conductor to nearest effectively grounded metal building frame. Unless otherwise indicated, make connection at neutral (grounded) bus in source enclosure.
 3. Provide bonding jumper to connect derived system grounded conductor to nearest metal building frame and nearest metal water piping in the area served by the derived system, where not already used as a grounding electrode for the derived system. Make connection at same location as grounding electrode conductor connection.
 4. Provide system bonding jumper to connect system grounded conductor to equipment ground bus. Make connection at same location as grounding electrode conductor connection. Do not make any other connections between neutral (grounded) conductors and ground on load side of separately derived system disconnect.
 5. Where the source and first disconnecting means are in separate enclosures, provide supply-side bonding jumper between source and first disconnecting means.
- G Bonding and Equipment Grounding:
1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
 2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
 3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
 4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.

5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
7. Provide bonding for metal building frame.

2.2 GROUNDING AND BONDING COMPONENTS

A General Requirements:

1. Provide products listed, classified, and labeled as suitable for the purpose intended.
2. Provide products listed and labeled as complying with UL 467 where applicable.

B Conductors for Grounding and Bonding, in Addition to Requirements of Section 260526:

1. Use insulated copper conductors unless otherwise indicated.
 - a. Exceptions:
 - 1) Use bare tinned copper conductors where installed underground in direct contact with earth.
 - 2) Use bare copper conductors where directly encased in concrete (not in raceway).

C Connectors for Grounding and Bonding:

1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
2. Unless otherwise indicated, use exothermic welded connections, high-pressure compression connections, or high-pressure compression connections for underground, concealed and other inaccessible connections.
3. Unless otherwise indicated, use compression connectors for accessible connections. For #6 AWG and smaller, use one-hole lugs. For #4 AWG and larger, use two-hole lugs.
 - a. Exceptions:
 - 1) Use exothermic welded connections or high-pressure compression connections for connections to metal building frame.
4. Manufacturers - High-Pressure Compression Connectors:
 - a. Burndy: www.burndy.com; Hyground System
 - b. Thomas & Betts: www.tnb.com.
 - c. Or pre-approved equivalent

D Ground Bars:

1. Description: Tinned copper rectangular ground bars with mounting brackets and insulators.
2. Size: As indicated.
3. Holes for Connections: As indicated or as required for connections to be made.

E Ground Rod Electrodes:

1. Comply with NEMA GR 1.
2. Material: Copper-bonded (copper-clad) steel.
3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.

PART 3 EXECUTION**3.1 EXAMINATION**

- A Verify that work likely to damage grounding and bonding system components has been completed.
- B Verify that field measurements are as indicated.
- C Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Install products in accordance with manufacturer's instructions.
- B Perform work in accordance with NECA 1 (general workmanship).
- C Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70 or install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70.
 - 1. Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.
 - 2. Indoor Installations: Unless otherwise indicated, install with 4 inches of top of rod exposed.
- D Mount ground bars in horizontal orientation.
- E Install each bonding conductor in a direct route, and parallel or perpendicular to building structure or surfaces, without interfering with other systems or equipment.
- F Install exterior grounding electrode conductors with a minimum bending radius of 12 inches.
- G Install interior grounding conductors with a minimum bending radius of 8 inches.
- H Install grounding conductors in EMT conduit unless otherwise indicated. Bond each end of the conduit to the grounding conductor using an appropriate grounding bushing.
- I Make grounding and bonding connections using specified connectors.
 - 1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
 - 2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
 - 3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
 - 4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
 - 5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

- J Identify grounding and bonding system components in accordance with Section 260553.
 - 1. Clean each surface prior to attachment of label.
 - 2. Follow manufacturer's recommendations for affixing labels.
 - 3. Ground Bars: Provide engraved laminate with 1-inch high letters. Locate at the upper left-hand side of bar. Engrave with bar designation followed by unique identifier as indicated on drawings.
 - a. MGB-
 - b. PBB-

3.3 TELECOMMUNICATIONS GROUNDING

- A When present, bond the following to the PBB:
 - 1. Building steel.
 - 2. Panelboards located in the same room as the PBB. Use ACEG connected to panelboard ground bus.
- B Conductor Labeling: Provide machine-printed, self-adhesive label equivalent to Brady label or Brother P-Touch label. Attach to each accessible end and at each break in the insulation for the cables indicated below. Indicate cable designation followed by unique numeric identifier.
 - 1. TBC
 - 2. TBB
 - 3. BBC
 - 4. ACEG

3.4 FIELD QUALITY CONTROL

- A Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- B Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.
- C Telecommunications Grounding system Testing and Documentation.
 - 1. Perform tests based on TIA/EIA-607, "Commercial Building Grounding and Bonding Requirements for Telecommunications" and document results to insure proper grounding of the telecommunications system.
 - 2. Tests require the following:
 - a. Equipment set-up and reference test.
 - b. Ground electrode resistance testing.
 - c. Grounding system continuity test.
 - d. Test result documentation.

END OF SECTION

SECTION 260529
HANGERS AND SUPPORTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

1.2 REFERENCE STANDARDS

- A ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- B ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- C ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- D MFMA-4 - Metal Framing Standards Publication.
- E NECA 1 - Standard for Good Workmanship in Electrical Construction.
- F NFPA 70 - National Electrical Code.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with actual equipment and components to be installed.
 - 2. Coordinate work to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at installed locations.
 - 4. Coordinate arrangement of supports with ductwork, piping, equipment and other potential conflicts.
 - 5. Notify Architect of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured.

1.4 DELIVERY, STORAGE, AND HANDLING

- A Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS**2.1 SUPPORT AND ATTACHMENT COMPONENTS****A General Requirements:**

1. Comply with the following. Where requirements differ, comply with most stringent.
 - a. NFPA 70.
 - b. Requirements of authorities having jurisdiction.
2. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of electrical work.
3. Provide products listed, classified, and labeled as suitable for purpose intended, where applicable.
4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
5. Do not use products for applications other than as permitted by NFPA 70 and product listing.
6. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
7. Steel Components: Use corrosion-resistant materials suitable for environment where installed.
 - a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B Conduit and Cable Supports: Straps and clamps suitable for conduit or cable to be supported.

1. Conduit Straps: One-hole or two-hole type; steel.
2. Conduit Clamps: Bolted type unless otherwise indicated.

C Outlet Box Supports: Hangers and brackets suitable for boxes to be supported.**D Metal Channel/Strut Framing Systems:**

1. Description: Factory-fabricated, continuous-slot, metal channel/strut and associated fittings, accessories, and hardware required for field assembly of supports.
2. Comply with MFMA-4.
3. Channel Material:
 - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.

E Hanger Rods: Threaded, zinc-plated steel unless otherwise indicated.**F Anchors and Fasteners:**

1. Unless otherwise indicated and where not otherwise restricted, use anchor and fastener types indicated for specified applications.
2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
4. Hollow Masonry: Use toggle bolts, expansion anchors, or expansion anchors.
5. Hollow Stud Walls: Use toggle bolts.
6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
7. Sheet Metal: Use sheet metal screws.

8. Plastic and lead anchors are not permitted.
 9. Powder-actuated fasteners are not permitted.
 10. Hammer-driven anchors and fasteners are not permitted.
- G Cable Supports for Vertical Conduit: Factory-fabricated body with insulated wedging plug, appropriately sized for conductors being supported.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated.
- B Verify that mounting surfaces are ready to receive support and attachment components.
- C Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Install products in accordance with manufacturer's instructions.
- B Install hangers and supports in accordance with NECA 1.
- C Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- E Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- F Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G Equipment Support and Attachment:
1. Use metal, fabricated supports or supports assembled from metal channel/strut to support equipment as required.
 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on walls when wall strength is not sufficient to resist pull-out.
 3. Use metal channel/strut to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 3-1/2 inch high concrete pad.
 5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
 6. Install surface-mounted cabinets and panelboards with minimum of four anchors.
- H Secure fasteners in accordance with manufacturer's recommended torque settings.
- I Remove temporary supports.

- J Identify independent electrical component support wires above accessible ceilings, where permitted, with color distinguishable from ceiling support wires in accordance with NFPA 70.

SECTION 260533.13

CONDUIT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Galvanized steel rigid metal conduit (RMC).
- B Galvanized steel intermediate metal conduit (IMC).
- C Flexible metal conduit (FMC).
- D Liquidtight flexible metal conduit (LFMC).
- E Galvanized steel electrical metallic tubing (EMT).
- F Rigid polyvinyl chloride (PVC) conduit.
- G Accessories.

1.2 REFERENCE STANDARDS

- A ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC).
- B ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S).
- C ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit.
- D NECA 1 - Standard for Good Workmanship in Electrical Construction.
- E NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT).
- F NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC).
- G NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
- H NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit.
- I NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
- J NFPA 70 - National Electrical Code.
- K UL 1 - Flexible Metal Conduit.
- L UL 6 - Electrical Rigid Metal Conduit-Steel.
- M UL 360 - Liquid-Tight Flexible Metal Conduit.

- N UL 514B - Conduit, Tubing, and Cable Fittings.
- O UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
- P UL 797 - Electrical Metallic Tubing-Steel.
- Q UL 1242 - Electrical Intermediate Metal Conduit-Steel.
- R UL 2419 - Outline of Investigation for Electrically Conductive Corrosion Resistant Compounds.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate minimum sizes of conduits with actual type and quantity of conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate arrangement of conduits with structural members, ductwork, piping, equipment, and other potential conflicts.
 - 3. Verify exact conduit termination locations required for boxes, enclosures, and equipment.
 - 4. Coordinate work to provide roof penetrations that preserve integrity of roofing system and do not void roof warranty.
 - 5. Notify Architect of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B Sequencing:
 - 1. Do not begin installation of conductors and cables until installation of conduit between termination points is complete.

1.4 DEFINITIONS

- A Telecommunications Pathway: Any item, raceway, box or enclosure in which telecommunications cabling is placed.

1.5 QUALITY ASSURANCE

1.6 DELIVERY, STORAGE, AND HANDLING

- A Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 CONDUIT APPLICATIONS

- A Do not use conduit and associated fittings for applications other than as permitted by NFPA 70, manufacturer's instructions, and product listing.
- B Outdoor Underground Installations:
 - 1. Unless otherwise indicated, use rigid non-metallic conduit
- C Outdoor Locations Above Grade: Use rigid steel conduit or intermediate metal conduit.

- D In Slab Above Grade or Beneath Slab-on-Grade:
 - 1. Use rigid non-metallic conduit.
- E Dry Locations:
 - 1. Concealed: Use electrical metallic tubing.
 - 2. Exposed: Use electrical metallic tubing.
- F Connection to Motors: Use liquid-tight flexible metal conduit, except use flexible metal conduit in air plenums.
- G Connection to Vibrating Equipment (including transformers):
 - 1. Indoors: Use flexible metal conduit.
 - 2. Outdoors: Use liquid-tight flexible metal conduit.

2.2 CONDUIT - GENERAL REQUIREMENTS

- A Comply with NFPA 70.
- B Provide conduit, fittings, supports, and accessories required for complete raceway system.
- C Provide products listed, classified, and labeled as suitable for purpose intended.
- D Minimum Conduit Size, Unless Otherwise Indicated:
 - 1. Branch Circuits: 1/2-inch trade size.
 - 2. Telecommunications Pathways: 1 inch trade size.
- E Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.3 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- A Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- B Fittings:
 - 1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6.
 - 2. Material: Use steel.
 - 3. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

2.4 GALVANIZED STEEL INTERMEDIATE METAL CONDUIT (IMC)

- A Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- B Fittings:
 - 1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 1242.
 - 2. Material: Use steel.

3. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

2.5 FLEXIBLE METAL CONDUIT (FMC)

- A Description: NFPA 70, Type FMC standard-wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems.
- B Fittings:
 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 2. Material: Use steel.

2.6 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360; rated for use with conductors rated 75 degrees C.
- B Fittings:
 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 2. Material: Use steel.

2.7 GALVANIZED STEEL ELECTRICAL METALLIC TUBING (EMT)

- A Description: NFPA 70, Type EMT galvanized steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- B Colored EMT:
 1. Manufacturer: Allied Tube and Conduit.
 2. Color Code:
 - a. Fire Alarm: Red
- C Fittings:
 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 2. Material: Use steel.
 3. Connectors and Couplings: Use compression/gland or set-screw type.
 - a. Do not use indenter type connectors and couplings.
 4. Damp or Wet Locations, Where Permitted: Use fittings listed for use in wet locations.

2.8 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

- A Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.
- B Fittings:
 1. Manufacturer: Same as manufacturer of conduit to be connected.

2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

2.9 ACCESSORIES

- A Conduit Joint Compound: Corrosion-resistant, electrically conductive compound listed as complying with UL 2419; suitable for use with conduit to be installed.
- B Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- C Pull Strings: Use nylon or polyester tape with average breaking strength of not less than 200 lbf.
- D Foam Conduit Sealant:
 1. Removable, two-part, closed-cell foam, specifically designed for sealing conduit openings against water, moisture, gases, and dust.
 2. Suitable for use with conductors/cables and associated insulation/jackets to be installed.
 3. Rated to hold minimum of 10 ft water head pressure.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated.
- B Verify that mounting surfaces are ready to receive conduits.
- C Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Install products in accordance with manufacturer's instructions.
- B Install conduit in accordance with NECA 1.
- C Galvanized Steel Rigid Metal Conduit (RMC): Install in accordance with NECA 101.
- D Intermediate Metal Conduit (IMC): Install in accordance with NECA 101.
- E Rigid Polyvinyl Chloride (PVC) Conduit: Install in accordance with NECA 111.
- F Conduit Routing:
 1. Unless dimensioned, conduit routing indicated is diagrammatic.
 2. When conduit destination is indicated without specific routing, determine exact routing required.
 3. Conceal conduits unless specifically indicated to be exposed.
 4. Conduits in the following areas may be exposed, unless otherwise indicated:
 - a. Electrical rooms.
 - b. Mechanical equipment rooms.
 5. Unless otherwise approved, do not route exposed conduits:

- a. Across floors.
 - b. Across roofs.
 - c. Across top of parapet walls.
 - d. Across building exterior surfaces.
6. Conduits installed underground or embedded in concrete may be routed in shortest possible manner unless otherwise indicated. Route other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
 7. Arrange conduit to maintain adequate headroom, clearances, and access.
 8. Arrange conduit to provide no more than equivalent of four 90-degree bends between pull points.
 9. Exterior Branch Circuits: Route conduits adjacent to curbs. Push or directional bore conduits beneath paved areas; otherwise, sawcut and remove pavement. Replace removed pavement to match existing.
 10. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
 11. Maintain minimum clearance of 12 inches between conduits and hot surfaces.
 12. Group parallel conduits in same area on common rack.

G Conduit Support:

1. Secure and support conduits in accordance with NFPA 70 using suitable supports and methods approved by authorities having jurisdiction; see Section 260529.
 - a. Support PVC conduit within 3 feet of termination points and at intervals not exceeding those listed below in accordance with NFPA 70 Table 352.30.
 - 1) 1/2" to 1" trade size = 3 feet spacing between supports.
 - 2) 1-1/4" to 2" trade size = 5 feet spacing between supports.
 - 3) 2-1/2" to 3" trade size = 6 feet spacing between supports.
 - 4) 3-1/2" to 5" trade size = 7 feet spacing between supports.
2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
4. Use of spring steel conduit clips for support of conduits is permitted only as follows:
 - a. Support of electrical metallic tubing (EMT) 1-1/2 inch trade size concealed above accessible ceilings and within hollow stud walls.
5. Use of wire for support of conduits is permitted only as follows:
 - a. For suspending conduits supported by spring steel conduit clips, where specifically indicated or permitted.

H Connections and Terminations:

1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
3. Use suitable adapters where required to transition from one type of conduit to another.
4. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
5. Provide insulated bushings on box connectors 1-inch and larger, on conduits stubbed above an accessible ceiling, and on conduits used for telecommunications pathways.

6. Secure joints and connections to provide mechanical strength and electrical continuity.
- I Penetrations:
1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
 2. Make penetrations perpendicular to surfaces unless otherwise indicated.
 3. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
 4. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty.
 5. Install firestopping to preserve fire resistance rating of partitions and other elements.
- J Conduits Beneath Slab on Grade:
1. Transition to rigid steel conduit, intermediate metal conduit, or electrical metallic tubing where conduit exits slab, except where concealed in walls rigid nonmetallic conduit may be stubbed a maximum of 14 inches above floor level.
- K Conduits Embedded in Concrete Slabs:
1. Install with at least 2 inches of concrete cover.
 2. Space a minimum of three diameters on center.
 3. Transition to rigid steel conduit, intermediate metal conduit, or electrical metallic tubing where conduit exits slab, except where concealed in walls rigid nonmetallic conduit may be stubbed a maximum of 14 inches above floor level.
 4. Do not place raceways in plain concrete, such as cement toppings on structural floors, without special permission. Do not displace reinforcing steel to accommodate raceway installation in reinforced concrete. Particular attention is called to the fact that there are many extenuating conditions where the Contractor may be instructed, during the course of the project, not to place embedded conduits in certain areas, generally due to the possibility of unsightly cracking or for structural reasons. Being so instructed shall not entitle the Contractor to extra compensation. Obtain permission from the Engineer for any raceway installation in reinforced concrete which requires concrete displacement exceeding the following:
 - a. Columns: 4 percent of plan area of column.
 - b. Floors : 1/3 of thickness of concrete.
 - c. Beams and Joists: 1/3 of least dimension.
- L Telecommunications Raceways: Install raceways in maximum lengths of 100 feet and with a maximum of two 90-degree bends or equivalent between boxes or pull points. Separate lengths with pull or junction boxes where necessary to comply with these requirements. Locate junction boxes in straight conduit runs. Do not install junction boxes where conduit runs change direction. Keep telecommunications raceways at least 5 inches away from light fixtures, transformers, panelboards, and feeders. Keep non-metallic telecommunications raceways at least 24 inches away from electrical equipment, feeders, and services.
- M Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:

1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
2. Where change in length, calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground, is expected to be 1/4 inch or greater between securely mounted items such as boxes, cabinets, elbows, or other conduit terminations, which includes the following conditions:
 - a. 100 foot intervals within spaces that have an ambient temperature range of 0-5 degrees Fahrenheit or less.
 - b. 60 foot intervals within spaces that have an ambient temperature range of 5-10 degrees Fahrenheit or less.
 - c. 40 foot intervals within spaces that have an ambient temperature range of 10-15 degrees Fahrenheit or less.
3. Where conduits are subject to earth movement by settlement or frost.

N Conduit Sealing:

1. Use foam conduit sealant to prevent entry of moisture and gases. This includes, but is not limited to:
 - a. Where conduits enter building from outside.
 - b. Where service conduits enter building from underground distribution system.
 - c. Where conduits enter building from underground.
 - d. Where conduits may transport moisture to contact live parts.
2. Where conduits cross barriers between areas of potential substantial temperature differential, use foam conduit sealant, junction box, or type C conduit at accessible point near penetration to prevent condensation. This includes, but is not limited to:
 - a. Where conduits pass from outdoors into conditioned interior spaces.
 - b. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.

O Provide pull string in each empty conduit and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.

P Provide grounding and bonding; see Section 260526.

Q Identify conduits; see Section 260553.

3.3 ELECTRICAL SERVICE

A Provide a primary duct bank consisting of PVC 40 conduit(s) for the power company primary cables unless otherwise indicated on the drawings or required by the power company. Provide 48-inch radius PVC 80 elbows at the transformer pad.

B Provide a secondary duct bank consisting of PVC 40 conduits sized as indicated on drawings. Provide 36-inch radius elbows at the transformer pad and beneath service equipment.

C In order to provide drainage for the duct banks, lay conduits with a minimum slope of 4 inches per 100 feet. Install duct lines so the top is not less than 48 inches below finish grade or finished paving. Where duct lines enter a manhole, terminate each conduit with an end bell.

D Symmetrically arrange concrete-encased duct banks with more than one conduit unless otherwise indicated on drawings. Provide plastic conduit spacers a maximum of 8 feet on center for the full

length of the duct bank. Maintain a 1-1/2 inch minimum spacing between ducts and a minimum 3-inch concrete envelope on all sides of duct bank.

- E Seal all secondary conduits watertight at the transformer pad and service entrance after installation of secondary conductors.
- F Provide pullboxes as required by the serving utility for all primary duct banks. Size and install pull boxes per code and in accordance with all power company requirements.

3.4 FIELD QUALITY CONTROL

- A Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- B Correct deficiencies and replace damaged or defective conduits.

3.5 CLEANING

- A Clean interior of conduits to remove moisture and foreign matter.

3.6 PROTECTION

- A Immediately after installation of conduit, use suitable caps to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

END OF SECTION

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SECTION 260533.16**BOXES****PART 1 GENERAL****1.1 SECTION INCLUDES**

- A Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
- C Floor boxes.

1.2 REFERENCE STANDARDS

- A NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- B NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
- C NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
- D NFPA 70 - National Electrical Code.
- E UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.
- F UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.
- G UL 508A - Industrial Control Panels.
- H UL 514A - Metallic Outlet Boxes.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
 - 4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
 - 5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
 - 6. Coordinate the work with other trades to preserve insulation integrity.

7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
8. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

- A Product Data: Provide manufacturer's standard catalog pages and data sheets for floor boxes.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 BOXES

- A General Requirements:
1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
 2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
 3. Provide products listed, classified, and labeled as suitable for the purpose intended.
 4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
 5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
- B Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
 2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
 3. Use suitable concrete type boxes where flush-mounted in concrete.
 4. Use suitable masonry type boxes where flush-mounted in masonry walls.
 5. Use raised covers suitable for the type of wall construction and device configuration where required.
 6. Do not use "through-wall" boxes designed for access from both sides of wall.
 7. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
 8. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
 9. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
 10. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.

11. Minimum Box Size, Unless Otherwise Indicated:
 - a. Wiring Devices (Other Than Communications Systems Outlets): 4 inch square by 1-1/2 inch deep (100 by 38 mm) trade size.
 - b. Communications Systems Outlets: 4 inch square by 2-1/8 inch deep trade size.
 - c. Ceiling Outlets: 4 inch octagonal or square by 1-1/2 inch deep (100 by 38 mm) trade size.
 12. Wall Plates: Comply with Section 262726.
- C Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
1. Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
 2. NEMA EN 10250 Environment Type, Unless Otherwise Indicated:
 - a. Indoor Clean, Dry Locations: Type 1, painted steel.
 - b. Outdoor Locations: Type 3R, painted steel.
 3. Junction and Pull Boxes Larger Than 100 cubic inches:
 - a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
 - b. Include cable supports if any dimension of the box is greater than 48 inches.
- D Floor Boxes:
1. See drawings for floor box requirements.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated.
- B Verify that mounting surfaces are ready to receive boxes.
- C Verify that conditions are satisfactory for installation prior to starting work.
- D Verify locations of floor boxes prior to rough-in.

3.2 INSTALLATION

- A Install products in accordance with manufacturer's instructions.
- B Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130.
- C Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.
- E Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.
- F Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.

G Box Locations:

1. Locate boxes to be accessible. Provide access panels as required where approved by the Architect.
2. Unless dimensioned, box locations indicated are approximate.
3. Locate boxes as required for devices installed under other sections or by others.
4. Locate boxes so that wall plates do not span different building finishes.
5. Locate boxes so that wall plates do not cross masonry joints.
6. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
7. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
8. Acoustic-Rated Walls: Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches horizontal separation.
9. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
 - a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
10. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 260533.13.
11. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect:
 - a. Concealed above accessible suspended ceilings.
 - b. Within joists in unfinished areas with no ceiling.
 - c. Electrical rooms.
 - d. Mechanical equipment rooms.

H Box Supports:

1. Secure and support boxes in accordance with NFPA 70 and Section 260529 using suitable supports and methods approved by the authority having jurisdiction.
2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
4. Use far-side support to secure flush-mounted boxes supported from single stud in hollow stud walls. Repair or replace supports for boxes that permit excessive movement.

I Install boxes plumb and level.**J Flush-Mounted Boxes:**

1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.

- 3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.
- K Install boxes as required to preserve insulation integrity.
- L Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- M Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified.
- N Close unused box openings.
- O Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- P Provide grounding and bonding in accordance with Section 260526.
- Q Identify boxes in accordance with Section 260553.
- R Orient boxes to accommodate wiring devices oriented as specified in Section 262726.
- S Orient each box located above an accessible ceiling so the box opening faces down or to one side.
- T Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.
- U Locate outlet boxes to allow luminaires positioned as shown on reflected ceiling plan.
- V Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 12 inches of box.

3.3 CLEANING

- A Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

END OF SECTION

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SECTION 260536
CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Metal cable tray systems:
 - 1. Metal wire mesh/basket cable tray.

1.2 REFERENCE STANDARDS

- A NECA 1 - Standard for Good Workmanship in Electrical Construction.
- A NECA/BICSI 568 - Standard for Installing Commercial Building Telecommunications Cabling.
- B NEMA BI-50016 - Cable Tray Installation Guidelines.
- C NEMA BI 50015 - Metal Cable Tray Systems.
- D NFPA 70 - National Electrical Code.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate arrangement of cable tray with structural members, ductwork, piping, equipment and other potential conflicts. Coordinate work to avoid installation of obstructions within cable tray required clearances.
 - 2. Coordinate arrangement of cable tray with dimensions and clearance requirements of actual products to be installed.
 - 3. Coordinate work with placement of supports and anchors required for mounting.
 - 4. Notify of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

- A Product Data: Provide data for each type of tray indicating material, finish, dimensions, fittings and accessories.

1.5 QUALITY ASSURANCE

- A Comply with NFPA 70.
- B Product Evaluation and Listing Organization Qualifications: Organization engaged in evaluation of products and services, including those recognized by OSHA as Nationally Recognized Testing Laboratories (NRTL), and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Receive, inspect, handle, and store products in accordance with manufacturer's instructions and NEMA BI-50016, except do not store cable tray outdoors without cover as permitted in NEMA BI-50016.
- B Handle products carefully to avoid damage to finish.

PART 2 PRODUCTS

2.1 CABLE TRAY SYSTEM - GENERAL REQUIREMENTS

- A Provide new cable tray system consisting of required components, fittings, supports, and accessories, as necessary for complete system.
- B Provide products listed, classified, and labeled as suitable for purpose intended.
- C Do not use cable tray for applications other than as permitted by NFPA 70 and product listing/classification.

2.2 METAL CABLE TRAY SYSTEMS

- A Manufacturers: Manufacturers listed in this paragraph apply except where manufacturers are listed for a specific product type below:
 - 1. B-Line Systems, Inc.
 - 2. Chalfant Cable Trays.
 - 3. MP Husky.
 - 4. PW Industries, Inc.
 - 5. Schneider Electric; Square D Products: www.schneider-electric.us.
 - 6. Thomas & Betts Corporation: www.tnb.com.
 - 7. T. J. Cope, Inc.
 - 8. Wiremold Company: www.wiremold.com.
 - 9. Or pre-approved equivalent
- B Comply with NEMA BI 50015.
- C Metal Wire Mesh/Basket Cable Tray:
 - 1. Material: Zinc electroplated steel.
 - 2. Tray Depth: As indicated on drawings.
 - 3. Mesh Spacing: 2 by 4 inches.
 - 4. Tray Width: As indicated on drawings.
 - 5. Hangers: Side rail hangers.
 - 6. Manufacturers:
 - a. B-Line Systems, Inc.
 - b. Cablofil.
 - c. GS Metals Corporation.
 - d. T. J. Cope, Inc.
 - e. Or pre-approved equivalent

PART 3 EXECUTION**3.1 EXAMINATION**

- A Verify that work likely to damage cable tray system has been completed.
- B Verify field measurements.
- C Verify that mounting surfaces are ready to receive cable tray and associated supports.
- D Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Install products in accordance with manufacturer's instructions.
- B Install cable tray in accordance with NECA 1 (general workmanship) and NEMA BI-50016.
- C Unless otherwise indicated, arrange cable tray to be parallel or perpendicular to building lines.
- D Remove sharp edges from trays.
- E Arrange cable tray to provide required clearances and maintain cable access.
 - 1. Cable Tray for Telecommunications Cables: Maintain recommended separation from sources of EMI greater than 5 kVA in accordance with NECA/BICSI 568.
- F Install cable tray plumb and level, with sections aligned and with horizontal runs at specified elevation.
- G Metal Wire Mesh/Basket Cable Tray:
 - 1. Field fabricate fittings in accordance with manufacturer's instructions, using only manufacturer-approved connectors classified for bonding.
 - 2. Cut tray using manufacturer's recommended cutting tool. File cut edges smooth.
 - 3. Locate supports a maximum of 5 feet on-center and no more than 30 inches from a tray joint.
 - 4. Install hardware with bolts oriented such that nuts are on the outside of the tray.
- H Cable Tray Movement Provisions:
 - 1. Provide expansion fittings where cable tray is subject to movement, including but not limited to:
 - a. Where cable tray crosses structural joints intended for expansion.
 - b. Long straight cable tray runs in accordance with NEMA BI-50016.
 - 2. Use expansion guides in lieu of hold-down clamps where prescribed in NEMA BI-50016.
 - 3. Set gaps for expansion fittings in accordance with NEMA BI-50016.
- I Cable and Conductors:
 - 1. Ampacity: As determined by applications listed in NFPA 70.
- J Cable Tray Support:

1. Use manufacturer's recommended hangers and supports, located in accordance with NEMA VE 2 and manufacturer's requirements, but not exceeding specified span. Provide required support and attachment in accordance with Section 260529, where not furnished by cable tray manufacturer.
 2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- K Grounding and Bonding Requirements:
1. Comply with grounding and bonding requirements of NEMA BI-50016.
 2. Metal Cable Tray Systems: Use suitable bonding jumpers or classified cable tray connectors to provide electrical continuity. Do not use classified cable tray connectors where cable tray sections have been modified, such as being bent, cut, or reshaped.
- L Provide a dropout fitting at the free end(s) of each cable tray run.
- M Penetrations: Install firestopping to preserve fire resistance rating of building elements, using materials and methods specified.

3.3 FIELD QUALITY CONTROL

- A Inspect cable tray system for damage and defects.
- B Correct deficiencies and replace damaged or defective cable tray system components.

3.4 CLEANING

- A Remove dirt and debris from cable tray.
- B Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.5 PROTECTION

- A Protect cable tray system from subsequent construction operations.

END OF SECTION

SECTION 260553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Electrical identification requirements.
- B Identification nameplates and labels.
- C Identification for conductors.
- D Underground warning tape.
- E Warning signs and labels.

1.2 REFERENCE STANDARDS

- A ANSI Z535.2 - American National Standard for Environmental and Facility Safety Signs.
- B ANSI Z535.4 - American National Standard for Product Safety Signs and Labels.
- C NFPA 70 - National Electrical Code.
- D NFPA 70E - Standard for Electrical Safety in the Workplace.

1.3 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.

1.4 FIELD CONDITIONS

- A Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.

PART 2 PRODUCTS

2.1 IDENTIFICATION REQUIREMENTS

- A Identification for Equipment:
 - 1. Use identification nameplate to identify electrical equipment.
 - a. Panelboards:
 - 1) Identify panelboard name.
 - 2) Identify power source and circuit number. Include location when not within sight of equipment.
 - 3) Use typewritten circuit directory to identify load(s) served for panelboards with a door.

- 4) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device.
 - b. Transformers:
 - 1) Identify transformer name.
 - 2) Identify power source and circuit number. Include location when not within sight of equipment.
 - c. Enclosed switches and circuit breakers:
 - 1) Identify power source and circuit number. Include location when not within sight of equipment.
 - 2) Identify load(s) served.
 - d. Ground Bars:
 - 1) Identify ground bar name.
 2. Service Equipment:
 - a. Use identification nameplate to identify each service disconnecting means.
 - b. For buildings or structures supplied by more than one service, or any combination of branch circuits, feeders, and services, use identification nameplate or means of identification acceptable to authority having jurisdiction at each service disconnecting means to identify all other services, feeders, and branch circuits supplying that building or structure. Verify format and descriptions with authority having jurisdiction.
 3. Use identification label to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".
 4. Available Fault Current Documentation: Use identification nameplate to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70 including but not limited to the following.
 - a. Service equipment.
 - b. Elevator control panels.
 5. Arc Flash Hazard Warning Labels: Use warning labels to identify arc flash hazards for electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are likely to require examination, adjustment, servicing, or maintenance while energized.
 - a. Legend: Include orange header that reads "WARNING", followed by the word message "Arc Flash and Shock Hazard; Appropriate PPE Required; Do not operate controls or open covers without appropriate personal protection equipment; Failure to comply may result in injury or death; Refer to NFPA 70E for minimum PPE requirements" or approved equivalent.
- B Identification for Conductors and Cables:
1. Color Coding for Power Conductors 600 V and Less: Comply with Section 260519.
 2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.
- C Identification for Raceways:
1. Use underground warning tape to identify underground raceways.
- D Identification for Boxes:
1. Use color-coded box covers to identify specified systems.

- a. Color-Coded Box Covers: Field-painted with two coats of enamel paint per the color code below:
 - 1) Fire Alarm System: Red.
 - b. For exposed boxes in public areas, do not color code.
 - 2. Use handwritten text using indelible marker to identify circuits enclosed.
 - a. For exposed boxes in public areas, provide identification on inside face of cover.
- E Identification for Devices:
- 1. Wiring Device and Wallplate Finishes: Comply with Section 262726.

2.2 IDENTIFICATION NAMEPLATES AND LABELS

- A Identification Nameplates:
- 1. Materials:
 - a. Indoor Clean, Dry Locations: Use plastic nameplates.
 - 2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
 - a. Color: White text on black background.
- B Identification Labels:
- 1. Manufacturers:
 - a. Brady Corporation: www.bradyid.com/#sle.
 - b. Brother International Corporation: www.brother-usa.com/#sle.
 - c. Panduit Corp: www.panduit.com/#sle.
 - 2. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
 - a. Use only for indoor locations.
 - 3. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.
 - 4. Color: Black text on clear background. Provide black text on white background when applying to a dark surface.
- C Format for Equipment Identification:
- 1. Minimum Size:
 - a. Plastic Nameplates: 1 inch by 2.5 inches.
 - b. Identification Labels: 0.5 inch by 2.5 inches.
 - 2. Legend:
 - a. Equipment designation or other approved description.
 - 3. Text: All capitalized unless otherwise indicated.
 - 4. Minimum Text Height:
 - a. Equipment Designation: 3/8 inch.

2.3 UNDERGROUND WARNING TAPE

- A Materials: Use foil-backed detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.

- B Foil-backed Detectable Type Tape: 3 inches wide, with minimum thickness of 5 mil, unless otherwise required for proper detection.
- C Legend: Type of service, continuously repeated over full length of tape.
- D Color:
 - 1. Tape for Buried Power Lines: Black text on red background.
 - 2. Tape for Buried Communication, Alarm, and Signal Lines: Black text on orange background.

2.4 WARNING SIGNS AND LABELS

- A Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.
- B Warning Labels:
 - 1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
 - 2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
 - 3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 EXECUTION

3.1 PREPARATION

- A Clean surfaces to receive adhesive products according to manufacturer's instructions.

3.2 INSTALLATION

- A Install products in accordance with manufacturer's instructions.
- B Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
 - 1. Surface-Mounted Equipment: Enclosure front.
 - 2. Flush-Mounted Equipment: inside of equipment door when installed in a finished location.
 - 3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
 - 4. Elevated Equipment: Legible from the floor or working platform.
 - 5. Boxes: Outside face of cover.
 - 6. Devices: Outside face of cover.
- C Install identification products centered, level, and parallel with lines of item being identified.
- D Secure nameplates to exterior surfaces of enclosures using stainless steel screws or self-adhesive backing and to interior surfaces using self-adhesive backing.
- E Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.

- F Install underground warning tape above buried lines with one tape per trench at 6 inches below finished grade.
- G Mark all handwritten text, where permitted, to be neat and legible.

3.3 FIELD QUALITY CONTROL

- A Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION

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SECTION 260583
WIRING CONNECTIONS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Electrical connections to equipment.

1.2 REFERENCE STANDARDS

- A NEMA WD 6 - Wiring Devices - Dimensional Specifications.
- B NFPA 70 - National Electrical Code.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
 - 2. Determine connection locations and requirements.
- B Sequencing:
 - 1. Install rough-in of electrical connections before installation of equipment is required.
 - 2. Make electrical connections before required start-up of equipment.

1.4 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.
- B Products: Listed, classified, and labeled as suitable for the purpose intended.

PART 2 PRODUCTS

2.1 MATERIALS

- 1. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
- 2. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

- A Make electrical connections in accordance with equipment manufacturer's instructions.

- B Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- C Provide receptacle outlet to accommodate connection with attachment plug.
- D Provide cord and cap where field-supplied attachment plug is required.
- E Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.
- F Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
- G Provide final power and control connections for equipment furnished under other Divisions of this specification and for Owner-furnished equipment. Where not specified in mechanical sections of this specification, connect motor controls and associated mechanical equipment as required for a complete and functional control system.
- H Provide interlocks and wiring to and between controls for Owner-furnished equipment, pumps, fans, rooftop units, unit heaters, and elevator life safety panels.
- I Verify control wiring requirements with manufacturer certified shop drawings for each piece of equipment or control system and install accordingly. Install control wiring in conduit.

3.3 EQUIPMENT REQUIREMENTS

- A Electric Water Coolers:
 - 1. Locate receptacle for each electric water cooler so that cord and plug are concealed inside or behind cooler.
- B Temperature Control / Energy Management System Panels:
 - 1. Provide a dedicated power circuit from the nearest 120 V general purpose panel to each temperature control, energy management system, or data gathering panel.
 - 2. Coordinate panel quantities and locations with Installing Contractor.
- C Elevators:
 - 1. Provide heat and smoke detectors as indicated on drawings and as required by code.
 - 2. Provide fire alarm connection to each elevator controller.
- D Power Operated Personnel Doors:
 - 1. Connect equipment and accessories provided with each power operated door including but not limited to:
 - a. Power supplies.
 - b. Pushbuttons.
 - 2. Coordinate wiring requirements with door supplier. Field verify locations of switches and pushbuttons.
 - 3. Where doors are installed in fire or smoke walls, provide relays and wiring to fire alarm panel as required to disconnect power to door operator during a fire alarm condition.

END OF SECTION

SECTION 260923
LIGHTING CONTROLS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Wall pushbutton stations.
- B Occupancy sensors.
- C Exterior photo controls.
- D Interior daylighting controls.

1.2 REFERENCE STANDARDS

- A NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B NECA 130 - Standard for Installing and Maintaining Wiring Devices.
- C NFPA 70 - National Electrical Code.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate placement of lighting control devices with millwork, furniture, equipment and other potential conflicts.
 - 2. Coordinate placement of wall switch occupancy sensors with installed door swings.
 - 3. Coordinate placement of occupancy sensors with millwork, furniture, equipment and other potential obstructions to motion detection coverage.
 - 4. Coordinate lighting control device product selections with luminaire characteristics; see Section 265100 and lighting fixture schedule.
 - 5. Notify Architect of conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.
- B Sequencing:
 - 1. Do not install lighting control devices until final surface finishes and painting are complete.
- C Pre-Wire Meeting:
 - 1. Include the services of a factory trained technician to attend and facilitate an on-site pre-wire meeting to review system installation requirements.
 - 2. Schedule meeting to occur after receipt of final shop drawings.

1.4 SUBMITTALS

- A Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features of products being provided.

- B Shop Drawings:
 - 1. Provide lighting plan, drawn to scale, indicating location, model number, and orientation of each device being provided.
 - 2. Daylighting Controls: Provide lighting plan indicating location, model number, and orientation of each photo sensor and associated system component.
 - 3. Pushbutton Stations: Provide elevation of each unique pushbutton station indicating button labeling.
 - 4. Interconnection diagram of field installed wiring.
- C Functional Performance Testing Reports.
- D Operation and Maintenance Data: Submit within 90 days of receipt of the Certificate of Occupancy. Include the following:
 - 1. Name and address of not less than one service agency for installed equipment.
 - 2. Narrative of how each system is intended to operate, including recommended setpoints.
 - 3. Submittal data indicating all selected options for each piece of lighting control equipment and lighting controls.
 - 4. Manual for each piece of lighting control equipment indicating required routine maintenance actions and cleaning.
 - 5. Schedule for inspecting and recalibrating lighting controls.
- E Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Occupancy Sensors, Daylight Harvesting Sensors, Outdoor Photosensor, Power Packs, Room Controllers, and Wall Pushbutton Stations (without labeling): Two percent of total quantity installed for each type, but not less than one of each type.
- F Project Record Documents: Submit within 90 days of receipt of the Certificate of Occupancy. Record actual installed location, catalog number, and settings for each lighting control device.

1.5 QUALITY ASSURANCE

- A Comply with NFPA 70.
- B Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum five years documented experience.
- C Product Evaluation and Listing Organization Qualifications: Organization engaged in evaluation of products and services, including those recognized by OSHA as Nationally Recognized Testing Laboratories (NRTL), and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND PROTECTION

- A Store products in clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

1.7 FIELD CONDITIONS

- A Maintain field conditions within manufacturer's required service conditions during and after installation.

1.8 WARRANTY

- A Provide five year manufacturer warranty for lighting control components.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Acuity Brands.
- B Encelium.
- C Lutron.
- D Wattstopper.
- E Or pre-approved equivalent
- F Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier, where possible, unless indicated otherwise.
- G Substitutions and Prior Approval Requests: Manufacturers not listed will be considered as a prior approval or substitution request. Provide the following:
 - 1. Manufacturer's cut sheets for proposed components.
 - 2. Example wiring schematic.
 - 3. Upon request, a working sample.

2.2 LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS

- A System Description: Distributed, low voltage, digital load controllers that control lighting within rooms/spaces. Link load controllers as part of a networked lighting control system as indicated on the Lighting Control Schedule.
- B Provide system consisting of wired components.
- C Provide products listed, classified, and labeled as suitable for purpose intended.
- D Unless specifically indicated to be excluded, provide all required conduit, wiring, connectors, hardware, components, accessories, etc. as required for a complete operating system compatible with controlled luminaires.
- E Provide controller as required to support time of day and astronomical time clock capabilities for scheduled lighting control events.
- F Provide factory pre-terminated and tested plenum rated cables for interconnection of system components, types as recommended by manufacturer.
 - 1. Select cable lengths based on actual installation conditions.
 - 2. Cables shall be as short as practical.
 - 3. Provide white cables unless noted otherwise.

- G Where dimming is indicated, provide a continuous flicker-free dimming system.
- H Where networked lighting control system is indicated, provide:
 - 1. Web-based user interface.

2.3 WALL PUSHBUTTON STATIONS

- A General Requirements: Low voltage, quiet operating, types as indicated on drawings, compatible with load types being controlled. Provide factory labeled pushbuttons.
- B Where dimming controls are indicated, provide separate raise and lower buttons.
- C Provide devices and plates with finishes matching wiring devices.

2.4 OCCUPANCY SENSORS

- A General Requirements:
 - 1. Provide the following type of sensor per area, unless indicated otherwise:
 - a. Offices: Dual technology.
 - b. Restrooms: Ultrasonic or microphonic.
 - c. Corridors: Passive infrared.
 - d. Other Areas: As recommended by manufacturer.
 - 2. Description: Factory-assembled commercial specification grade devices for indoor use capable of sensing both major motion, such as walking, and minor motion, such as small desktop level movements, according to published coverage areas, for automatic control of load indicated.
 - 3. Provide LED to visually indicate motion detection.
 - 4. Operation: Unless otherwise indicated, occupancy sensor to turn load on when occupant presence is detected and to turn load off when no occupant presence is detected during adjustable turn-off delay time interval.
 - 5. Dual Technology Occupancy Sensors: Field configurable turn-on and hold-on activation with settings for activation by either or both sensing technologies.
 - 6. Passive Infrared Lens Field of View: Field customizable by addition of factory masking material, adjustment of integral blinders, or similar means to block motion detection in selected areas.
 - 7. Turn-Off Delay: Field adjustable, with time delay settings up to 30 minutes.
 - 8. Sensitivity: Field adjustable.
 - 9. Compatibility (Non-Dimming Sensors): Suitable for controlling incandescent lighting, low-voltage lighting with electronic and magnetic transformers, fluorescent lighting with electronic and magnetic ballasts, and fractional motor loads, with no minimum load requirements.
 - 10. Load Rating for Line Voltage Occupancy Sensors: As required to control load indicated on drawings.
 - 11. Isolated Relay for Low Voltage Occupancy Sensors: Where indicated, SPDT dry contacts, ratings as required for interface with system indicated.
- B Wall Switch Occupancy Sensors:
 - 1. General Requirements:

- a. Description: Occupancy sensors designed for installation in standard wall box at standard wall switch mounting height with field of view of 180 degrees, integrated manual control capability, and no leakage current to load in off mode.
 - b. Unless otherwise indicated or required to control load indicated on drawings, provide line voltage units with self-contained relay.
 - c. Where indicated or required, provide two-circuit units for control of two separate lighting loads, with separate manual controls and separately programmable operation for each load.
 - d. Operation: Field selectable to operate either as occupancy sensor (automatic on/off) or as vacancy sensor (manual-on/automatic off).
 - e. Where dimming is indicated or required, comply with the following:
 - 1) Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, and listed as complying with UL 1472; type and rating suitable for load controlled.
 - 2) Provide field adjustable dimming preset for occupied state.
 - 3) Provide fade-to-off operation to notify occupant of impending load turn-off.
2. Passive Infrared (PIR) Wall Switch Occupancy Sensors: Capable of detecting motion within area of 900 square feet.
 3. Ultrasonic Wall Switch Occupancy Sensors: Capable of detecting motion within area of 400 square feet.
 4. Passive Infrared/Ultrasonic Dual Technology Wall Switch Occupancy Sensors: Capable of detecting motion within area of 900 square feet.
- C Ceiling Mounted Occupancy Sensors:
1. General Requirements:
 - a. Description: Low profile occupancy sensors designed for ceiling installation.
 - b. Occupancy sensor to be field selectable as either manual-on/automatic-off or automatic on/off.
 - c. Finish: White unless otherwise indicated.
 2. Passive Infrared (PIR) Ceiling Mounted Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within area of 450 square feet at mounting height of 9 feet, with field of view of 360 degrees.
 3. Ultrasonic Ceiling Mounted Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within area of 500 square feet at mounting height of 9 feet, with field of view of 360 degrees.
 - b. Medium Range Sensors: Capable of detecting motion within area of 1,000 square feet at mounting height of 9 feet, with field of view of 360 degrees.
 4. Passive Infrared/Ultrasonic Dual Technology Ceiling Mounted Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within area of 450 square feet at mounting height of 9 feet, with field of view of 360 degrees.
 5. Passive Infrared/Acoustic Dual Technology Ceiling Mounted Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within area of 450 square feet at mounting height of 9 feet, with field of view of 360 degrees.
- D Directional Occupancy Sensors:
1. General Requirements:

- a. Description: Occupancy sensors designed for wall or ceiling mounting, with integral swivel for field adjustment of motion detection coverage.
 2. Passive Infrared (PIR) Directional Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within distance of 40 feet at mounting height of 10 feet.
 3. Passive Infrared/Ultrasonic Dual Technology Directional Occupancy Sensors: Capable of detecting motion within distance of 40 feet at mounting height of 10 feet.
- E Power Packs for Occupancy Sensors:
1. Description: Plenum rated, self-contained class 2 transformer and relay compatible with specified occupancy sensors for switching of line voltage loads.
 2. Provide quantity and configuration of power and slave packs with associated wiring and accessories as required to control load indicated on drawings.
 3. Input Supply Voltage: Dual rated for 120/277 V ac.
 4. Load Rating: As required to control load indicated on drawings.
 5. Provide auxiliary contact closure output where indicated.
 6. Rated Life of Relay: One million cycles.

2.5 EXTERIOR PHOTO CONTROLS

- A General requirements:
1. Control system consisting of photo sensors and compatible control modules and power packs, contactors, or relays as required for automatic control of exterior lighting load indicated according to available daylight.
- B Outdoor photo controls general requirements:
1. Control system consisting of photosensors and compatible control modules and power packs, contactors, or relays as required for automatic control of exterior lighting load indicated according to available natural light.
- C Outdoor Light Level Sensors:
1. Description: Listed and labeled as complying with UL 773A.
 2. Housing: Weatherproof, impact resistant polycarbonate.
 3. Light Level Activation: 1 to 5 footcandles turn-on and 3 to 1 turn-off to turn-on ratio with delayed turn-off.
 4. Voltage: As required to control the load indicated on the drawings.
 5. Failure Mode: Fails to the on position.
 6. Load Rating: As required to control the load indicated on the drawings.

2.6 INTERIOR DAYLIGHTING CONROLS

- A General requirements:
1. Control system consisting of photo sensors and compatible control modules and power packs, contactors, or relays as required for automatic reduction of interior lighting load indicated according to available daylight; capable of integrating with occupancy sensors and manual override controls.
- B Indoor Light Level Sensors: Low voltage photo sensor units with output signal proportional to the measured light level and provision for zero or offset based signal.

1. For each room with a daylighting zone indicated on drawings, provide a dedicated sensor for control of the indicated daylighting zone.
 2. Sensor Type: Filtered silicon photo diode.
 3. Sensor Range:
 - a. Indoor Photo Sensors: 5 to 100 footcandles.
 4. Finish: White unless otherwise indicated.
- C Dimming Photo Sensors: Photo sensor compatible with specified dimming ballasts/drivers or associated control modules, for direct continuous dimming.
- D Daylighting Control Switching Modules: Control unit compatible with specified photo sensors, for switching of compatible power packs, contactors, or relays in response to changes in measured light levels according to selected settings.
1. Control Capability:
 - a. Single Zone Switching Modules: Capable of controlling one programmable channel.
 - b. Multi-Zone Switching Modules: Capable of controlling up to three separately programmable channels.
- E Daylighting Control Dimming Modules: Control unit compatible with specified photo sensors and with specified dimming ballasts/drivers, for both continuous dimming of compatible dimming ballasts/drivers and switching of compatible power packs, contactors, or relays in response to changes in measured light levels according to selected settings.
1. Load to be turned off or dimmed to a minimum level when available daylight is sufficient to fully dim the load, after the selected time delay.
 2. Dimming and Fade Rates: Adjustable from 5 to 60 seconds.
 3. Cut-Off Delay: Selectable and adjustable from 0 to 20 minutes.
 4. Output Voltage: Compatible with specified dimming ballasts/drivers.
- F Power Packs for Low Voltage Daylighting Control Modules:
1. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage daylighting control modules for switching of line voltage loads. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on drawings.
 2. Input Supply Voltage: Dual rated for 120/277 V ac.
 3. Load Ratings: As required to control the load indicated on drawings.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated.
- B Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.
- D Verify that final surface finishes are complete, including painting.

- E Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.
- F Verify that service voltage and ratings of lighting control devices are appropriate for service voltage and load requirements at location to be installed.
- G Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A Provide extension rings to bring outlet boxes flush with finished surface.
- B Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A Install lighting control devices in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B Coordinate locations of outlet boxes as required for installation of lighting control devices; see Section 260533.16.
 - 1. Orient outlet boxes for vertical installation of lighting control devices unless otherwise indicated.
 - 2. Locate wall switch occupancy sensors on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Architect to obtain direction prior to proceeding with work.
- C Install lighting control devices in accordance with manufacturer's instructions.
- D Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- E Install lighting control devices plumb and level, and held securely in place.
- F Where required and not furnished with lighting control device, provide wall plate; see Section 262726.
- G Provide required supports; see Section 260529.
- H Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- I Identify lighting control devices; see Section 260553.
- J Occupancy Sensor Locations:

1. Drawings are diagrammatic and only intended to indicate which rooms or areas require devices. Provide quantity and locations as required for complete coverage of respective room or area based on manufacturer's recommendations for installed devices.
 2. Locate ultrasonic and dual technology passive infrared/ultrasonic occupancy sensors minimum of 4 feet from air supply ducts or other sources of heavy air flow and as per manufacturer's recommendations, in order to minimize false triggers.
 3. Locate sensors so that coverage does not extend beyond the area controlled.
 4. Drawings are diagrammatic and only intended to indicate which rooms or areas require devices. Provide quantity and locations as required for proper control of respective room or area based on manufacturer's recommendations for installed devices.
- K Unless otherwise indicated, install emergency lighting relays and power packs for lighting control devices above accessible ceiling or above access panel in inaccessible ceiling near the sensor location.
- L Where indicated, install separate compatible wall switches for manual control interface with lighting control devices or associated power packs.
- M Unless otherwise indicated, install low voltage control cabling in conduit in areas with exposed structure and above inaccessible ceilings.
- N Low voltage control cabling may be installed without conduit where concealed above an accessible ceiling. For wall-mounted devices, provide conduit stubbed to above the nearest accessible ceiling. Route cabling parallel or perpendicular to building structure or surfaces.
1. Support using J-hook cable hangers or plenum rated cable ties attached to conduit supports or to branch circuit conduits as allowed by Code. Locate supports with a maximum spacing of 10 feet.
 2. Do not support from piping, ductwork or other systems. Do not provide support from ceiling grid or allow conductors and cables to lay on ceiling tiles.
 3. Coil and support excess cable slack.
- O Maintain separation of normal and emergency branch circuit wiring connected to emergency lighting relays as required by NFPA 70. Normal and emergency branch circuits can be combined only within the emergency lighting relay enclosure.
- P Fire Alarm System Integration: Program emergency lighting relay(s) to drive emergency lighting to full brightness upon signal from fire alarm system under general fire alarm.

3.4 SYSTEM STARTUP AND PROGRAMMING

- A Coordinate system programming and device engraving with Owner.
- B Provide factory startup and programming of system. Program according to Owner's requirements.
- C Coordinate high end and/or low end trim levels with Owner and Architect during system programming.

3.5 FIELD QUALITY CONTROL

- A Inspect each lighting control device for damage and defects.
- B Perform functional performance tests as required by this specification section and as required by applicable codes.
- C Correct wiring deficiencies and replace damaged or defective conductors, cables, and lighting control devices.

3.6 ADJUSTING

- A Adjust devices and wall plates to be flush and level.
- B Adjust position of directional occupancy sensors and outdoor motion sensors to achieve optimal coverage as required.

3.7 CLEANING

- A Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.8 FUNCTIONAL PERFORMANCE TESTING

- A Prior to final inspection, perform functional performance testing and submit documentation to the Architect that control hardware and software are calibrated, adjusted, programmed and in proper working condition in accordance with the construction documents and manufacturer's instructions.
 - 1. Occupancy sensor controls.
 - a. Certify that each occupancy sensor has been located and aimed in accordance with manufacturer recommendations
 - b. Test each occupancy sensor.
 - c. Verify the following:
 - 1) Where included, status indicators operate correctly.
 - 2) The controlled lights turn off or down to the permitted level within the required time.
 - 3) For auto-on occupancy sensor controls, the lights turn on to the permitted level when an occupant enters the space.
 - 4) For manual-on occupancy sensor controls, the lights turn on only when manually activated.
 - 5) The lights are not incorrectly turned on by movement in adjacent areas or by HVAC operation.
 - 2. Time switch controls.
 - a. Confirm that the time switch control is programmed with accurate weekday, weekend and holiday schedules.
 - b. Provide documentation to the Owner of time switch controls programming including weekday, weekend, holiday schedules, and set-up and preference program settings.
 - c. Verify the correct time and date in the time switch.
 - d. Verify that any battery backup is installed and energized.
 - e. Verify that the override time limit is set to not more than 2 hours.

- f. Simulate occupied condition. Verify and document the following:
 - 1) All lights can be turned on and off by their respective area control switch.
 - 2) The switch only operates lighting in the enclosed space in which the switch is located.
- g. Simulate unoccupied condition. Verify and document the following:
 - 1) Nonexempt lighting turns off.
 - 2) Manual override switch allows only the lights in the enclosed space where the override switch is located to turn on or remain on until the next scheduled shutoff occurs.
- 3. Daylight responsive controls.
 - a. Verify the following:
 - 1) Control devices have been properly located, field calibrated and set for accurate setpoints and threshold light levels.
 - 2) Daylight controlled lighting loads adjust to light level setpoints in response to available daylight.
 - 3) The calibration adjustment equipment is located for ready access only by authorized personnel.
- 4. Provide a report of the test results. Include the following:
 - a. Results of functional performance tests.
 - b. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.

3.9 CLOSEOUT ACTIVITIES

- A Training: Train Owner's personnel on operation, adjustment, programming, and maintenance of lighting control devices.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Instructor: Manufacturer's authorized service representative.
 - 4. Location: At project site.

3.10 MAINTENANCE

- A Occupancy Adjustments: Within one year of Substantial Completion, provide on-site assistance by a manufacturer's authorized service representative to make system adjustments or to provide training. Provide three visits, at approximately three, six and twelve months after Substantial Completion for this purpose.

END OF SECTION

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SECTION 262200
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A General purpose transformers.

1.2 REFERENCE STANDARDS

- A 10 CFR 431, Subpart K - Energy Efficiency Program for Certain Commercial and Industrial Equipment - Distribution Transformers.
- B IEEE C57.94 - IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type Distribution and Power Transformers.
- C IEEE C57.96 - IEEE Standard Guide for Loading Dry-Type Distribution and Power Transformers.
- D NECA 1 - Standard for Good Workmanship in Electrical Construction.
- E NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers.
- F NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- G NEMA ST 20 - Dry Type Transformers for General Applications.
- H NFPA 70 - National Electrical Code.
- I UL 506 - Standard for Specialty Transformers.
- J UL 1561 - Standard for Dry-Type General Purpose and Power Transformers.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work with placement of supports, anchors, etc. required for mounting.
 - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

- A Product Data: Provide outline dimensions of enclosures and accessories, unit weight, voltage, kVA, tap configurations, insulation system type, and rated temperature rise.
- B Maintenance Data: Include recommended maintenance procedures and intervals.
- C Project Record Documents: Record actual locations of transformers.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.
- B Products: Listed and classified by testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

1.7 FIELD CONDITIONS

- A Ambient Temperature: Do not exceed the following maximum temperatures during and after installation of transformers.
 - 1. Greater than 10 kVA: 104 degrees F maximum.
 - 2. Less than 10 kVA: 77 degrees F maximum.

PART 2 PRODUCTS**2.1 MANUFACTURERS**

- A ABB/GE: www.electrification.us.abb.com.
- B Eaton Corporation: www.eaton.com.
- C Schneider Electric; Square D Products: www.schneider-electric.us.
- D Siemens Industry, Inc: www.usa.siemens.com.
- E Or pre-approved equivalent
- F Source Limitations: Provide transformers produced by same manufacturer as other electrical distribution equipment used for project and obtained from single supplier.

2.2 TRANSFORMERS - GENERAL REQUIREMENTS

- A Description: Factory-assembled, dry type transformers for 60 Hz operation designed and manufactured in accordance with NEMA ST 20 and listed, classified, and labeled as suitable for the purpose intended.
- B Unless noted otherwise, transformer ratings indicated are for continuous loading according to IEEE C57.96 under the following service conditions:
 - 1. Altitude: Less than 3,300 feet.
- C Core: High grade, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Keep magnetic flux densities substantially below saturation point, even at 10 percent primary overvoltage. Tightly clamp core laminations to prevent plate movement and maintain consistent pressure throughout core length.
- D Impregnate core and coil assembly with non-hygroscopic thermo-setting varnish to effectively seal out moisture and other contaminants.
- E Basic Impulse Level: 10 kV.
- F Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.
- G Isolate core and coil from enclosure using vibration-absorbing mounts.
- H Nameplate: Include transformer connection data, ratings, wiring diagrams, and overload capacity based on rated winding temperature rise.

2.3 GENERAL PURPOSE TRANSFORMERS

- A Description: Self-cooled, two winding transformers listed and labeled as complying with UL 506 or UL 1561; ratings as indicated on the drawings.
- B Insulation System and Allowable Average Winding Temperature Rise:
 - 1. Less than 15 kVA: Class 180 degrees C insulation system with 115 degrees C average winding temperature rise.
 - 2. 15 kVA and Larger: Class 220 degrees C insulation system with 150 degrees C average winding temperature rise.
- C Coil Conductors: Continuous copper or aluminum windings with terminations brazed or welded.
- D Winding Taps:
 - 1. Less than 3 kVA: None.
 - 2. 3 kVA through 15 kVA: Two 5 percent full capacity primary taps below rated voltage.
 - 3. 15 kVA through 300 kVA: Two 2.5 percent full capacity primary taps above and four 2.5 percent full capacity primary taps below rated voltage.
 - 4. 500 kVA and Larger: Two 2.5 percent full capacity primary taps above and two 2.5 percent full capacity primary taps below rated voltage.
- E Energy Efficiency: Comply with 10 CFR 431, Subpart K.

- F Sound Levels: Standard sound levels complying with NEMA ST 20
- G Mounting Provisions:
 - 1. Less than 15 kVA: Suitable for wall mounting.
 - 2. 15 kVA through 75 kVA: Suitable for wall, floor, or trapeze mounting.
 - 3. Larger than 75 kVA: Suitable for floor mounting.
- H Transformer Enclosure: Comply with NEMA ST 20.
 - 1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor clean, dry locations: Type 1.
 - 2. Construction: Steel.
 - a. Less than 15 kVA: Totally enclosed, non-ventilated.
 - b. 15 kVA and Larger: Ventilated.
 - 3. Finish: Manufacturer's standard grey, suitable for outdoor installations.
 - 4. Provide lifting eyes or brackets.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated.
- B Verify that suitable support frames and anchors are installed where required and that mounting surfaces are ready to receive transformers.
- C Perform pre-installation tests and inspections on transformers per manufacturer's instructions and as specified in NECA 409. Correct deficiencies prior to installation.
- D Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Perform work in accordance with NECA 1 (general workmanship).
- B Install products in accordance with manufacturer's instructions.
- C Install transformers in accordance with NECA 409 and IEEE C57.94.
- D Use flexible conduit, under the provisions of Section 260533.13, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- E Arrange equipment to provide minimum clearances as specified on transformer nameplate and in accordance with manufacturer's instructions and NFPA 70.
- F Install transformers plumb and level.
- G Transformer Support:
 - 1. Provide required support and attachment in accordance with Section 260529, where not furnished by transformer manufacturer.

2. Use integral transformer flanges, accessory brackets furnished by manufacturer, or field-fabricated supports to support wall-mounted transformers.
 3. Unless otherwise indicated, mount floor-mounted transformers on properly sized 3.5 inch high concrete pad.
 4. Use trapeze hangers assembled from threaded rods and metal channel (strut) to support suspended transformers. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- H Provide grounding and bonding in accordance with Section 260526.
- I Remove shipping braces and adjust bolts that attach the core and coil mounting bracket to the enclosure according to manufacturer's recommendations in order to reduce audible noise transmission.
- J Where not factory-installed, install lugs sized as required for termination of conductors as indicated.
- K Identify transformers in accordance with Section 260553.

3.3 ADJUSTING

- A Measure primary and secondary voltages and make appropriate tap adjustments. Set taps for transformers with 208Y/120 volt secondaries to 213/123 volts.
- B Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.4 CLEANING

- A Clean dirt and debris from transformer components according to manufacturer's instructions.
- B Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

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SECTION 262416

PANELBOARDS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Power distribution panelboards.
- B Lighting and appliance panelboards.
- C Overcurrent protective devices for panelboards.

1.2 REFERENCE STANDARDS

- A NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B NECA 407 - Standard for Installing and Maintaining Panelboards.
- C NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- D NEMA PB 1 - Panelboards.
- E NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
- F NFPA 70 - National Electrical Code.
- G UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.
- H UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.
- I UL 67 - Panelboards.
- J UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
- K UL 869A - Reference Standard for Service Equipment.
- L UL 943 - Ground-Fault Circuit-Interrupters.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.

3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

- A Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
- B Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 1. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
- C Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.
- D Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- E Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. Panelboard Keys: six of each different key.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A ABB/GE: www.electrification.us.abb.com.
- B Eaton Corporation: www.eaton.com.

- C Schneider Electric; Square D Products: www.schneider-electric.us.
- D Siemens Industry, Inc: www.usa.siemens.com.
- E Or pre-approved equivalent
- F Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier, where possible.

2.2 PANELBOARDS - GENERAL REQUIREMENTS

- A Provide products listed, classified, and labeled as suitable for the purpose intended.
- B Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet.
 - 2. Ambient Temperature:
 - a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
 - b. Panelboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.
- C Short Circuit Current Rating:
 - 1. Provide panelboards with listed short circuit current rating as indicated on the drawings. Where the available fault current is indicated, provide panelboards with listed short circuit current rating not less than the available fault current.
 - 2. Listed series ratings are acceptable only where specifically indicated.
 - 3. Label equipment utilizing series ratings as required by NFPA 70.
- D Panelboards Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- E Mains: Configure for top or bottom incoming feed as indicated or as required for the installation. Do not reduce panelboard pole quantity or mounting spaces indicated on drawings by installation of branch-mounted main device, where used. Provide additional poles or spaces as required.
- F Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- G Bussing: Sized in accordance with UL 67 temperature rise requirements.
 - 1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
 - 2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
- H Conductor Terminations: Suitable for use with the conductors to be installed.
- I Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.

1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 2. Boxes: Galvanized steel unless otherwise indicated.
 - a. Provide wiring gutters sized to accommodate the conductors to be installed.
 3. Fronts:
 - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
 - b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
 - c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
 4. Lockable Doors: All locks keyed alike unless otherwise indicated.
- J Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- K Multi-Section Panelboards: Provide enclosures of the same height, with feed-through lugs or sub-feed lugs and feeders as indicated or as required to interconnect sections.

2.3 POWER DISTRIBUTION PANELBOARDS

- A Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B Conductor Terminations:
1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 2. Main and Neutral Lug Type: Mechanical.
- C Bussing:
1. Phase and Neutral Bus Material: Aluminum or copper.
 2. Ground Bus Material: Aluminum or copper.
- D Circuit Breakers:
1. Provide bolt-on type or plug-in type secured with locking mechanical restraints.
 2. Provide thermal magnetic circuit breakers unless otherwise indicated.
- E Enclosures:
1. Provide surface-mounted enclosures unless otherwise indicated.
 2. Fronts: Provide trims to cover access to load terminals, wiring gutters, and other live parts, with exposed access to overcurrent protective device handles.
 3. Minimum dimensions: 6-1/2 inches deep, 26 inches wide.
- F Panelboard Construction: Lighting and appliance panelboard construction is not acceptable.
- G Arc Flash Energy-Reducing Maintenance Switching: For circuit breakers rated 1200 A or higher, provide a local accessory switch with status indicator light that permits selection of a maintenance mode with alternate electronic trip unit settings for reduced fault clearing time.

2.4 LIGHTING AND APPLIANCE PANELBOARDS

- A Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B Conductor Terminations:
 - 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 2. Main and Neutral Lug Type: Mechanical.
- C Bussing:
 - 1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
 - 2. Phase and Neutral Bus Material: Aluminum or copper.
 - 3. Ground Bus Material: Aluminum or copper.
- D Circuit Breakers: Thermal magnetic bolt-on type.
- E Enclosures:
 - 1. Provide surface-mounted or flush-mounted enclosures as indicated.
 - 2. Fronts: Provide lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
 - 3. Provide clear plastic circuit directory holder mounted on inside of door.
 - 4. Minimum dimensions: 5-1/2 inches deep, 20 inches wide.

2.5 OVERCURRENT PROTECTIVE DEVICES

- A Molded Case Circuit Breakers:
 - 1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489; ratings, configurations, and features as indicated on the drawings.
 - 2. Interrupting Capacity:
 - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 - 1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - 2) 14,000 rms symmetrical amperes at 480 VAC.
 - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
 - 3. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
 - a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
 - 5. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
 - 6. Provide the following circuit breaker types where indicated:

- a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
- 7. Do not use tandem circuit breakers.
- 8. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.
- 9. Provide the following features and accessories where indicated or where required to complete installation:
 - a. Handle Pad-Lock Provision: For locking circuit breaker handle in OFF position.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated.
- B Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.
- C Verify that mounting surfaces are ready to receive panelboards.
- D Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Perform work in accordance with NECA 1 (general workmanship).
- B Install products in accordance with manufacturer's instructions.
- C Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E Provide required support and attachment in accordance with Section 260529.
- F Install panelboards plumb.
- G Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- H Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- I Provide minimum of five spare 3/4 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling.
- J Provide grounding and bonding in accordance with Section 260526.
- K Install all field-installed branch devices, components, and accessories.

- L Multi-Wire Branch Circuits: Group grounded and ungrounded conductors together in the panelboard as required by NFPA 70.
- M Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- N Provide filler plates to cover unused spaces in panelboards.
- O Identify panelboards in accordance with Section 260553.
- P If the overcurrent protection for a panelboard feeder is less than the nameplate rating of the panelboard, provide a plastic nameplate indicating the ampacity of the feeder circuit. Attach nameplate to the inside of the panelboard so it is visible when the panelboard door is opened.
- Q Connections:
 - 1. Connect phase conductors A, B, C left to right as viewed from the front of the panel unless bus bars are factory labeled otherwise.
 - 2. Connect each branch circuit served by a lighting and appliance branch circuit panelboard to a 20A 1-pole breaker unless otherwise indicated.
 - 3. Circuit numbering indicated for lighting and appliance branch circuit panelboards is based on pole position within the panelboard. For multipole breakers, the circuit number corresponds to the first pole position occupied by the breaker.
 - 4. Circuit number indicated for distribution panelboards is based on consecutive numbering.

3.3 FIELD QUALITY CONTROL

- A Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
- B Test GFCI circuit breakers to verify proper operation.
- C Correct deficiencies and replace damaged or defective panelboards or associated components.

3.4 ADJUSTING

- A Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B Adjust alignment of panelboard fronts.

3.5 CLEANING

- A Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.
- B Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

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SECTION 262726

WIRING DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Wall switches.
- B Receptacles.
- C Device plates and box covers.

1.2 REFERENCE STANDARDS

- A NEMA WD 1 - General Color Requirements for Wiring Devices.
- B NEMA WD 6 - Wiring Devices - Dimensional Specifications.
- C NFPA 70 - National Electrical Code.
- D UL 20 - General-Use Snap Switches.
- E UL 498 - Attachment Plugs and Receptacles.
- F UL 514D - Cover Plates for Flush-Mounted Wiring Devices.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
 - 2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
 - 3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
 - 4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
 - 5. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.
- B Sequencing:
 - 1. Do not install wiring devices until final surface finishes and painting are complete.

1.4 SUBMITTALS

- A Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.
- B Products: Listed, classified, and labeled as suitable for the purpose intended.

1.6 DELIVERY, STORAGE, AND PROTECTION

- A Store in a clean, dry space in original manufacturer's packaging until ready for installation.

PART 2 PRODUCTS**2.1 WIRING DEVICES - GENERAL REQUIREMENTS**

- A Provide wiring devices suitable for intended use with ratings adequate for load served.

2.2 MANUFACTURERS

- A Cooper Wiring Devices: www.cooperwiringdevices.com.
- B Hubbell Incorporated: www.hubbell-wiring.com.
- C Leviton Manufacturing Company, Inc: www.leviton.com.
- D Pass & Seymour, a brand of Legrand North America, Inc: www.legrand.us
- E Or pre-approved equivalent
- F Source Limitations: Where possible, provide products for each type of wiring device produced by a single manufacturer and obtained from a single supplier.

2.3 WIRING DEVICE FINISHES

- A Device Color: Manufacturer's standard to be selected by Architect.

2.4 WALL SWITCHES

- A Wall Switches - General Requirements: AC only, quiet operating, general-use snap switches with silver alloy contacts, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 20; types as indicated on the drawings.
 - 1. Wiring Provisions: Terminal screws for side wiring and screw actuated binding clamp for back wiring with separate ground terminal screw.

- B Acceptable products are listed below for specific device types.

- C Standard Switches: 20A, 120/277 V AC

Description	Cooper	Hubbell	Leviton	P & S
Single pole	CSB120	CSB120	CS120-2	CSB20AC1
Double pole	CSB220	CSB220	CS220-2	CSB20AC2
Three-way	CSB320	CSB320	CS320-2	CSB20AC3

Four-way	CSB420	CSB420	CS420-2	CSB20AC4

D Keyed Switches: 20A, 120/277 V AC

Description	Cooper	Hubbell	Leviton	P & S
Single Pole	AH1221L	HBL1221L	1221-2L	PS20AC1L
Double Pole	AH1222L	HBL1222L	1222-2L	PS20AC2L
Three-way	AH1223L	HBL1223L	1223-2L	PS20AC3L
Four-way	AH1224L	HBL1224L	1224-2L	PS20AC4L

E Special Switches

Description	Cooper	Hubbell	Leviton	P & S
Single pole with pilot light	AH1201PL	HBL1221PL	1221-PLR	PS20AC1RPL
Single pole momentary contact	1995	HBL1557	1257	1251
Single pole lighted toggle	AH1221LT	HB1221IL	1221-LH	PS20AC1ISL
Combination switch/receptacle	TR291	RR108	5335	671
Door switch	-	RDS50	1865	-

2.5 RECEPTACLES**A Receptacles - General Requirements:** Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498; types as indicated on the drawings.

1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
2. NEMA configurations specified are according to NEMA WD 6.

B Acceptable products are listed below for specific device types.**C Straight Blade Receptacles: 20A, 125V.**

Description	Cooper	Hubbell	Leviton	P & S
Simplex	1877	HBL5361	5891	5361
Duplex	BR20	BR20	5362	CRB5362
Duplex tamper resistant	TRBR20	BR20TR	T5362	TR5362
Duplex GFCI	SGF20	GFRST20	GFNT2	2097
Duplex GFCI tamper resistant	TRSGF20	GFTRST20	GFTR2	2097TR
Duplex GFCI weather resistant	WRSGF20	GFRWR20	GFWT2	2097TRWR
Duplex GFCI weather resistant, tamper resistant	WRSGF20	GFRTW20	GFWR2	2097TRWR

Duplex isolated ground	IG5362	IG20CR	5362-IG	IG5362
Duplex tamper resistant with USB-A and USB-C charging ports	TRUSBAC20	USB20AC5	T5833	TR20USBAC6
Duplex TVSS	5362S	HBL5362SA	7380	5362SP
Clock hanger	775V	RR151CHI	688	S3713

2.6 WALL PLATES AND COVERS

- A Wall Plates: Comply with UL 514D.
 - 1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
 - 2. Screws: Metal with slotted heads finished to match wall plate finish.
- B Wall Plates for Flush Devices: Type 302 or 304, satin finished stainless steel, minimum thickness 0.03 inches.
- C Weatherproof Receptacle Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated.
- B Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D Verify that final surface finishes are complete, including painting.
- E Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- F Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A Provide extension rings to bring outlet boxes flush with finished surface.
- B Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of wiring devices provided under this section.
 - 1. Provide minimum of 24 inches horizontal separation between flush mounted outlet boxes installed on opposite sides of fire rated walls.
 - 2. Where multiple devices are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
 - 3. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.
- B Install wiring devices in accordance with manufacturer's instructions.
- C Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- D Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.
- E Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- F Provide GFCI receptacles with integral GFCI protection at each location indicated. Do not use feed-through wiring to protect downstream devices unless otherwise indicated.
- G Install wiring devices plumb and level with mounting yoke held rigidly in place.
- H Install wall switches with OFF position down.
- I Install vertically mounted receptacles with grounding pole on bottom.
- J Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- K Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.
- L Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas and above accessible ceilings.

3.4 FIELD QUALITY CONTROL

- A Inspect each wiring device for damage and defects.
- B Operate each wall switch and wall dimmer with circuit energized to verify proper operation.
- C Test each receptacle to verify operation and proper polarity.
- D Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.

- E Correct wiring deficiencies and replace damaged or defective wiring devices.

3.5 ADJUSTING

- A Adjust devices and wall plates to be flush and level.

3.6 CLEANING

- A Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION

SECTION 262813

FUSES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Fuses.

1.2 REFERENCE STANDARDS

- A NEMA FU 1 - Low Voltage Cartridge Fuses.
- B NFPA 70 - National Electrical Code.
- C UL 248-1 - Low-Voltage Fuses - Part 1: General Requirements.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate fuse clips furnished in equipment provided under other sections for compatibility with indicated fuses.
 - 2. Coordinate fuse requirements according to manufacturer's recommendations and nameplate data for actual equipment to be installed.
 - 3. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

- A Product Data: Provide manufacturer's standard data sheets including voltage and current ratings, interrupting ratings, time-current curves, and current limitation curves.
- B Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Fuses: Three of each type and size, unless a greater quantity is indicated on drawings.
 - 2. Fuse Pullers: One set(s) compatible with each type and size installed.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Bussmann, a division of Eaton Corporation: www.cooperindustries.com/#sle.
- B Littelfuse, Inc: www.littelfuse.com/#sle.
- C Mersen: ep-us.mersen.com/#sle.

- D Or pre-approved equivalent

2.2 APPLICATIONS

- A Fuses Larger Than 600 Amps: Class L, time delay, equivalent to Bussmann Low Peak.
- B Fuses 600 Amps or Smaller: Class RK1, time delay, equivalent to Bussmann Low Peak. Provide with open fuse indication where available.
- C Plug Fuses: Class S, time delay, equivalent to Bussmann Fustat. Provide with a Bussmann catalog number SSY device cover incorporating a switch and fuse holder. Where a lockable switch is required, provide a Bussmann catalog number SOY box cover with fuse holder mounted adjacent to a locking toggle switch.
- D In-Line Protection for Pole-Mounted Luminaires: Class CC, time-delay.

2.3 FUSES

- A Provide products listed, classified, and labeled as suitable for the purpose intended.
- B Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.
- C Provide fuses of the same type, rating, and manufacturer within the same switch.
- D Comply with UL 248-1.
- E Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.
- F Voltage Rating: Suitable for circuit voltage.
- G Provide the following accessories where indicated or where required to complete installation:
 - 1. Fuseholders: Compatible with indicated fuses.
 - 2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that fuse ratings are consistent with circuit voltage and manufacturer's recommendations and nameplate data for equipment.
- B Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Do not install fuses until circuits are ready to be energized.

- B For motor circuits, provide fuses rated at 125 percent of motor nameplate full load current.
- C Install fuses with label oriented such that manufacturer, type, and size are easily read.

END OF SECTION

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SECTION 262816.16
ENCLOSED SWITCHES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Enclosed safety switches.
- B Elevator disconnect switches.

1.2 REFERENCE STANDARDS

- A NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- C NEMA BS 31047 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).
- D NFPA 70 - National Electrical Code.
- E UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.
- F UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.
- G UL 98 - Enclosed and Dead-Front Switches.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 4. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

- A Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.
- B Project Record Documents: Record actual locations of enclosed switches.

- C Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

1.7 FIELD CONDITIONS

- A Maintain ambient temperature between -22 degrees F and 104 degrees F during and after installation of enclosed switches.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A ABB/GE: www.electrification.us.abb.com.
- B Eaton Corporation: www.eaton.com.
- C Schneider Electric; Square D Products: www.schneider-electric.us.
- D Siemens Industry, Inc: www.usa.siemens.com.
- E Or pre-approved equivalent
- F Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier, where possible.

2.2 ENCLOSED SAFETY SWITCHES

- A Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.
- B Provide products listed, classified, and labeled as suitable for the purpose intended.
- C Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet.
 - 2. Ambient Temperature: Between -22 degrees F and 104 degrees F.

- D Horsepower Rating: Suitable for connected load.
- E Voltage Rating: Suitable for circuit voltage.
- F Provide with switch blade contact position that is visible when the cover is open.
- G Fuse Clips for Fusible Switches: As required to accept fuses indicated.
 - 1. Switches 600 Amps or smaller: Class R.
- H Conductor Terminations: Suitable for use with the conductors to be installed.
- I Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
- J Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- K Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 - 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
- L Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- M Heavy Duty Switches:
 - 1. Comply with NEMA BS 31047.
 - 2. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
- N Provide the following features and accessories where indicated or where required to complete installation:
 - 1. Auxiliary Switch: SPDT switch suitable for connection to system indicated, with auxiliary contact operation before switch blades open and after switch blades close.

2.3 ELEVATOR DISCONNECT SWITCHES

- A Description: Elevator disconnect switch to meet elevator shutdown and disconnect requirements, listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.
- B Provide products listed, classified, and labeled as suitable for the purpose intended.
- C Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:

1. Altitude: Less than 6,600 feet.
 2. Ambient Temperature: Between -22 degrees F and 104 degrees F.
- D Horsepower Rating: Suitable for connected load.
- E Voltage Rating: Suitable for circuit voltage.
- F Short Circuit Current Rating:
1. Provide enclosed safety switches, when protected by the fuses or supply side overcurrent protective devices to be installed, with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
- G Provide with switch blade contact position that is visible when the cover is open.
- H Fuse Clips for Fusible Switches: As required to accept fuses indicated.
1. Switches 600 Amps or smaller: Class J.
- I Conductor Terminations: Suitable for use with the conductors to be installed.
- J Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
- K Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- L Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
- M Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- N Provide with internally powered 120V shunt trip with voltage monitoring per NFPA 72.
- O Provide with key-test switch and green pilot light "ON".
- P Disconnect shall be lockable in the OFF position.
- Q Provide with a fire alarm voltage monitoring relay to monitor the shunt trip voltage.
- R Provide two NO/NC auxiliary contacts.
1. Auxiliary contact shall be positively opened mechanically and shall not be solely dependent on springs.
 2. Auxilliary contact shall cause any additional power source connected to the load side of the elevator disconnecting means to be disconnected from its load when the disconnecting

means is in the open position to allow automatic movement of the car to permit evacuation of passengers.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated.
- B Verify that the ratings of the enclosed switches are consistent with the indicated requirements.
- C Verify that mounting surfaces are ready to receive enclosed safety switches.
- D Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Install products in accordance with manufacturer's instructions.
- B Perform work in accordance with NECA 1 (general workmanship).
- C Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D Provide required support and attachment in accordance with Section 260529.
- E Install enclosed switches plumb.
- F Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 60 inches above the floor or working platform.
- H Provide grounding and bonding in accordance with Section 260526.
- I Provide fuses complying with Section 262813 for fusible switches as indicated or as required by equipment manufacturer's recommendations.
- J Identify enclosed switches in accordance with Section 260553.
- K Install fuses in fusible disconnect switches.
- L Bolt closed exterior grade level enclosures.

3.3 FIELD QUALITY CONTROL

- A Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.4 ADJUSTING

- A Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

- A Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.
- B Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

SECTION 264300
SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Surge protective devices for service entrance locations.
- B Surge protective devices for branch panelboard locations.

1.2 ABBREVIATIONS AND ACRONYMS

- A SPD: Surge Protective Device.

1.3 REFERENCE STANDARDS

- A NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- C NFPA 70 - National Electrical Code.
- D UL 1449 - Standard for Surge Protective Devices.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Coordination: Coordinate size and location of overcurrent device compatible with the actual surge protective device and location to be installed. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to ordering equipment.

1.5 SUBMITTALS

- A Product Data: Include detailed component information, voltage, surge current ratings, repetitive surge current capacity, voltage protection rating (VPR) for all protection modes, maximum continuous operating voltage (MCOV), nominal discharge current (I-n), short circuit current rating (SCCR), connection means including any required external overcurrent protection, enclosure ratings, outline and support point dimensions, weight, service condition requirements, and installed features.
- B Specification Compliance Review: See Section 260400 - Common Requirements for Electrical, for requirements.
- C Certificates: Manufacturer's documentation of listing for compliance with the following standards:
 - 1. UL 1449.
- D Operation and Maintenance Data: Include information on status indicators and recommended maintenance procedures and intervals.

- E Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

1.6 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.

1.7 DELIVERY, STORAGE, AND PROTECTION

- A Store in a clean, dry space in accordance with manufacturer's written instructions.

1.8 FIELD CONDITIONS

- A Maintain field conditions within manufacturer's required service conditions during and after installation.

1.9 WARRANTY

- A Manufacturer's Warranty: Provide minimum five year warranty covering repair or replacement of surge protective devices showing evidence of failure due to defective materials or workmanship.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Factory-installed, Internally Mounted Surge Protective Devices:
 - 1. Same as manufacturer of equipment containing surge protective device, to provide complete listed assembly including SPD.

2.2 SURGE PROTECTIVE DEVICES - GENERAL REQUIREMENTS

- A Description: Factory-assembled surge protective devices (SPDs) for 60 Hz service; listed, classified, and labeled as suitable for the purpose intended; system voltage as indicated on the drawings.
- B Unless otherwise indicated, provide factory-installed, internally-mounted SPDs.
- C List and label as complying with UL 1449, Type 1 when connected on line side of service disconnect overcurrent device and Type 1 or 2 when connected on load side of service disconnect overcurrent device.
- D Surge Protection Technology: Metal oxide varistor technology. Silicone avalanche diode technology is not acceptable.
- E Protected Modes:
 - 1. Wye Systems: L-N, L-G, N-G, L-L.
- F UL 1449 Voltage Protection Ratings (VPRs):
 - 1. 208Y/120V System Voltage: Not more than 700 V for L-N, L-G, and N-G modes and 1,200 V for L-L mode.

2. 480Y/277V System Voltage: Not more than 1 200 V for L-N, L-G, and N-G modes and 2,000 V for L-L mode.
- G UL 1449 Maximum Continuous Operating Voltage (MCOV): Not less than 115% of nominal system voltage.
- H Fuses, if used, shall allow rated surge current to flow through the device.
- I Enclosure Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
1. Indoor clean, dry locations: Type 1.

2.3 SURGE PROTECTIVE DEVICES FOR SERVICE ENTRANCE LOCATIONS

- A Surge Protective Device:
1. Protection Circuits: Field-replaceable modular or non-modular.
 2. Surge Current Rating: Not less than 120 kA per mode/240 kA per phase.
 3. UL 1449 Nominal Discharge Current (I-n): 20 kA.
 4. UL 1449 Short Circuit Current Rating (SCCR): Not less than the short circuit current rating of the equipment the SPD is connected to, including any series ratings.
 5. Diagnostics:
 - a. Protection Status Monitoring: Provide indicator lights to report the protection for each phase.
 - b. Remote Status Monitoring: Provide Form C dry type contacts (normally open and normally closed) for remote annunciation of status.
 6. Provide surge rated integral disconnect switch for SPDs installed integral to switchboards or panelboards.

2.4 SURGE PROTECTIVE DEVICES FOR DISTRIBUTION LOCATIONS

- A Distribution locations include SPDs connected to distribution panelboards and switchboards not used as service equipment.
- B Surge Protective Device:
1. Protection Circuits: Field-replaceable modular or non-modular.
 2. Surge Current Rating: Not less than 60 kA per mode/120 kA per phase.
 3. UL 1449 Nominal Discharge Current (I-n): 20 kA.
 4. UL 1449 Short Circuit Current Rating (SCCR): Not less than the short circuit current rating of the equipment the SPD is connected to, including any series ratings.
 5. Diagnostics:
 - a. Protection Status Monitoring: Provide indicator lights to report the protection status for each phase.
 - b. Remote Status Monitoring: Provide Form C dry type contacts (normally open and normally closed) for remote annunciation of status.
 6. Provide surge rated integral disconnect switch for SPDs installed integral to switchboards or panelboards.

2.5 SURGE PROTECTIVE DEVICES FOR BRANCH PANELBOARD LOCATIONS

- A Surge Protective Device:
1. Protection Circuits: Field-replaceable modular or non-modular.
 2. Surge Current Rating: Not less than 25 kA per mode/50 kA per phase.
 3. UL 1449 Nominal Discharge Current (I-n): 20 kA.
 4. UL 1449 Short Circuit Current Rating (SCCR): Not less than the short circuit current rating of the equipment the SPD is connected to, including any series ratings.
 5. Diagnostics:
 - a. Protection Status Monitoring: Provide indicator lights to report the protection status for each phase.
 - b. Remote Status Monitoring: Provide Form C dry type contacts (normally open and normally closed) for remote annunciation of status.
 6. Provide surge rated integral disconnect switch for SPDs not connected to a dedicated circuit breaker or fused switch or not direct bus connected.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that the service voltage and configuration marked on the SPD are consistent with the service voltage and configuration at the location to be installed.
- B Verify that electrical equipment is ready to accept connection of the SPD and that installed overcurrent device is consistent with requirements of drawings and manufacturer's instructions.
- C Verify system grounding and bonding is in accordance with Section 260526, including bonding of neutral and ground for service entrance and separately derived systems where applicable. Do not energize SPD until deficiencies have been corrected.
- D Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Perform work in accordance with NECA 1 (general workmanship).
- B Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- C Provide conductors with minimum ampacity as indicated on the drawings, as required by NFPA 70, and not less than manufacturer's recommended minimum conductor size.
- D Install conductors between SPD and equipment terminations as short and straight as possible, not exceeding manufacturer's recommended maximum conductor length. Breaker locations may be reasonably rearranged in order to provide leads as short and straight as possible. Twist conductors together to reduce inductance.

- E Do not energize SPD until bonding of neutral and ground for service entrance and separately derived systems is complete in accordance with Section 260526 where applicable. Replace SPDs damaged by improper or missing neutral-ground bond.
- F Disconnect SPD prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPD connected.

3.3 FIELD QUALITY CONTROL

- A Perform startup inspection and testing in accordance with manufacturer's instructions.
- B Repair or replace malfunctioning units. Retest after repairs or replacements are made.

END OF SECTION

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SECTION 265100
INTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Interior luminaires.
- B Luminaires mounted on exterior of building.
- C Exit signs.
- D Drivers

1.2 REFERENCE STANDARDS

- A IEEE C62.41.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits.
- B IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products.
- C IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources.
- D NECA 1 - Standard for Good Workmanship in Electrical Construction.
- E NECA/IESNA 500 - Standard for Installing Indoor Lighting Systems.
- F NECA/IESNA 502 - Standard for Installing Industrial Lighting Systems.
- G NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility.
- H NFPA 70 - National Electrical Code.
- I NFPA 101 - Life Safety Code.
- J UL 924 - Emergency Lighting and Power Equipment.
- K UL 1598 - Luminaires.
- L UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for

- mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
 3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
 4. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.4 SUBMITTALS

- A Shop Drawings:
1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
 2. Provide dimensioned drawing for each custom length luminaire.
- B Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.
1. LED Luminaires:
 - a. Include estimated useful life, calculated based on IES LM-80 test data.
 - b. Include IES LM-79 test report upon request.
 - c. Include color temperature, CRI, luminaire input wattage and delivered lumen output.
 - d. Include color information based on IES TM-30 test upon request.
 2. Drivers: Include product data, dimming protocol, voltage and environmental rating.
- C Operation and Maintenance Data: Instructions for each product including information on replacement parts.
- D Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra Drivers: Two percent of total quantity installed for each type, but not less than one of each type.
- E Project Record Documents: Record actual connections and locations of luminaires and any associated remote components.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.
- B Products: Listed and classified by testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.
- C Luminaires for the project shall be submitted through an electrical distributor within 250 miles of the project site. Deviations from this requirement must be submitted for prior approval.

1.6 DELIVERY, STORAGE, AND PROTECTION

- A Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.
- B Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.7 WARRANTY

- A Provide minimum five year manufacturer warranty for all LED luminaires, including drivers.

PART 2 PRODUCTS**2.1 LUMINAIRE TYPES**

- A Furnish products as indicated in schedule included on the drawings.
- B Substitutions (for cost reduction after bid) and Prior Approval Requests (prior to bid): Luminaires not specified or listed as an alternate in the Luminaire Schedule will be considered as a prior approval or substitution request. Provide and identify the following information with the manufacturer's cut sheet:
 - 1. Estimated useful life, calculated based on IES LM-80 test data.
 - 2. Delivered lumen output, calculated based on IES LM-79.
 - 3. Color temperature, CRI, luminaire input wattage and warranty.
 - 4. Color information, based on IES TM-30 test report.
 - 5. Upon request, IES LM-79 report, LM-80 report, and TM-30 report.
 - 6. Upon request, photometric calculation comparison to the basis of design luminaire for the applicable project space/area.
 - 7. Upon request, a working sample with 120 Volt cord and plug.
 - 8. Deviations from the specified luminaire.

2.2 LUMINAIRES

- A Provide products that comply with requirements of NFPA 70 and NFPA 101.
- B Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C Unless otherwise indicated, for each type of lamp/luminaire, provide products which are consistent in perceived color temperature. Replace lamps/luminaires that are determined by the Architect to be inconsistent in perceived color temperature.
- D Provide products listed, classified, and labeled as suitable for the purpose intended.
- E Unless otherwise indicated, provide luminaires including lamp(s) and all sockets, ballasts/drivers, reflectors, lenses, housings, wiring and other appurtenances required for a complete and operational system.

- F Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operational system.
- G Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- H For continuous wall-to-wall luminaires, field verify exact wall-to-wall dimensions prior to ordering.
- I Sheet Metal Components: Steel, unless otherwise indicated, without sharp corners or edges.
- J Doors and Frames: Free of light leaks.
- K Recessed Luminaires:
 - 1. Ceiling Compatibility: Comply with NEMA LE 4.
 - 2. Luminaires Recessed in Insulated Ceilings: Listed and labeled as IC-rated, suitable for direct contact with insulation and combustible materials.
 - 3. Luminaires Recessed in Sloped Ceilings: Provide suitable sloped ceiling adapters.
- L LED Luminaires:
 - 1. Components: UL 8750 recognized or listed as applicable.
 - 2. Tested in accordance with IES LM-79 and IES LM-80.
 - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.

2.3 EXIT SIGNS

- A Description: Exit signs complying with NFPA 101 and applicable state and local codes, and listed and labeled as complying with UL 924.
 - 1. Number of Faces: Single- or double-face as indicated or as required for installed location.
 - 2. Directional Arrows: As indicated or as required for installed location.
- B Powered Exit Signs: Internally illuminated with LEDs unless otherwise indicated.
 - 1. Self-Powered Exit Signs:
 - a. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
 - b. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
 - c. Provide low-voltage disconnect to prevent battery damage from deep discharge.

2.4 DRIVERS

- A Drivers - General Requirements:
 - 1. Provide drivers containing no polychlorinated biphenyls (PCBs).
 - 2. Minimum Efficiency/Efficacy: Provide drivers complying with all current applicable federal and state driver efficiency/efficacy standards.

3. Drivers: Inrush currents not exceeding peak currents specified in NEMA 410.

B Dimmable LED Drivers:

1. Dimming Range: Continuous dimming from 100 percent to ten percent relative light output unless dimming capability to lower level is indicated, without flicker.
2. Control Compatibility: Fully compatible with the dimming controls to be installed.

2.5 ACCESSORIES

- A** Provide accessories and fittings as recommended by the manufacturer to properly and completely install and wire luminaires.
- B** Provide accessory plaster frames as required, designed and finished to preclude the possibility of rust stains on surrounding surfaces.
- C** Fixture Whips: Flexible whips including phase, neutral and grounding conductors, #18 AWG minimum; minimum length, 4 feet; maximum length, 6 feet, unless otherwise indicated.

PART 3 EXECUTION

3.1 EXAMINATION

- A** Verify that field measurements are as indicated.
- B** Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C** Verify that suitable support frames are installed where required.
- D** Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E** Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A** Provide extension rings to bring outlet boxes flush with finished surface.
- B** Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A** Verify ceiling and wall details from general construction documents prior to ordering luminaires. Provide proper mounting accessories for the intended installation. Install fixture trim tight to surrounding surfaces. Secure to prevent movement.
- B** Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of luminaires provided under this section.
- C** Perform work in accordance with NECA 1 (general workmanship).

- D Install products in accordance with manufacturer's instructions.
- E Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting) and NECA 502 (industrial lighting).
- F Provide required support and attachment in accordance with Section 260529.
- G Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- H Suspended Ceiling Mounted Luminaires:
 - 1. Do not use ceiling tiles to bear weight of luminaires.
 - 2. Support luminaires from grid. Provide additional supports or support clips as required.
 - 3. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.
 - 4. Luminaires smaller than grid openings: Center in acoustical panels unless otherwise indicated on reflected ceiling plan. Provide supporting members as required.
 - 5. Secure surface-mounted luminaires to building structure.
 - 6. Secure pendant-mounted luminaires to building structure.
- I Recessed Luminaires:
 - 1. Install trims tight to mounting surface with no visible light leakage.
- J Suspended Luminaires:
 - 1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
 - 2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
 - 3. Install canopies tight to mounting surface.
- K Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- L Surface Mounted Luminaires:
 - 1. Mount tight to surrounding surfaces.
 - 2. Locate outlet boxes in finished areas so they are concealed by luminaires.
- M Install accessories furnished with each luminaire.
- N Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within fixture.
- O Fixture Whips:
 - 1. Use for recessed luminaires installed in an accessible ceiling.
 - 2. Anchor according to code.
 - 3. Install between each fixture and a junction box located above the ceiling. Wire from fixture to fixture only for tandem ballast installations.
- P Bond products and metal accessories to branch circuit equipment grounding conductor.

- Q Dimmable Luminaires: Provide required control wiring, as recommended by the manufacturer, between each luminaire and its associated control device.
- R Exit Signs:
 - 1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- S Remote Ballasts and Drivers: Install in accessible location as indicated or as required to complete installation, using conductors per manufacturer's recommendations not exceeding manufacturer's recommended maximum conductor length to luminaire.

3.4 FIELD QUALITY CONTROL

- A Inspect each product for damage and defects.
- B Operate each luminaire after installation and connection to verify proper operation.
- C Test self-powered exit signs, emergency lighting units, and fluorescent emergency power supply units to verify proper operation upon loss of normal power supply.
- D Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.

3.5 ADJUSTING

- A Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.
- B Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Architect or authority having jurisdiction.

3.6 CLEANING

- A Clean surfaces according to NECA 500 (commercial lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.7 CLOSEOUT ACTIVITIES

- A Just prior to Substantial Completion, review proper operation of luminaires and correct deficiencies or make adjustments as required. Replace failed components as required.

3.8 PROTECTION

- A Protect installed luminaires from subsequent construction operations.

END OF SECTION

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SECTION 265600
EXTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Exterior luminaires. See Section 26 5100 - Interior Lighting for luminaires mounted to building.
- B Drivers.
- C Poles and accessories.

1.2 REFERENCE STANDARDS

- A AASHTO LTS - Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.
- B IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products.
- C IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources.
- D NECA 1 - Standard for Good Workmanship in Electrical Construction.
- E NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems.
- F NEMA 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.
- G NFPA 70 - National Electrical Code.
- H NFPA 101 - Life Safety Code.
- I UL 924 - Emergency Lighting and Power Equipment.
- J UL 1598 - Luminaires.
- K UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc. installed under other sections or by others. Coordinate elevation to obtain specified foundation height.
 - 2. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.4 SUBMITTALS

- A Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, weight, effective projected area (EPA), and installed accessories; include model number nomenclature clearly marked with all proposed features.
 - 1. LED Luminaires:
 - a. Include estimated useful life, calculated based on IES LM-80 test data.
 - b. Include IES LM-79 test report upon request.
 - c. Include color temperature, CRI, luminaire input wattage and delivered lumen output.
 - d. Include color information based on IES TM-30 test upon request.
 - 2. Drivers: Include product data, dimming protocol, voltage, and environmental rating.
- B Operation and Maintenance Data: Instructions for each product including information on replacement parts.
- C Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Drivers: Two percent of total quantity installed for each type, but not less than one of each type.
- D Project Record Documents: Record actual connections and locations of pole foundations, luminaires, and any pull or junction boxes.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.
- B Products: Listed and classified by testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.
- C Luminaires for the project shall be submitted through an electrical distributor within 250 miles of the project site. Deviations from this requirement must be submitted for prior approval.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Receive, handle, and store products according to NECA/IESNA 501 and manufacturer's written instructions.

1.7 WARRANTY

- A Provide minimum three year manufacturer warranty for all LED luminaires, including drivers.
- B Provide minimum three year manufacturer warranty for pole finish adhesion and corrosion.

PART 2 PRODUCTS

2.1 LUMINAIRE TYPES

- A Furnish products as indicated in schedule included on the Drawings.

- B Substitutions (for cost reduction after bid) and Prior Approval Requests(prior to bid): Luminaires not specified or listed as an alternate in the Luminaire Schedule will be considered as a prior approval or substitution request. Provide and identify the following information with the manufacturer's cut sheet:
1. Estimated useful life, calculated based on IES LM-80 test data.
 2. Delivered lumen output, calculated based on IES LM-79.
 3. Color temperature, CRI, luminaire input wattage and warranty.
 4. Color information, based on IES TM-30 test report.
 5. Upon request, IES LM-79 report, LM-80 report, and TM-30 report.
 6. Upon request, photometric calculation comparison to the basis of design luminaire for the applicable project space/area.
 7. Upon request, a working sample.
 8. Deviations from the specified luminaire.

2.2 LUMINAIRES

- A Provide products that comply with requirements of NFPA 70.
- B Unless otherwise indicated, for each type of lamp/luminaire, provide products which are consistent in perceived color temperature. Replace lamps/luminaires that are determined by the Architect to be inconsistent in perceived color temperature.
- C Provide products that are listed and labeled as complying with UL 1598, where applicable.
- D Provide products listed, classified, and labeled as suitable for the purpose intended.
- E Unless otherwise indicated, provide luminaires including lamp(s) and all sockets, ballasts/drivers, reflectors, lenses, housings, wiring and other appurtenances required for a complete and operational system.
- F Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, poles, foundations, supports, trims, accessories, etc. as necessary for a complete operating system.
- G Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- H Provide luminaires listed and labeled as suitable for wet locations unless otherwise indicated.
- I LED Luminaires:
1. Components: UL 8750 recognized or listed as applicable.
 2. Tested in accordance with IES LM-79 and IES LM-80.
 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.
- J Exposed Hardware: Stainless steel.

2.3 DRIVERS

A Drivers - General Requirements:

1. Provide drivers containing no polychlorinated biphenyls (PCBs).
2. Minimum Efficiency/Efficacy: Provide drivers complying with all current applicable federal and state driver efficiency/efficacy standards.
3. Drivers: Inrush currents not exceeding peak currents specified in NEMA 410.

B Dimmable LED Drivers:

1. Dimming Range: Continuous dimming from 100 percent to ten percent relative light output unless dimming capability to lower level is indicated, without flicker.
2. Control Compatibility: Fully compatible with the dimming controls to be installed.

2.4 POLES

A All Poles:

1. Provide poles and associated support components suitable for the luminaire(s) and associated supports and accessories to be installed.
2. Structural Design Criteria:
 - a. Comply with AASHTO LTS.
 - b. Wind Load: Include effective projected area (EPA) of luminaire(s) and associated supports and accessories to be installed.
 - 1) Design Wind Speed: Based on current AASHTO Wind Speed Map for the project location, with gust factor of 1.3.
 - c. Dead Load: Include weight of proposed luminaire(s) and associated supports and accessories.
3. Finish: Match luminaire finish, unless otherwise indicated.
 - a. Prime Coat: High build epoxy powder, average dry film thickness of 3 mils.
 - b. Exterior Coat: Polyester powder, electrostatically applied, average dry film thickness of 3 mils.
4. Mounting: Install on concrete foundation, height as indicated on the drawings, unless otherwise indicated.
5. Unless otherwise indicated, provide with the following features/accessories:
 - a. Top cap.
 - b. Handhole.
 - c. Anchor bolts with leveling nuts.
 - d. Metallic anchor base cover.
 - e. Internal vibration dampener.

B Metal Poles: Provide ground lug, accessible from handhole.

PART 3 EXECUTION

3.1 EXAMINATION

A Verify that field measurements are as indicated.

B Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.

- C Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Perform work in accordance with NECA 1 (general workmanship).
- B Install products in accordance with manufacturer's instructions.
- C Install luminaires in accordance with NECA/IESNA 501.
- D Provide required support and attachment in accordance with Section 260529.
- E Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- F Pole-Mounted Luminaires:
 - 1. Foundation-Mounted Poles:
 - a. Provide cast-in-place or precast concrete foundations for poles as indicated.
 - 1) Install anchor bolts plumb per template furnished by pole manufacturer.
 - 2) Position conduits to enter pole shaft.
 - b. Install foundations plumb.
 - c. Install poles plumb, using leveling nuts as required to adjust to plumb.
 - d. Tighten anchor bolt nuts to manufacturer's recommended torque.
 - e. Install non-shrink grout between pole anchor base and concrete foundation, leaving small channel for condensation drainage.
 - f. Install anchor base covers or anchor bolt covers as indicated.
 - 2. Grounding:
 - a. Bond luminaires, metal accessories, metal poles, and foundation reinforcement to branch circuit equipment grounding conductor.
- G Install accessories furnished with each luminaire.
- H Bond products and metal accessories to branch circuit equipment grounding conductor.

3.3 FIELD QUALITY CONTROL

- A Inspect each product for damage and defects.
- B Operate each luminaire after installation and connection to verify proper operation.
- C Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.

3.4 ADJUSTING

- A Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.
- B Luminaires with Field-Rotatable Optics: Position optics according to manufacturer's instructions to achieve lighting distribution as indicated or as directed by Architect.

3.5 CLEANING

- A Clean surfaces according to NECA/IESNA 501 and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.6 CLOSEOUT ACTIVITIES

- A Just prior to Substantial Completion, replace all components that have failed.

3.7 PROTECTION

- A Protect installed luminaires from subsequent construction operations.

END OF SECTION

SECTION 270501**COMMON WORK RESULTS FOR COMMUNICATIONS****PART 1 – GENERAL****1.1 SECTION INCLUDES**

- A This section describes the general communications infrastructure requirements of these specifications and applies to all phases of the work specified, indicated on the drawings, or required to provide the complete installation of communications infrastructure for this project.

1.2 ALTERNATES

- A Alternates, if required, shall be as described in the “Alternates” section of the project manual, as described on the proposal form, or as indicated on the drawings.

1.3 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

- A If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Architect for clarification.
- B Any definitive interpretation or clarification of the contract documents will be published by addenda and properly issued to each person holding documents prior to the bid date.
- C Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents.
- D When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.
- E The Architect shall be the sole judge regarding interpretations of conflicts within the contract documents.

1.4 CONTRACT DOCUMENT DISCREPANCIES

- A If any ambiguities should appear in the contract documents, request clarification from the Architect before proceeding with the work.
- B If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Architect.
- C Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work, unless a written clarification from the Architect was requested and obtained before submission of proposed methods or materials.
- D The Architect shall be the sole judge regarding interpretations of conflicts within the contract documents.

1.5 DEFINITIONS

- A Furnish:
1. Supply and deliver to the site, ready for use, items required to complete tasks or perform tests required to build a complete and ready-to-use system.
- B Install:
1. Supply labor to construct complete system, ready for intended use.
- C Provide:
1. Furnish, install, connect, and test, supplying required labor to construct a complete system, ready for the intended use.
- D Administration:
1. The method for labeling, documentation, and usage needed to implement moves, adds, and changes to the telecommunications infrastructure.
- E Backbone Cabling:
1. Cabling or conductors that deliver interconnection between entrance facilities, equipment rooms, and telecommunication rooms; usually installed from floor to floor, but can also be installed between spaces on the same floor.
- F Entrance Facility (EF):
1. An enclosed architectural space housing service provider, campus, or building communications cabling, terminations, cross-connects, and hardware. Where an EF contains sensitive electronic communications equipment, it shall be environmentally-controlled.
- G Equipment Room (ER):
1. An enclosed, environmentally-controlled, and centralized architectural space where the structured cabling system is terminated and communications equipment is installed. ERs usually house a main or intermediate cross-connect which serves a building, campus, tenant, or service provider. Historically, these spaces have been known as Main Distribution Frames (MDFs). The MDF may also be the EF.
- H Horizontal Cabling:
1. Cabling or conductors that run from a telecommunications space to a work area outlet location. It may be installed in either a horizontal or vertical plane.
- I Inside Plant Cable (ISP):
1. The part of the structured cabling system that runs within a building. This definition applies to inside plant cable elements passing through any element of the outside plant pathway. Inside plant cable includes the work area outlet assembly (WAO), backbone cabling, horizontal cabling, telecommunications equipment, and all termination hardware not terminating outside plant cables.
- J Outside Plant Cable (OSP):

1. The part of the structured cabling system that runs between buildings, from a building to a definable exterior point, between definable exterior points, or from another outside source to the building or exterior definable point. It includes termination hardware, transition splices, and any other device into which cable attaches. Outside plant cable includes underground and overhead cabling.
- K Pathway:
1. The part of a cable distribution system that may consist of raceways, cable trays, cable ladder runways, cable managers, conduits, sleeves, distribution rings, j-hooks, junction boxes, fire-rated pathway devices, and mechanical cable-supporting devices.
- L Structured Cabling System (SCS):
1. The part of a telecommunications cable distribution system that may consist of twisted-pair copper, fiber optic, coaxial, networked audiovisual (AV), and networked security cabling systems.
- M Telecommunications Enclosure (TE):
1. A case or housing where the structured cabling system is terminated and telecommunications equipment is installed.
- N Telecommunications Room (TR):
1. An enclosed, environmentally-controlled, and centralized architectural space where the structured cabling system is terminated and communications equipment is installed. TRs usually house a horizontal cross-connect which serves a floor, area, or tenant. Historically, these spaces have been known as Intermediate Distribution Frames (IDFs).
- O Telecommunications Space (TS):
1. A room or area where the structured cabling system is terminated and telecommunications equipment is installed.
- P Work Area Outlet (WAO):
1. A connecting device for the termination of horizontal telecommunications cabling that provides connectivity for patch cables, which in turn connect to end-user network equipment, such as computers or telephones. A WAO can be recessed or surface-mounted in the wall, floor, or ceiling. WAOs may consist of connectors, jacks, plugs, termination blocks, and faceplates.

1.6 SYMBOLS

- A Items of equipment and materials are indicated on the drawings in accordance with the symbols on the plans. Some of the symbols scheduled may not be required for the project. Because of the scale of the drawings, symbols are shown on drawings as close as possible to the installation location. Verify exact locations with the Architect and the Owner.

1.7 ABBREVIATIONS

- A The following abbreviations apply throughout the contract documents:
1. ACR: Attenuation-to-Crosstalk Ratio

2. ADA: Americans with Disabilities Act
3. AFF: Above Finished Floor
4. ANSI: American National Standards Institute
5. ASME: American Society of Mechanical Engineers
6. ASTM: American Society for Testing Materials
7. ATM: Asynchronous Transfer Mode
8. AWG: American Wire Gauge
9. BICSI: Building Industry Consulting Services International
10. CATV: Community Antenna Television
11. CCA: Communications Cable and Connectivity Association
12. CCTV: Closed-Circuit Television
13. CFR: Code of Federal Regulations
14. CSA: Canadian Standards Association
15. EF: Entrance Facility
16. ELFEXT: Equal Level Far-End Crosstalk
17. EMC: Electromagnetic Compatibility
18. EMI: Electromagnetic Interference
19. EMT: Electrical Metallic Tubing
20. ENT: Electrical Nonmetallic Tubing
21. ER: Equipment Room
22. ETL: Electrical Testing Laboratories
23. FCC: Federal Communications Commission
24. FDDI: Fiber Distribution Data Interface
25. FEXT: Far-End-Crosstalk
26. FM: Factory Mutual Engineering Corporation
27. FM: Frequency Modulation
28. FMC: Flexible Metal Conduit
29. FO: Fiber Optic
30. Gbps: Gigabits Per Second
31. GbE: Gigabit Ethernet
32. GND: Ground
33. GPS: Global Positioning System
34. HH: Handhole
35. HVAC: Heating, Ventilation, and Air Conditioning
36. Hz: Hertz
37. IC: Intermediate Cross-Connect
38. ID: Inner Diameter
39. IDC: Insulation Displacement Connector
40. IDF: Intermediate Distribution Frame
41. IEEE: Institute of Electrical and Electronics Engineers
42. IP: Internet Protocol
43. ISP: Inside Plant Cable System
44. LAN: Local Area Network
45. Mbps: Megabits Per Second
46. MC: Main Cross-Connect
47. MDF: Main Distribution Frame
48. MGB: Main Ground Bar

49. MH: Manhole
50. MIMO: Multiple-Input and Multiple-Output
51. MM: Multi-Mode
52. MPTL: Modular Plug Terminated Link
53. NCTA: National Cable & Telecommunications Association
54. NEC: National Electrical Code
55. NECA: National Electrical Contractors Association
56. NEMA: National Electrical Manufacturers Association
57. NFPA: National Fire Protection Association
58. NTP: Network Time Protocol
59. NTSC: National Television Standards Committee
60. NVP: Nominal Velocity of Propagation
61. OD: Outer Diameter
62. OFE: Owner-Furnished Equipment
63. OFL: Overfilled Launch
64. OSHA: Occupational Safety and Health Administration
65. OSP: Outside Plant Cable System
66. OTDR: Optical Time Domain Reflectometer
67. Pr: Pair
68. PBB: Primary Bonding Busbar
69. PDU: Power Distribution Unit
70. PSIG: Pounds Per Square Inch Gauge
71. PSTN: Public Switched Telephone Network
72. PVC: Polyvinyl Chloride
73. RCDD: Registered Communications Distribution Designer
74. RF: Radio Frequency
75. RFI: Radio Frequency Interference
76. SBB: Secondary Bonding Busbar
77. ScTP: Screened Twisted-Pair
78. SFP: Small Form-Factor Pluggable
79. SISO: Single-Input and Single-Output
80. SM: Single-Mode
81. SNMP: Simple Network Management Protocol
82. SNTP: Simple Network Time Protocol
83. SPD: Surge Protection Device
84. STP: Shielded Twisted-Pair
85. TBB: Telecommunications Bonding Backbone
86. TBC: Telecommunications Bonding Conductor
87. TIA: Telecommunications Industry Association
88. TR: Telecommunications Room
89. UL: Underwriters Laboratories
90. UPS: Uninterruptible Power Supply
91. UTP: Unshielded Twisted-Pair
92. VoIP: Voice Over Internet Protocol
93. WAP: Wireless Access Point
94. WPA: Wi-Fi Protected Access

1.8 CODES AND STANDARDS

- A The work shall be performed by competent tradespeople skilled in the trade involved and shall be done in a manner consistent with normal industry standards. All work shall conform to all applicable sections of currently adopted editions of the codes and standards listed below or the codes, standards, and specifications published by the organizations listed below:
1. American National Standards Institute (ANSI).
 2. ASTM International.
 3. Building Industry Consulting Service International (BICSI).
 4. Code of Federal Regulations (CFR).
 5. FM Global, or other recognized national laboratories.
 6. International Building Code (IBC).
 7. Institute of Electrical and Electronics Engineers (IEEE).
 8. Insulated Power Cable Engineers Association (IPCEA).
 9. Intertek.
 10. Life Safety Code (NFPA 101), latest edition.
 11. National Electrical Code (NFPA 70), latest edition.
 12. National Electrical Manufacturers Association (NEMA).
 13. National Electrical Safety Code (NESC).
 14. National Fire Protection Association (NFPA).
 15. Occupational Safety and Health Administration (OSHA): National Consensus Standards, Established Federal Standards, and Safety and Health Regulations for Construction.
 16. State and Local Codes.
 17. Telecommunications Industry Association (TIA).
 18. Underwriters Laboratories (UL).
 19. Uniform Building Code (UBC).
- B Where there is a conflict between the code or referenced standards and the contract documents, the code or standard shall have precedence only when it is more stringent than the contract documents. Items that are allowed by the code, but are less stringent than those specified, shall not be substituted.

1.9 MATERIALS AND EQUIPMENT MANUFACTURERS

- A Options in selecting materials and equipment are limited by requirements of the contract documents and governing regulations. They are not controlled by industry traditions or procedures experienced on previous construction projects.
- B Materials and equipment shall be provided in accordance with the following:
1. Primary Design Products:
 - a. Primary design products are those products around which the project was designed in terms of capacity, performance, physical size, and quality.
 - b. Primary design products are indicated by use of a single manufacturer's name, model number, or similar data on drawings or schedules, or within the specifications.
 - c. Provide primary design products unless substitutions are made in accordance with the following paragraphs.
 2. Acceptable Equivalent Substitutions:

- a. Acceptable equivalent substitutions are products of manufacturers other than those listed for the primary design products. Equivalent acceptable substitutions shall meet each of the following requirements.
 - b. The product shall be manufactured by one of the acceptable manufacturers listed in the project manual, drawings, or addenda.
 - c. The product shall meet or exceed the requirements of the contract documents in terms of quality, performance, suitability, appearance, and physical characteristics.
 - d. The Contractor providing the substitution shall bear the total cost of changes due to substitutions. These costs may include additional compensation to the Architect for redesign and evaluation services, increased cost of work by the Owner or other contractors, and similar considerations.
3. Performance Requirements:
 - a. Where the contract documents list performance requirements or describe a product or assembly generically, provide products that comply with the specific requirements indicated and that are recommended by the manufacturer for the respective application.
 4. Compliance with Standards, Codes, and Regulations:
 - a. Where the specifications require only compliance with an imposed standard, code, or regulation, the Contractor has the option of selecting a product that complies with the specification requirements, including the standards, codes, and regulations.
 5. Proposed substitutions will be judged on the basis of quality, performance, appearance, and the governing space limitations. The reputation of the manufacturer, delivery time requirements, and the availability of repair or replacement parts may also be considered.
 6. The Architect shall be the sole and final judge as to the suitability of substitution items.

1.10 SUBMITTALS

- A Submittal Requirements:
 1. Other sections in the project manual shall be adhered to if more stringent than the following paragraphs.
 2. When required by other sections of the project manual, submit shop drawings, product data, or samples to the Architect for review.
 3. Submittals deemed unnecessary by the Architect shall be returned indicating "No Action Taken".
 4. A completed copy of the transmittal form included with the project manual shall accompany each submittal.
 5. Submittals shall be numbered consecutively by specification section (i.e., 270501-01, 270501-02, etc.).
 6. Unless otherwise noted, submit one (1) copy electronically of shop drawings and product data for review. Review comments will be returned electronically. A hard copy of the electronic submittal will be returned if requested.
 7. Each submittal shall clearly indicate proposed items, capacities, characteristics, and details in conformance with the contract documents. Equipment items shall be marked with the same item number as used on drawings or schedules. Capacities, dimensions, and special features required shall be certified by the manufacturer.
 8. Submittals shall indicate manufacturer's delivery time for the item after review by the Architect.

9. When required by other sections of the project manual, the Contractor shall submit a "specification compliance review" (SCR) consisting of a paragraph-by-paragraph review of the specifications and addenda. Markings may be made in the margins of the original specification or addenda. Unless a deviation or exception is specifically noted in the SCR, it is assumed that the equipment, product, or material is in complete compliance with the contract documents. Submit the SCR with shop drawings and product data.
10. Submittals will be returned to the Contractor by the Architect with one of the following responses:
 - a. "A": Reviewed, No Exceptions Taken.
 - b. "B": Reviewed, Exceptions Taken as Noted.
 - c. "C": Revise and Resubmit.
 - d. "D": Rejected.
 - e. "E": No Action Taken.
11. The Architect shall review or take other appropriate action upon the Contractor's submittals such as shop drawings, product data, and samples, but only to determine conformance with the design concept of the work and the information given in the contract documents.
12. Contractor shall not be relieved of responsibility for any deviation from the requirements of the contract documents by the Architect's review of shop drawings, product data, or samples.
13. Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data, or samples by the Architect's review of those drawings.
14. No portion of the work requiring submission of a shop drawing, product data, or sample shall be commenced until the submittal has been reviewed by the Architect. Such portions of the work shall be in accordance with reviewed submittals.
15. The successful Contractor may, at their option, obtain DXF or AutoCAD DWG electronic files for use in preparation of shop drawings.
 - a. This information is available from Alvine upon written request.
 - b. The use of these drawing files is intended solely for the preparation of shop drawings as required by these contract documents.
 - c. Any other use is strictly prohibited by copyright laws.
 - d. The user of these electronic drawing files assumes full responsibility for their accuracy and scale.

B Bid Submittals:

1. The Contractor shall submit a resume with their proposal containing the qualification data listed below.
 - a. A list of five (5) recently completed projects of similar type and size with contact names and telephone numbers for each.
 - b. Installer qualifications.
 - c. RCDD certificate(s).
 - d. Letter of good standing from structured cabling system manufacturer(s).

C Pre-Construction Submittals:

1. The Contractor shall submit shop drawings in accordance with the requirements listed below.
 - a. Shop drawings are drawings, diagrams, schedules, and other data specifically prepared for this project by the Contractor to illustrate some portion of the work. Shop drawings

- shall also detail fabrication and installation for metal and wood supports, and anchorage for mechanical materials and equipment.
- b. Shop drawings shall be drawn to accurate scale and of adequate size to illustrate required details.
 - c. Maximum sheet size shall be 36 inches by 48 inches. For each hard copy shop drawing sheet larger than 11 inches by 17 inches, submit one (1) drawing on reproducible media.
 - d. The Architect's action shall be indicated on the reproducible drawing and the drawing shall be returned to the Contractor.
2. The Contractor shall submit product data in accordance with the requirements listed below.
 - a. Product data are illustrations, schedules, performance charts, instruction brochures, diagrams, and other information furnished by the Contractor to illustrate a product, material, or system for some portion of the work.
 - b. Includes data on features, ratings, and performance for each component specified.
 3. A proposed test plan shall be submitted to the Owner for approval prior to commencement of testing.

D Operation and Maintenance Manuals:

1. Prepare an electronic copy of the operation and maintenance manuals for the equipment furnished. Manuals shall be submitted to the Architect for review and distribution to the Owner not less than thirty (30) days prior to substantial completion of the project. Manuals not meeting the following requirements may be rejected by the Architect.
2. Each manual shall be assembled in a three-ring binder with hard cover and plastic finish. Binders shall not exceed a 3-inch thickness. Where more than one binder is required, the manuals shall be separated into a logical grouping, i.e., "Telecommunications", "Audiovisual", "Maintenance", "Operation", "Parts", "Shop Drawings", etc. Each binder shall have the following information clearly printed on its front cover:
 - a. Project name and address.
 - b. Portion of the work covered by each volume (if more than one volume in the set). Where more than one volume is required, label each volume as "Volume _____ of _____".
 - c. Name, address, and telephone number of Contractor and subcontractors, including night or emergency number.
3. Manual shall include, but shall not be limited to, the following:
 - a. A Complete Index:
 - 1) Contractor may submit the index to the Architect for review prior to submittal of complete manuals, if desired.
 - b. Names, Addresses, and Telephone Numbers:
 - 1) This list shall include the manufacturer(s) and local representative(s) who stocks or furnishes repair parts for all items of equipment and shall be typed on a single page in front of the binder.
 - c. Startup, Operation, and Shutdown Procedures:
 - 1) Provide a written description of procedures for startup, operation, and shutdown of each electrical item or system. This description shall include switches to operate, buttons to push, etc., in proper sequence, and the location of switches, starters, and push-buttons. Description shall include item references or labels used in the contract documents, unless otherwise instructed in advance by the Owner.

- d. Equipment Accessory Schedule:
 - 1) Upon completion of the work, furnish the Owner with a complete equipment accessory schedule listing each piece of equipment and the related size, type, number required, and the manufacturer(s) of renewable items.
 - e. Emergency Procedures:
 - 1) Provide a written description of emergency operating procedures or a list of service organizations (including addresses and telephone numbers) capable of rendering emergency services to the various parts of the system.
 - f. Provide all manufacturer operation and maintenance manuals and parts lists.
 - g. One (1) copy of shop drawings and product data, clearly marked for each item furnished using the designation label specified or indicated on the drawings.
 - h. Manufacturers' warranty information.
 - i. Detailed operating instructions covering operation under both normal and abnormal conditions.
 - j. Routine maintenance requirements for system components.
 - k. Normal maintenance schedule: Include a listing of work to be performed at various time intervals; i.e., 30, 90, 180 days, and yearly.
 - l. Lists of spare parts and replacement components recommended to be stored at the site for ready access.
- E Post-Construction Submittals:
- 1. Field quality-control test reports in PDF format.
 - 2. As-built shop drawings in accordance with the requirements listed below.
 - a. Work area outlet, equipment room, telecommunications space, telecommunications enclosure, telecommunications space, and pathway identifiers.
 - b. Routing of cables from equipment racks to devices.
 - c. Routing of cables between equipment racks.
 - d. Revisions to construction documents (addenda and field changes).
 - e. Floor plans with all final device locations, equipment rack locations, and labels.
 - f. Network diagrams, configurations, connections, and uplinks.
 - 3. Cable labeling schedule(s).
 - 4. When required, submit manufacturer's printed instructions for delivery, storage, assembly, installation, adjusting, and finishing, in quantities specified for shop drawings and equipment brochures.
 - 5. Maintain current documents at the construction site. Submit with operations and maintenance manuals.

1.11 OPERATING TRAINING

- A Complete operating instructions for each system and item of equipment shall be provided to the Owner.
- B Operation and maintenance manuals must be reviewed and accepted by the Architect and provided to the Owner prior to operating training.
- C Training shall be scheduled at the convenience of the Owner. A minimum of four (4) hours of training shall be provided.

- D Training shall include, but not be limited to, instructions on the following:
 - 1. Startup and shutdown procedures.
 - 2. Periodic maintenance.
 - 3. Emergency operation.
 - 4. Safety.
 - 5. Infrastructure management, such as cable patching.
 - 6. Infrastructure identification, such as patch panel labels.
 - 7. Configuration and setup.
 - 8. Additional training identified in other sections.
- E In addition to the instructions required above, wherever possible, perform the operations being described in order to fully illustrate system operation.
- F At the completion of training, the Contractor shall turn over to the Owner all required keys and special tools for installed equipment. Each key or tool shall be labeled with its use.
- G Train the Owner in cable management operations, such as rerouting signals in failed cables.

1.12 QUALITY ASSURANCE

- A Provide one of the following warranties:
 - 1. Belden 25-Year Product Warranty.
 - 2. CommScope Network Infrastructure System 25-Year Extended Product Warranty.
 - 3. Corning 25-Year Warranty.
 - 4. Hubbell Mission Critical 25-Year Warranty.
 - 5. Leviton Limited 25-Year Warranty.
 - 6. Panduit Certification Plus 25-Year Warranty.
 - 7. Proterial Cable America Lifetime Warranty.
 - 8. Prysmian (General Cable) 25-Year GenAssurance Warranty.
 - 9. Siemon Cabling System 25-Year Premium Warranty.
 - 10. Superior Essex PerformaLink 25-Year Warranty.
 - 11. Or pre-approved equivalent.
- B The Contractor shall prepare and submit all required performance warranty documentation to the manufacturer and shall deliver all complete and final warranty information to the Owner prior to project closeout.
- C The Contractor shall have an existing quality assurance and quality control plan for the installation. Upon request, the Contractor shall submit the quality assurance and control plan for the project.
- D The Contractor shall have extensive experience (5+ years) with the specified manufacturer(s), hardware, and cabling type(s).
- E The Contractor shall:
 - 1. Employ an experienced installer to supervise the project who is a Registered Communications Distribution Designer (RCDD) certified by BICSI and who has a minimum of five (5) years of experience installing and certifying similar systems.

2. Allow only installers trained and certified by the manufacturer to install, terminate, and test the structured cabling system products. Others may pull or place product only if under the direct supervision of the certified installer and trained by the manufacturer of the product.
 3. Be experienced in all aspects of the work.
 4. Have the manufacturer's recommended number of employees on the job site who have completed the required training courses for the above-mentioned warranties.
 5. Be certified by the manufacturer for the project location to install and warranty the product specified herein.
- F The Contractor shall employ a qualified project manager (PM) who must meet the following requirements:
1. Required participation in meetings and conferences.
 2. Be present at the project site for substantial completion inspection and final inspection.
 3. Approve the operation and maintenance manuals.
 4. Provide any additional instruction as needed to the Owner.
 5. Be responsible for supervision of all technical work that is part of this specification.
 6. Supervise preparation of shop drawings and submittals, and sign all submittals.
 7. Supervise the shop fabrications and field installation work to ensure strict conformance in accordance to the drawings, specifications, and the reviewed shop drawings to assure workmanship of the specified quality.
 8. Oversee the testing of all assemblies and all sub-assemblies prior to their delivery to the project site.
 9. Lead in the specified testing of completed installation to assure the Owner that all contract requirements were met. Work with and assist the Owner in the final testing for approval and acceptance of the system by the Owner.
- G The Contractor must provide proof of registration(s) and certification(s) along with the list of planned installers prior to commencing work.

1.13 WARRANTIES

- A The Contractor shall warrant all materials, workmanship, and equipment against defects for a period of one (1) year after the date of substantial completion. Certain equipment shall be warranted beginning at the time of final acceptance or for longer periods of time as specified in those sections of the project manual. The Contractor shall repair or replace, at no additional cost to the Owner, any item which may become defective within the warranty period. Any manufacturer warranties concerning any item installed will run to the benefit of the Owner. The Contractor agrees not to void or impair, or to allow subcontractors to void or impair, any warranties regarding products or items installed as part of this project. The repair of faulty workmanship shall be considered to be included in the contract.

1.14 REFERENCE STANDARDS

- A The Contractor's performance of work shall comply with applicable federal, state, and local laws, rules, and regulations. The Contractor shall give required notices, shall procure necessary governmental licenses, permits, and inspections, and shall pay without burden to the Owner all fees and charges in connection therewith, unless specifically provided otherwise. In the event of

violation, the Contractor shall pay all fines and penalties including attorney's fees and other defense costs and expenses in connection therewith.

- B Federal Communications Commission (FCC) registration or approval for any equipment requiring such approval shall be appropriately identified and obtained by the Contractor.
- C Design, manufacture, test, and install communications cabling per manufacturer requirements, state codes, local codes, requirements of authorities having jurisdiction, and particularly the most recent edition of the following standards:
 - 1. ANSI/TIA-568-B.1: Commercial Building Telecommunications Cabling Standard – Part 1: General Requirements.
 - 2. ANSI/TIA-568-B.2: Commercial Building Telecommunications Cabling Standard – Part 2: Balanced Twisted-Pair Cabling Components.
 - 3. ANSI/TIA-568-B.3: Optical Fiber Cabling Components Standard.
 - 4. ANSI/TIA-569-A: Commercial Building Standard for Telecommunications Pathways and Spaces.
 - 5. ANSI/TIA-606-D: Administration Standard for Telecommunications Infrastructure.
 - 6. ANSI/TIA-607-D: Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
 - 7. ANSI/TIA 526-7-A: Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.
 - 8. ANSI/TIA 526-14-D: Optical Power Loss Measurement of Installed Multi-Mode Fiber Cable Plant.
 - 9. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Standard.
 - 10. TIA/EIA-TSB-67: Transmission Performance Specifications for Field Testing of Twisted-Pair Cabling Systems.
- D Install communications cabling in accordance with the most recent edition of the following publications:
 - 1. BICSI Telecommunications Distribution Methods Manual (TDMM).
 - 2. BICSI Outside Plant Design Reference Manual (OSPDRM).
 - 3. ANSI/BICSI 007-2020: Information Communication Technology Design and Implementation Practices for Intelligent Buildings and Premises.
 - 4. ANSI/BICSI 008-2018: Wireless Local Area Network (WLAN) Systems Design and Implementation Best Practices.
 - 5. ANSI/BICSI N1-2019: Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure.
 - 6. ANSI/BICSI N2-17: Practices for the Installation of Telecommunications and ICT Cabling Intended to Support Remote Power Applications.
 - 7. ANSI/BICSI N3-20: Planning and Installation Methods for the Bonding and Grounding of Telecommunication and ICT Systems and Infrastructure.
- E Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F The aforementioned and following additional federal, state, and local rules, regulations, and ordinances govern the work as fully a part of the specifications as if herein attached. Where

requirements of the drawings or specifications are more stringent than the applicable codes, rules, regulations, and ordinances, the drawings or specifications shall apply.

1. ASTM E814: Standard Test Method for Fire Tests of Penetration Firestop Systems.
2. UL 1479: Standard For Fire Tests of Through-Penetration Firestops.
3. Americans with Disabilities Act (ADA): Accessibility Guidelines.
4. Code of Federal Regulations, Title 29, Subtitle B, Chapter XVII, Part 1910 (Occupational Safety and Health Standards).

- G Follow the Owner's installation standards unless otherwise shown on the drawings or stated herein. Where requirements of installation standards conflict with performance standards or a manufacturer's recommendations, refer to the Owner for a decision before proceeding.

1.15 COORDINATION

- A Coordinate and schedule all construction work with the General Contractor prior to beginning work. Do not interrupt building activities without strict coordination with the General Contractor. Unscheduled appearance to work without prior scheduling with the General Contractor is not allowed.
- B The Contractor shall attend all meetings as required by the General Contractor.
- C Convene a meeting at least one (1) week prior to commencing the work of this section, with the following agenda at a minimum:
1. Tour, inspect, and discuss building conditions related to the structured cabling system.
 2. Review submittals, both completed and yet to be completed.
 3. Review plans, specifications, and proposed equipment.
 4. Review construction schedule, availability of materials, personnel, equipment, and facilities needed to proceed without delay.
 5. Review required inspections and testing.
 6. Review cable routing, cable support, primary pathways, communications spaces, and environmental conditions.
- D The Contractor's project manager must be readily available on-site when needed.
- E Coordinate layout and installation of communications cabling with Owner's workstation and network equipment suppliers, if applicable.
- F Coordinate service entrance arrangements with Owner's service provider(s), if applicable.
- G Meet jointly with the Architect, network equipment suppliers, service provider representative(s), and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
- H Coordinate network configuration requirements for communications equipment with the Owner.
- I Record agreements reached in meetings and distribute to other participants.

- J Coordinate communications device rough-ins and conduit with general construction work. Coordinate the arrangement of these items within the building structure during progress of construction to facilitate the communications installations that follow.
- K Coordinate exact location(s) of ceiling-mounted equipment and devices with architectural plans, reflected ceiling plans, structural plans, and all affected trades prior to construction and installation.
- L Coordinate exact location(s) of all equipment and devices mounted to desktops and countertops with the millwork, casework, and furniture plans prior to installation.
- M Adjust arrangements and locations of distribution frames, cross-connect blocks, and patch panels in equipment rooms and telecommunications rooms to accommodate and optimize arrangement and space requirements of network equipment.
- N Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the installations that follow.
- O Fully examine the drawings and specifications for other trades and coordinate the installation of communications work with the work of the other trades. Consult and cooperate with the other trades for determining space requirements and for determining that adequate clearance is allowed with respect to their equipment, other equipment, and the building.
- P Coordinate installation of communications cabling with the raceway installer. Verify raceways are installed according to current TIA standards before installing cabling.
- Q Environmental Conditions:
1. Do not deliver or install cables and connecting materials to the installation location until areas are complete, dry, and temporary or permanent HVAC systems are operating and maintaining acceptable ambient temperature and humidity conditions for the remainder of the project. Communications cabling damaged (including painted cables) as a result of premature occupancy of the site will be replaced at the expense of the Contractor.
 2. Do not deliver or install equipment racks, network cabinets, and network electronics until communications rooms are enclosed, painted, water-tight, complete, dry, dust-free, and work above and in ceiling spaces is complete. Communications equipment damaged as a result of premature occupancy of the communications spaces will be replaced at the expense of the Contractor.
 3. System components shall be equipped and rated for the environments where installed.
 4. Rate outdoor equipment for continuous operation under specified environmental conditions, unless otherwise indicated.
 - a. Temperature range of -40 °C (-40 °F) to +70 °C (+158 °F).
 - b. Relative humidity range of five percent (5%) to one-hundred percent (100%).
 - c. Provide enclosures to prevent entry of moisture due to melting ice buildup, or driven rain or snow.
 5. Rate indoor equipment for continuous operation under specified environmental conditions, unless otherwise indicated.
 - a. Temperature range of 0 °C (32 °F) to +70 °C (+158 °F).

- b. Relative humidity range of zero percent (0%) to ninety-five percent (95%).
- R Provide offsets and elevation changes in cable tray, cable ladder runway, conduit, and devices as required to complete the layout and coordination process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.
- S Painted Cables and Devices:
 - 1. Protect communications cabling from direct painting or over-spray and coordinate the painting and cable installation schedules with respective subcontractors. Painted cables shall be replaced at the Contractor's expense.
 - 2. Protect faceplates and connectors from direct painting or over-spray. Painted faceplates and connectors will be replaced at the Contractor's expense.

1.16 STRUCTURAL COORDINATION

- A In cases where the Contractor determines that superimposed loads (such as suspended or floor-mounted mechanical, electrical, plumbing systems or equipment) exist which exceed design loads indicated on the structural contract documents, the Contractor shall submit the load data to the Architect for review prior to proceeding with the work.
- B Distribute the maximum load hung from any structural member for mechanical, electrical, plumbing, ductwork, piping, etc., over the member's tributary area in a way that the design superimposed dead loads listed in the structural contract documents are not exceeded. The Contractor shall coordinate the loads and provide additional support or distribution framing as required to achieve allowable load distribution.
- C Connections of systems designed by the Contractor such as, but not limited to, mechanical, electrical, and plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

PART 2 – PRODUCTS

2.1 PERFORMANCE, CAPACITIES, AND CHARACTERISTICS

- A Refer to the drawings for equipment schedules and equipment performance requirements when capacities and characteristics are not indicated in the specifications.

2.2 MATERIALS

- A Unless otherwise specified, all materials and equipment shall be new, unused, and undamaged. Materials and equipment shall be the current and standard designs of manufacturers regularly engaged in their production and shall bear the UL listing, or listing by other recognized testing laboratory when such listings are available. Materials shall be free of damage or corrosion and shall be of the best quality obtainable for the purpose intended.

- B Refer to individual specification sections for manufacturers.

2.3 COMPLETENESS OF WORK

- A The contract documents depict low voltage systems which are intended to be complete and functioning systems. All products, labor, and programming necessary to render a full and functional system to fulfill the design intent shown on the documents shall be provided by the Contractor.
- B Catalog numbers referenced throughout the drawings and specifications are intended to convey the understanding of the type and quality of the product required. Where written descriptions differ from information conveyed by a catalog number, the written description shall govern. No extra charge will be allowed because a catalog number is found to be incomplete or obsolete.

2.4 MATERIALS AND EQUIPMENT FURNISHED BY OTHERS

- A Where materials and equipment are indicated as furnished by others and installed or connected under this contract, it shall be the Contractor's responsibility to verify installation details and requirements.

2.5 QUANTITY OF SPECIFIED ITEMS REQUIRED

- A Wherever in these specifications an article, device, or piece of equipment is referred to in the singular number, such reference shall apply to as many such articles as are shown on the drawings or required to complete the installation.

2.6 SLEEVE SEALS

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
1. Sleeve Seals:
 - a. Calpico, Inc.
 - b. Flexicraft Industries.
 - c. Metraflex.
 - d. Link-Seal.
 - e. Or pre-approved equivalent.
 2. Seal Sleeves:
 - a. Pipe Shields, Inc.
 - b. ProSet Systems, Inc.
 - c. Crete-Sleeve.
 - d. Or pre-approved equivalent.
- B Description:
1. Modular design with interlocking rubber links, shaped to continuously fill annular space between pipe and sleeve.
- C Sealing Elements:

1. EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
- D Pressure Plates:
1. Plastic. Include two for each sealing element.
- E Connecting Bolts and Nuts:
1. Carbon steel with corrosion-resistant coating, of length required to secure pressure plates to sealing elements. Include one (1) for each sealing element.

2.7 SLEEVES

- A Electrical Metallic Tubing:
1. Pre-fabricated, galvanized steel, deburred, with plastic bushings on each end.
- B Fire-Rated Pathway Devices:
1. Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - a. Specified Technologies, Inc. (STI).
 - b. Hilti.
 2. Pre-fabricated pathway with intumescent pads conforming to cabling loads from zero percent (0%) to one-hundred percent (100%) fill capacity.
 3. Provide sizes and quantities as indicated on the drawings.

2.8 SEALANTS

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
1. Sealants:
 - a. Dow.
 - b. Pecora.
 - c. Sonneborn.
 - d. Tremco.
 - e. Or pre-approved equivalent.
- B Silicone Sealant:
1. Single-component, air-curing, non-staining, non-bleeding, capable of continuous water immersion, non-sagging type for application in vertical joints and in horizontal joints, color as selected.
- C Primer:
1. Non-staining type, recommended by sealant manufacturer to suit application.
- D Joint Cleaner:
1. Non-corrosive and non-staining type, recommended by sealant manufacturer, compatible with joint forming materials.
- E Joint Backing:

1. In compliance with ASTM D1056, round, closed-cell, polyethylene foam rod, oversized 30% to 50% larger than joint width.
- F Bond Breaker:
1. Pressure-sensitive tape recommended by sealant manufacturer to suit application.
- G Firestopping Materials:
1. Subject to compliance with the requirements of Division 07, provide one of the following:
 - a. Specified Technologies, Inc. SpecSeal SSS Intumescent Firestop Sealant.
 - b. 3M Fire Barrier Sealant CP 25WB+.
 - c. Tremco TREMstop Fyre-Sil Gun-Grade Silicone Firestop Sealant.
 - d. Metacaulk.
 - e. Dow.
 - f. Or pre-approved equivalent.

PART 3 – EXECUTION

3.1 EXAMINATION

- A Examine pathway elements intended for cables. Check raceways, cable trays, cable ladder runways, conduits, sleeves and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Provide all specified materials, installation hardware, and labor required to complete the work shown on the drawings and specified in this section and other Division 28 security specifications sections. This shall include work and miscellaneous items that are not explicitly specified, but are necessary to build a complete system installation, including all tools and test equipment, accessories, appurtenances, and all items required for testing the system. All systems shall be complete, operational, and ready for use by the Owner.
- B Bring to the attention of the Owner and Architect conflicts between manufacturer instructions and contract documents.
- C Cabling Installation Method:
1. Provide cabling in raceway, cable tray, cable ladder runway, conduit, and sleeves except within consoles, cabinets, desks, and counters. Conceal pathways and cabling, except in unfinished spaces.
- D Use UL-listed, plenum-rated cabling in environmental air spaces, including plenum ceilings.
- E Install cables without damaging conductors, shield, or jacket.
- F Use cable bundling hardware rated for the environment and application in which used. Applications include, but are not limited to, general purpose, outdoor, chemical-resistant, flame-retardant, high-temperature, and vibration.

- G Provide reusable cable management straps for bundling and securing cables. Do not use nylon cable ties.
- H Do not bend cables, in handling or in installation, to smaller radii than minimums recommended by manufacturer.
- I Pull cables without exceeding cable manufacturer's recommended pulling tensions.
- J Install exposed cables parallel and perpendicular to surfaces or exposed structural members. Follow surface contours where possible.
- K Secure and support cables at intervals not exceeding 48 inches, and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, equipment racks, frames, and terminals.
- L Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by the manufacturer.
- M Comply with ANSI/TIA-569-D for separating unshielded copper data communications cabling from potential EMI sources, including electrical power lines and equipment.
- N Make splices and terminations only at indicated outlets, terminals, cross-connects, patch panels, and splices.
- O Use splice connectors compatible with media types.
- P Install cabling using techniques, practices, and methods that are consistent with Category rating of components and that ensure Category performance of completed and linked signal paths, end-to-end.

3.3 FIRESTOPPING

- A Firestop all smoke-rated and fire-rated walls, partitions, and openings after the installation of communications cabling in sleeves and pathways. Firestop material shall be approved for use with the communications cables and jackets being installed.
- B Provide all services, labor, materials, tools, and equipment required for the complete and proper installation of firestopping for communications cabling as called for in these specifications and related drawings.
- C Deliver firestopping products to the project site in original, unopened containers or packages with intact and legible manufacturer labels identifying project, manufacturer, date of manufacture, lot number, shelf life (if applicable), qualified testing and inspecting agency's classification marking applicable to the project, curing time, and mixing instructions for multi-component materials.
- D Creation of such openings, as necessary, for cable passage between locations as shown on the drawings shall be the responsibility of the Contractor.
- E Sealing of openings between floors, through rated fire and smoke walls, existing or created by the Contractor for cabling pass-through, shall be the responsibility of the Contractor.

- F Any openings created by or for the Contractor and left unused shall be sealed as part of this work.
- G Firestop system installation must meet requirements of ASTM E814, UL 1479, or UL 2079 tested assemblies that provide a fire rating equal to that of construction being penetrated.
- H Do not install firestopping when ambient or substrate temperatures are outside limits permitted by firestopping manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.
- I Ventilate firestopping per the firestopping manufacturer's instructions by natural means or, where this is inadequate, forced air circulation.
- J During installation, provide masking and drop cloths to prevent firestopping materials from contaminating any adjacent surfaces.
- K Do not use materials that contain flammable solvents.
- L Clean out openings and joints immediately prior to installing firestopping to comply with recommendations of the firestopping manufacturer and the following requirements:
 - 1. Remove all foreign materials from surfaces of openings and joint substrates and from penetrating items that could interfere with adhesion of firestopping.
 - 2. Clean openings and joint substrates and penetrating items to produce clean, sound surfaces capable of developing the optimum bond with firestopping. Remove loose particles remaining from the cleaning operation.
- M When the firestop system has been installed, place a label next to the system. The label shall contain the following items:
 - 1. UL rating and any other pertinent certification information.
 - 2. The date the firestop was installed.
 - 3. Name of contractor who installed the firestop.
- N Protect firestopping during and after the curing period from contact with contaminating substances or form damage resulting from construction operations or other causes so that they are without deterioration or damage at the time of substantial completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated firestopping immediately and install new materials to produce firestopping complying with specified requirements.
- O Keep areas of work accessible until inspection by applicable code authorities.

3.4 AS-BUILT DRAWINGS

- A As-built drawings shall include all information required for shop drawings and, in addition, shall indicate the following:
 - 1. All construction changes posted to all portions of the documents including, but not limited to, communications drawings, enlarged plans, wall and rack elevations, schematics, labeling, and installation details. As-built documents shall include and clearly show final cable labeling designations down to the individual outlet and port.

- B Final drawings shall be provided to the Architect in electronic format.
- C As-built drawings shall be complete and organized to be suitable for use as disaster recovery and cable infrastructure administration documents.
- D Post a complete set of as-built documents in the MDF serving the project. In each MDF and IDF, post a final floor plan of the outlets served by the MDF or respective IDF on the wall behind a protective plexiglass wall frame.

3.5 TRENCHING, EXCAVATION, BACKFILLING, AND REPAIRS

- A Trenching, excavation, backfilling, and repairs are the responsibility of the Contractor. Coordinate the extent of all work with the General Contractor where applicable and coordinate related work with all trades. Failure to properly coordinate this effort resulting in additional trenching, excavation, backfilling, or repairs shall be performed at no additional cost by the Contractor.

3.6 OBSERVATIONS

- A Specifications and drawings represent work to be done in view of the total project requirements. Final locations of all pathways, cables, outlets, equipment racks, components, etc., to eliminate possible conflict with other trades is the responsibility of the Contractor. The Contractor is to provide all project management and supervision required for their personnel to ensure installation is made in accordance with the plans and specifications and that all codes, safety rules, and regulations are observed. In the event of conflicts with other trades, the Contractor is to make every reasonable effort to resolve the conflict with other trades involved, by preparation of drawings or sketches, or by other appropriate action. Only after this on-site coordination has taken place, and a resolution cannot be found, is the Contractor to request assistance. Assistance shall be requested in adherence with the request for information (RFI) process defined for this project.

3.7 DEMONSTRATION

- A Participate in project site observations, walkthroughs, and punch lists as requested by the Owner and/or the Architect.
- B Demonstrate completeness of work relative to completion percentages submitted for payment.

3.8 CLEANING

- A After completing system installation, including outlet fittings and devices, inspect exposed finishes.
- B Remove burrs, dirt, and construction debris, and repair damaged finishes, including chips, scratches, and abrasions.

END OF SECTION

SECTION 270527**GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS****PART 1 – GENERAL****1.1 SECTION INCLUDES**

- A This section describes the grounding and bonding requirements for telecommunications systems and equipment. Grounding and bonding requirements specified in this section may be supplemented by special requirements of systems described in other sections.

1.2 SUBMITTALS

- A As specified in Section 270501.
- B Product Data:
 - 1. Lugs and connectors.
 - 2. Conductors.
- C Shop Drawings.
- D Test Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action(s) taken to achieve test results that comply with requirements.

1.3 QUALITY ASSURANCE

- A Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.
 - 2. Comply with UL 467.
- B Comply with NFPA 70.
- C Comply with NFPA 780.
- D Comply with ANSI/TIA-607-D: Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.

PART 2 – PRODUCTS**2.1 MANUFACTURERS**

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.

1. Lugs and Connectors:
 - a. Chatsworth Products.
 - b. CommScope.
 - c. Harger.
 - d. Hubbell.
 - e. Legrand.
 - f. nVent.
 - g. Panduit.
 - h. Or pre-approved equivalent.

2.2 GROUNDING CONDUCTORS

- A For insulated conductors, comply with Division 26.
- B On larger conductors where green insulation is not available, insulate with green-colored insulation. Use green-colored tape at each termination point or splice to identify bonding conductor, with the exception of the use of manufacturer-recommended straps to bond cable trays, cable ladder runways, or equipment racks.

2.3 CONNECTOR PRODUCTS

- A Comply with IEEE 837, UL 467, and ANSI/TIA-607; listed for use of specific types, sizes, and combinations of conductors and connected items.
- B High-Pressure Compression Connectors:
 1. Hubbell Burndy HYGROUND, Panduit StructuredGround, or approved equivalent.

PART 3 – EXECUTION

3.1 APPLICATION

- A Use only copper conductors for bonding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B In raceways, use insulated equipment grounding conductors.
- C Equipment Grounding Conductor Terminations:
 1. Use bolted pressure clamps.
- D Underground Grounding Conductors:
 1. Use copper conductor, 2/0 AWG minimum. Bury at least 24 inches (600 mm) below grade.

3.2 EQUIPMENT GROUNDING CONDUCTORS

- A Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
- B Signal and Communication Systems:

1. For all communications systems, provide #6 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - a. For service and central equipment locations and wiring closets, terminate bonding conductors on a 12-inch long by 2-inch wide by 1/4-inch thick busbar.
 - b. For terminal cabinets: Terminate bonding conductors on cabinet grounding terminal.

3.3 INSTALLATION

A Bonding Conductors:

1. Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors or high-pressure compression connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

1. Install such that vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly-mounted equipment. Use exothermic-welded connectors or high-pressure compression connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure, taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

C Install each bonding conductor in a direct route and parallel or perpendicular to building structure or surfaces, without interfering with other systems or equipment.

D Install exterior grounding electrode conductors with a minimum bending radius of 12 inches.

E Install interior bonding conductors with a minimum bending radius of 8 inches.

F Install bonding conductors in EMT conduit unless otherwise indicated. Bond each end of the conduit to the bonding conductor using an appropriate bushing.

3.4 CONNECTIONS

A General:

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

5. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
 7. Clean ground bars and apply a light coating of antioxidant between the busbar and lug.
- B Bonding Conductor Terminations:
1. Provide compression lugs. For #4 AWG and larger, use two-hole lugs. For #6 AWG and smaller, use one-hole lugs.
- C Non-Contact Metal Raceway Terminations:
1. If metallic raceways terminate at metal housings without mechanical and electrical connection to housing or at a nonmetallic housing, terminate each conduit with a bushing. Connect bushings with a bare bonding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with bushings and bare bonding conductors, unless otherwise indicated.
- D Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.
- E High-Pressure Compression-Type Connections:
1. Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
- F Moisture Protection:
1. If insulated bonding conductors are connected to rods or busbars, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.5 TELECOMMUNICATIONS GROUNDING

- A When present, bond the following to the Primary Bonding Busbar (PBB):
1. Metallic equipment racks.
 2. Cable shields.
 3. Metal raceways, cable trays, and cable ladder runways for communications cabling extending from the same room or space where the PBB is located.
 4. Entrance protectors.
- B When present, bond the following to the nearest Secondary Bonding Busbar (SBB):
1. Metallic equipment racks.
 2. Cable shields.
 3. Metal raceways, cable trays, and cable ladder runways for communications cabling extending from the same room or space where the SBB is located.

3.6 LABELING

A Busbars:

1. Clean all surfaces prior to attachment of any label.
2. Follow manufacturer's recommendations for cleaning and affixing labels.
3. Label location shall be in the upper right-hand corner of the busbar.
4. Refer to the drawings for label identifier information.
5. Labels shall be self-adhesive, engraved plastic nameplate, black with white letters.
6. Format shall be all capital letters; font shall be as large as possible to fill the label space with the required information. The font shall be Helvetica, or equal, and bold. One-line format. Letters shall be at least 1/2 inch tall for readability.

B Bonding Conductors:

1. Label location shall be on the conductor at each end where it terminates.
2. Refer to the drawings for label identifier information.
3. Labels shall be machine-printed; design basis is Brady WML-1223-292.
4. Format shall be all capital letters; font shall be as large as possible to fill the label space with the required information. The font shall be Helvetica, or equal, and bold. One-line format.

C Examples:

1. Telecommunications Bonding Conductor (TBC). The TBC bonds the MGB to the PBB.
2. Telecommunications Bonding Backbone (TBB). The TBB bonds the PBB to the SBB. There may be multiple TBBs.
3. Telecommunications Equipment Bonding Conductors: EK, followed by the sequence numbers (e.g., EK001, EK002, etc.).

END OF SECTION

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SECTION 270528**PATHWAYS FOR COMMUNICATIONS SYSTEMS****PART 1 – GENERAL****1.1 SECTION INCLUDES**

- A This section includes pathways used for low-voltage communications cabling.

1.2 SUBMITTALS

- A As specified in Section 270501.
- B Product Data:
1. Cable trays.
 2. Cable ladder runways.
 3. J-hooks.
 4. Fire-rated pathway devices.
 5. Pathway accessories (e.g., cable dropouts, conduit waterfalls, etc.).
- C Shop Drawings.
- D Warranty.

1.3 QUALITY ASSURANCE

- A Comply with Division 26.
- B Confirm locations of cable pathways and supports during installation to identify and remedy potential cable installation conflicts before installation of cables.
- C Insure that all minimum bend radius requirements are maintained.
- D Coordinate the placement of pathway elements with other trades.

PART 2 – PRODUCTS**2.1 MANUFACTURERS**

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
1. J-Hooks:
 - a. Eaton.
 - b. nVent.
 - c. Legrand.
 - d. Or pre-approved equivalent.
 2. Cable Tray:

- a. Atkore.
 - b. Basor.
 - c. Chalfant.
 - d. Chatsworth Products.
 - e. Eaton.
 - f. Legrand.
 - g. MP Husky.
 - h. NavePoint.
 - i. nVent.
 - j. Panduit.
 - k. Or pre-approved equivalent.
3. Cable Ladder Runway:
- a. Basor.
 - b. Chalfant.
 - c. Chatsworth Products.
 - d. Eaton.
 - e. Legrand.
 - f. MP Husky.
 - g. nVent.
 - h. Or pre-approved equivalent.

2.2 SYSTEM REQUIREMENTS

- A Coordinate the features of materials and equipment which comprise the communications pathway system so that they form an integrated system.
- B Match components and interconnections for optimum future cable installation and performance.
- C UL-classified for suitability as an equipment grounding conductor.
- D Comply with NEMA BI 50015-2024 (VE1) and NEMA BI 50016-2024 (VE2).

2.3 CABLE RACEWAYS

- A Conduit:
 - 1. Comply with Division 26.
- B Boxes:
 - 1. Comply with Division 26.

2.4 J-HOOKS

- A Size:
 - 1. Between 3/4 inch and 4 inches as required to serve quantity of cables being run.
- B Category 6A-rated.
- C With wire spring cable retaining clips or slots for cable ties.

2.5 DROPOUTS & WATERFALLS:

- A Cable Tray:
 - 1. Provide dropouts above all equipment racks and network cabinets (minimum of two [2] per rack, unless noted otherwise), and at all locations where cable bundles leave cable tray above wall termination fields.
- B Cable Ladder Runway:
 - 1. Provide dropouts above all equipment racks and network cabinets (minimum of two [2] per rack, unless noted otherwise), and at all locations where cable bundles leave cable ladder runway above wall termination fields.
- C Conduit Waterfalls:
 - 1. Provide conduit end waterfalls for all 4-inch conduits or sleeves where located 12 inches or more above cable trays, cable ladder runways, or wall termination fields.
- D Provide additional cable dropouts and waterfalls as indicated on the drawings.

2.6 WIRE-MESH CABLE TRAY

- A Description:
 - 1. 2-inch by 4-inch wire-mesh pattern.
- B Material:
 - 1. Steel.
- C Finish:
 - 1. Zinc-electroplated.
- D Depth:
 - 1. Refer to drawings.
- E Width:
 - 1. Refer to drawings.
- F Hangers:
 - 1. Refer to drawings.
- G Provide manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.

2.7 CABLE LADDER RUNWAY

- A Material:
 - 1. Steel.
- B Bar Spacing:
 - 1. 12 inches.

- C Width:
 - 1. Refer to drawings.
- D Finish:
 - 1. Black.
- E Provide manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.
- F Accessories:
 - 1. Cable-retaining posts.
 - 2. Brackets for auxiliary cable pathway.
 - 3. Radius dropouts.
 - 4. Movable cross members.
 - 5. Cable spools.

PART 3 – EXECUTION

3.1 EXAMINATION

- A Examine pathway elements intended for cables. Check raceways, conduits, sleeves, cable trays, cable ladder runways, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B Examine all pathways for obstructions and clear prior to installation of cabling.
- C Examine all pathways for burrs and sharp edges. Remove prior to the installation of cabling. All cables damaged as a result of improperly prepared pathways shall be the responsibility of the installer.

3.2 J-HOOK INSTALLATION

- A Provide hook-and-loop ties around J-hooks to secure cables.
- B Strategically place J-hooks to aid in cable routing at corners and at changes in height.
- C If cable tray or cable ladder runway is not used as a primary pathway, use 2-inch or larger J-hooks to support cabling in primary pathways. Provide a second J-hook in a tiered or back-to-back configuration for each J-hook installed only when the quantity of outlets served from that primary pathway exceeds 40% of the manufacturer's rated capacity.
- D J-hooks used to support cable in secondary pathways can be 3/4 inch or larger. Provide a second J-hook for each J-hook installed only when the quantity of outlets served from that secondary pathway exceeds 40% of the manufacturer's rated capacity.
- E Provide J-hooks as indicated on drawings and as required between discontinuous sections of cable tray or cable ladder runway.

- F Where multiple J-hooks are installed, place J-hooks back-to-back if possible; otherwise, stack J-hooks one above the other.
- G Install J-hooks at maximum of 5-foot intervals, unless cable manufacturer requires different interval to maintain warranty. Unevenly space J-hooks to avoid standing waves on the cables.
- H Attach J-hooks to building structure.

3.3 PATHWAY INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Secure cable tray or cable ladder runway directly to top of equipment racks and network cabinets using manufacturer's recommended solution for attachment.
- C Install raceways securely, in a neat and workmanlike manner, as specified in NECA 1.
- D Use flat-head screws, clips, and straps to fasten raceway channel to surfaces. Mount plumb and level.
- E Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
- F For wireway supports, provide steel channel as specified in Division 26.
- G Close ends of wireways and unused conduit openings.
- H Ground and bond raceways and wireways under provisions of Division 26.
- I Install metallic cable tray and cable ladder runway in accordance with NEMA VE 1.
- J Remove sharp edges from pathways.
- K Support pathways in accordance with Division 26. Provide supports at each connection point, at the end of each run, and at other points to maintain spacing between supports of 10 ft maximum.
- L Additional requirements for cable management tray and cable ladder runway:
 - 1. Cut using manufacturer's recommended cutting tool. File cut edges smooth.
 - 2. Locate supports a maximum of 5 feet on center and no more than 30 inches from a joint.
 - 3. Install hardware with bolts oriented such that nuts are on the outside pathway element.
- M Provide a dropout fitting at the free end(s) of each run of cable tray or cable ladder runway and at elevation changes.
- N Install cable tray and cable ladder runway with sufficient space to allow access for cabling installation and for future cabling moves, adds, and changes.
- O Use expansion connectors where required.

- P Provide firestopping under provisions of Division 07 to sustain ratings when passing cable tray or cable ladder runway through fire-rated elements.
- Q Install cable trays and cable ladder runways to preserve fire-resistance rating of partitions and other elements.
- R Ground and bond cable tray and cable ladder runway under provisions of Division 26:
 - 1. Provide continuity between pathway components. Use lugs and grounding clamps compatible with tray material.
 - 2. Provide #2 AWG bare copper equipment grounding conductor through entire length of pathway; bond to each component.
 - 3. Connections may be made using mechanical or exothermic connectors.

END OF SECTION

SECTION 270553.01

IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 – GENERAL

1.1 SECTION INCLUDES

- A This section includes instructions for labeling and documentation of communications infrastructure.

1.2 SUBMITTALS

- A As specified in Section 270501.
- B Product Data:
 - 1. Label printer.
 - 2. Label tape.
- C Shop Drawings:
 - 1. Cable labeling scheme.
- D Maintenance Data:
 - 1. Include all information required for shop drawings.

1.3 QUALITY ASSURANCE

- A Comply with ANSI/TIA-606-D: Administration Standard for Telecommunications Infrastructure.
- B Comply with BICSI Telecommunications Distribution Methods Manual (TDMM), current edition.

PART 2 – PRODUCTS

2.1 IDENTIFICATION PRODUCTS

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Brady.
 - 2. Brother.
 - 3. Dymo.
 - 4. Panduit.
 - 5. Or Equal.
 - 6. Or pre-approved equivalent.
- B Cable Labels:
 - 1. Self-adhesive vinyl or vinyl-cloth wraparound tape markers, machine-printed with alphanumeric cable designations.

C Label Maker:

1. Suitable for cable wraps, cable flags, patch panels, punch blocks, faceplates, barcodes, etc.

PART 3 – EXECUTION**3.1 IDENTIFICATION & LABELING**

A General Label Requirements:

1. Mechanically print and install all labels per drawings.
2. Select font size to be readable and to fit all information required without overlap of text. Recommended font is Helvetica (bold).
3. Use all capital letters.
4. Clean all surfaces prior to attachment of any label. Follow manufacturer's recommendations for cleaning and affixing labels.
5. Coordinate room name and/or number information used in labels with final approved room signage. Final room signage may not match room tags used in construction documents.

B Cable Labeling System:

1. Use a unique alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects. Use logical and systematic designations for facility's architectural arrangement.
2. Refer to drawings.

C Work Area Outlets:

1. Label each terminated work area outlet jack per drawings.
2. Refer to drawings for label information.
3. Outlet identifiers shall be unique to the building.
4. Method:
 - a. Use manufacturer's white paper inserts or approved equal. Utilize commercial software to print the information on an adhesive label and affix the label to the paper insert or type the information on the strip. Do not affix labels to the clear plastic window. If label information does not legibly fit within window, then affix individual label above each jack.

D Patch Panels:

1. Label each patch panel per drawings.
2. Refer to drawings for label information.
3. Patch panel identifiers shall be unique to the telecommunications room in which they are installed.
4. Method:
 - a. Affix label to the left-hand side of the patch panel without covering any port numbers.

E Outside Plant Cables:

1. Label location shall be on the jack or sheath of the cable at the ends and at every splice, case, and manhole. Place near the hardware on which the cable is terminated.
2. Locate label in a visible and readable location.

3. Label information shall contain the cable identifier, which shall include the cable number followed by the cable pair count (numeric characters), both the beginning and ending count. The cable identifier is unique to the building. Refer to drawings.
 4. Provide polyethylene non-conductive cable tags with cable numbers as shown on the plans.
 5. Install tags at all splices (on each cable that enters the splice case), terminations, cable tray or cable ladder runway to conduit transitions, in manholes (at least once on each cable as it passes through the manhole), and at other locations as directed.
- F Inside Plant Cables (Including Coaxial):
1. Label location shall be within 12 inches of each termination and tap, where it is accessible in an equipment rack, network cabinet, junction box or outlet box, and elsewhere as indicated.
 2. Refer to drawings for label information.
- G Equipment Racks, Network Cabinets, and Wall Enclosures:
1. Label location shall be centered at the top and bottom of the rack or cabinet in both the front and rear.
 2. Refer to drawings for label information.
- H Fiber Termination Enclosure:
1. Label location shall be on the outside of the enclosure surface in the top-left corner of the front panel.
 2. Refer to drawings for label information.
- I Fiber Termination Enclosure Ports:
1. Label location shall be on the inside front panel of the enclosure in the location identified by the manufacturer for the label. In most cases, the manufacturer's insert can be used for which to affix installer-provided labels. The connector layout within each enclosure may vary. In general, the columns of fiber connectors are grouped in units of six (6) connectors. Columns count from left to right. Termination positions within a column count from top to bottom.
 2. Refer to drawings for label information.
- J Cable Labeling System Schedule:
1. Post in prominent location in each telecommunications room. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for project, in approved software and format.
- K Cable Administration Drawings:
1. Show building floor plans with cable administration labeling. Identify labeling convention and show labels for telecommunications spaces, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas outlets, grounding buses and pathways, and equipment grounding conductors. Follow conventions of ANSI/TIA-606-D. Furnish electronic record of all drawings, in approved software and format.

END OF SECTION

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SECTION 271101**COMMUNICATIONS EQUIPMENT ROOM FITTINGS****PART 1 – GENERAL****1.1 SECTION INCLUDES**

- A This section includes telecommunications infrastructure for equipment rooms, telecommunications rooms, and service entrance facilities including, but not limited to, equipment racks, network cabinets, cable management hardware, and plywood backboards.

1.2 SUBMITTALS

- A As specified in Section 270501.
- B Product Data:
 - 1. Equipment racks and network cabinets.
 - 2. Vertical and horizontal cable managers.
 - 3. Plywood backboards.
 - 4. UPSs and PDUs.
- C Shop Drawings:
 - 1. Communications room layouts.
- D Warranty.

1.3 QUALITY ASSURANCE

- A Coordinate layout and installation of communications equipment with the Owner as directed.
- B Coordinate entrance arrangements with the Owner's service provider(s) as directed.
- C Coordinate location of power raceways and receptacles with locations of communications equipment requiring power to operate with Division 26.

PART 2 – PRODUCTS**2.1 MANUFACTURERS**

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Equipment Racks:
 - a. Chatsworth Products.
 - b. CommScope.
 - c. Eaton.
 - d. Great Lakes.
 - e. Hubbell.

- f. Legrand.
- g. nVent.
- h. Panduit.
- i. Or pre-approved equivalent.
- 2. Cable Management and Support:
 - a. Chatsworth Products.
 - b. CommScope.
 - c. Eaton.
 - d. Great Lakes.
 - e. HellermannTyton.
 - f. Legrand.
 - g. MacLean Network Solutions.
 - h. nVent.
 - i. Panduit.
 - j. Velcro.
 - k. Or pre-approved equivalent.

2.2 SYSTEM REQUIREMENTS

- A Coordinate the features of materials and equipment so that they form an integrated system.
- B Match components and interconnections for optimum future performance.

2.3 EXPANSION CAPACITY

- A Provide spare fibers and copper conductor pairs in cables, positions in cross-connects and patch panels, and terminal strips to accommodate a 20 percent future increase in active work area outlets.
 - 1. 84 inches (45U).

2.4 FOUR-POST EQUIPMENT RACK

- A Description:
 - 1. Four-post free-standing equipment rack.
- B Finish:
 - 1. Baked-polyester powder coat.
- C Material:
 - 1. Steel.
- D Color:
 - 1. Black.
- E Grounding and Bonding:
 - 1. Provide each equipment rack with a ground lug.
- F Configuration:

1. Comply with EIA-310-E for 19-inch equipment racks.
- G Height:
1. 84 inches (45U).
- H Depth:
1. 36 inches.
- I Equipment Rails:
1. Square-punched. Provide cage nuts to install all rack-mounted equipment.
 2. Front and rear.
- J Accessories:
1. 1U shelf.
 2. Tool-less vertical PDU mounting bracket accessory kit.

2.5 VERTICAL CABLE MANAGEMENT

- A Description:
1. Includes components that aid in routing, managing, and organizing cabling to and from equipment. Protects network equipment by controlling cabling bend radii and providing cable strain relief.
- B Configuration:
1. Front and rear.
- C Width:
1. 6 inches (between equipment racks) and 6 inches (at the ends of equipment rack rows).
- D Cover:
1. Dual-hinged.
- E Color:
1. Black.
- F Quantity:
1. Refer to drawings.

2.6 HORIZONTAL CABLE MANAGEMENT

- A Description:
1. Includes components that aid in routing, managing, and organizing cabling to and from equipment. Protects network equipment by controlling cabling bend radii and providing cable strain relief.
- B Configuration:
1. Front and rear.
- C Height:

1. Refer to drawings.
- D Nominal Depth:
1. 8 inches.
- E Cover:
1. Hinged.
- F Color:
1. Black.
- G Quantity:
1. Refer to drawings.
- H Provide removable wire retainers to retain cabling during cover removal and #12-24 mounting screws.
- I Provide an integral strain relief bracket on either side to allow for easy cover placement.

2.7 CABLE MANAGEMENT

- A Cable trays and cable ladder runways shall comply with Section 270528 and Division 26.
- B Raceways and boxes shall comply with Division 26.
- C Wall Mounted 6-Inch Distribution Rings:
1. Plastic, Chatsworth Products no. 10812-001 or equivalent.
 2. Metal, MacLean Network Solutions no. SI-4754 or equivalent.
- D Wall Mounted 4-Inch Distribution Rings:
1. Plastic, Chatsworth Products no. 12127-001 or equivalent.
 2. Metal, MacLean Network Solutions no. SI-4753 or equivalent.
- E Cable Distribution Spools:
1. Chatsworth Products no. 15002-002 or equivalent.
- F Cable Bundling Hardware:
1. Reusable hook-and-loop cable ties.
 2. Plenum-rated.
 3. Match cable bundle
- G Cable Straps:
1. Reusable, adjustable, and capable of withstanding fastening to walls with screws or equipped with snap-and-button fasteners.
 2. Provide with or without cinch ring as applicable.
 3. Color shall be black.

2.8 PLYWOOD BACKBOARDS

- A Refer to drawings.
- B Fire-Retardant Paint:
 - 1. Premium-quality intumescent fire-retardant paint, white in color.
 - 2. Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - a. Benjamin Moore & Co.
 - b. PPG Industries, Inc.
 - c. Sherwin-Williams Company.
 - d. Or pre-approved equivalent.
- C Refer to drawings for locations and placement of plywood backboards.

2.9 PATHWAYS

- A Comply with ANSI/TIA-569-D, Section 270528, and Division 26.
- B Locate, coordinate placement, and install sleeves, conduits, cable trays, cable ladder runways, distribution rings, and associated appurtenances in accordance with the drawings.
- C Provide and install all cable trays or cable ladder runways in accordance with the drawings. When installed above equipment racks or network cabinets, leave 3" between the equipment racks or network cabinets and the cable tray or cable ladder runway. Provide dropouts for cabling entrance to equipment racks or network cabinets. Secure cable tray or cable ladder runway to equipment racks or network cabinets.
- D All pathways shall be free of sharp edges and shall be physically and electrically continuous. Utilize manufactured radius bends, tees, and corners, or utilize approved manufacturer methods for field fabrication of corners, bends, offsets, and tees. Cable trays or cable ladder runways installed at variance with published manufacturer standards or the drawings will be removed and reinstalled at the Contractor's expense.

PART 3 – EXECUTION

3.1 ENTRANCE FACILITIES

- A Unlisted outside-plant cables entering buildings shall adhere to NEC Articles 770, 800, 820, 830, and 840 (or their successors') requirements for conduit if these cables extend beyond 50 feet from their point of entrance.

3.2 EQUIPMENT RACKS AND NETWORK CABINETS

- A Provide equipment racks and network cabinets as indicated on the drawings.
- B Bolt free-standing equipment racks to the floor. Securely fasten hinged wall brackets to the wall on which they are mounted.

- C Bag and leave all spare hardware attached to the equipment rack or network cabinet.

3.3 GROUNDING & BONDING

- A Comply with Section 270527 and Division 26.
- B Ground and bond all equipment per ANSI/TIA-607-D.
- C Refer to drawings.

3.4 INSTALLATION IN TELECOMMUNICATIONS SPACES

- A Prepare telecommunications spaces with respect to power, pathways, plywood backboards, and other required hardware.
- B Anchor (screw) plywood 18" on center continuous and within 4" of edge and corners with galvanized or stainless steel anchors.
- C Mount terminal strips and other connecting hardware on backboards, unless noted otherwise.
- D Mount patch panels in equipment racks or network cabinets.
- E Group connecting hardware for cables into separate logical fields.
- F Use patch panels to terminate cables entering the space, unless noted otherwise.
- G Plastic or metal cable ties shall not be used in the telecommunications spaces (except for armored cables). Hook-and-loop ties shall be used.
- H Service loops shall be secured to cable tray, cable ladder runway, or plywood backboards with appropriate straps and/or distribution ring hardware.
- I Refer to drawings.

END OF SECTION

SECTION 271513

COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 – GENERAL

1.1 SECTION INCLUDES

- A This section includes cabling requirements and installation methods for horizontal twisted-pair copper communications systems to be used for voice and high-speed data transmission.
- B Horizontal cabling communications systems shall include the installation of twisted-pair copper cabling, connecting hardware, supports, faceplates, patch cords, cable terminations, cable testing, and cutover to form a complete and functioning system.

1.2 SUBMITTALS

- A As specified in Section 270501.
- B Product Data:
 - 1. Twisted-pair copper cabling.
 - 2. Patch panels.
 - 3. Patch cords.
 - 4. Punch-down blocks.
- C Shop Drawings:
 - 1. Cabling interconnection diagram(s) and work area outlet locations.
 - 2. Connector and termination hardware layouts.
- D Maintenance Data.
- E Qualifications:
 - 1. Documentation of certification from the cabling manufacturer.
- F Warranty.
- G Test Reports:
 - 1. Documentation of the test results, test equipment, equipment certification, and calibration of test equipment utilized.

1.3 QUALITY ASSURANCE

- A Coordinate layout and installation of communications equipment with the Owner as directed.
- B Coordinate entrance arrangements with the Owner's service provider(s) as directed.
- C The Contractor shall be responsible for verifying that all conduits and raceways are ready for cabling placement.

- D Coordinate with pathway installer to ensure that TIA distance limits and installation tolerances are maintained. Outlets that are beyond TIA distance shall be brought to the attention of the Owner and the Architect as soon as possible. Owner and Architect shall not be responsible for outlets beyond distance limits as a result of deviation from the plans and/or incorrectly routed sleeves and/or pathways.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Twisted-Pair Copper Horizontal Cabling:
 - a. Belden.
 - b. CommScope Uniprise.
 - c. Corning.
 - d. Hubbell.
 - e. Leviton.
 - f. Panduit.
 - g. Proterial Cable America.
 - h. Prysmian Group (General Cable).
 - i. Siemon.
 - j. Superior Essex.
 - k. Or pre-approved equivalent.
 - 2. Copper Termination Equipment:
 - a. Belden.
 - b. CommScope Uniprise.
 - c. Corning.
 - d. Hubbell.
 - e. Legrand.
 - f. Leviton.
 - g. Panduit.
 - h. Siemon.
 - i. Or pre-approved equivalent.
 - 3. Manufacturer(s) shall comply with specified warranty in Section 270501.

2.2 SYSTEM REQUIREMENTS

- A Coordinate the features of materials and equipment so that they form an integrated system.
- B Match components and interconnections for optimum future performance.
- C Obtain all cabling products through one source from a single manufacturer.
- D Horizontal cabling shall provide interconnections between telecommunications spaces and work area outlets. The horizontal cabling system shall consist of all cables, horizontal cross-connects, mechanical terminations, patch cords used for termination or cross-connection.

- E Horizontal cabling shall be installed in a star topology. Each work area outlet shall be cabled directly to telecommunications space serving the area.
- F All horizontal cabling terminations shall be located in telecommunications spaces. Bridged taps, splitters, or other unapproved hardware and facilities not specifically indicated on the drawings shall not be used as a part of the horizontal cabling.
- G Multi-user telecommunications outlet assemblies (MUTOAs) are not allowed unless otherwise specifically detailed in the construction documents.
- H Consolidation points and intermediate cross-connects are not allowed unless otherwise specifically detailed in the construction documents.
- I All cables placed in conduits, cable trays, and cable ladder runways shall not exceed the fill capacities as listed in ANSI/TIA-569-E even though maximum fill quantities as listed in NFPA 70 are less strict.
- J Upon entering a telecommunications space, cabling shall be neatly combed and separated according to service application. All added cables shall consistently follow the same path. Separate system cabling by pathway sleeve where possible.
- K All cabling shall be new and unused, provided, installed, terminated, and tested to form a complete system. The Contractor shall not deviate from the specified structured cabling system components and any substitutions not approved via the formal substitution process will be rejected and removed and replaced with the approved products at the Contractor's expense.
- L General Data Device, Wireless Access Point, Networked Security Device, and Networked Audiovisual Device Cables:
 - 1. Provide horizontal cabling to each device outlet location where indicated on the drawings.
 - 2. Cables and jacks for these devices shall be provided with a unique coloring scheme.
 - 3. Cables shall be terminated, tested, and warranted utilizing the same criteria as the work area outlet horizontal cabling system.

2.3 EXPANSION CAPACITY

- A Provide spare positions in patch panels and punch-down blocks to accommodate a twenty percent (20%) future increase in active work area outlets.

2.4 MATERIALS

- A Twisted-Pair Cables:
 - 1. Listed as complying with ANSI/TIA-568-B.
 - 2. Conductors shall be composed of solid copper.
 - 3. Unshielded twisted-pair, thermoplastic-insulated, individually twisted pairs of conductors, #23 AWG, color-coded, and enclosed in PVC jacket.
 - 4. Listed for use in air-handling (plenum) spaces. Features are as specified for cables and conductors, except materials are modified as required for listing.
 - 5. Cabling shall be UL-listed.

6. Rated for use in indoor (inside plant) environments, and rated for use in outdoor (outside plant) environments where noted. Refer to drawings.

B Category 6:

1. Four (4) pairs.
2. Jacket color scheme shall be unique to the device type being served.
 - a. General Data Device: Blue.
 - b. Wireless Access Point: Blue.
 - c. Networked Security Device: White.

C Patch Panels:

1. Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
2. Flat configuration.
3. Compliant with EIA-310-E for mounting within 19-inch equipment racks or network cabinets.
4. Unloaded front connections.
5. Unloaded rear connections.
6. T568B wiring scheme.
7. 48-port.
8. Capacity shall account one jack for each 4-pair cable, plus spares and blank positions adequate to satisfy specified expansion criteria.

2.5 PATCH CORDS

A Telecommunications Room

1. Quantity:
 - a. One (1) for each terminated jack.
2. Length:
 - a. 12 inches.
3. Color:
 - a. Jacket color shall match color of copper horizontal cabling jacket.
4. Jacket Rating:
 - a. CM.

B General Data Device (e.g., Workstation, VoIP Telephone, Printer, etc.)

1. Quantity:
 - a. One (1) for each terminated jack.
2. Length:
 - a. 7 feet.
3. Color:
 - a. Jacket color shall match color of copper horizontal cabling jacket.
4. Jacket Rating:
 - a. CM.

C Wireless Access Point

1. Quantity:
 - a. One (1) for each terminated jack.
2. Length:

- a. 3 feet.
 - 3. Color:
 - a. Jacket color shall match color of copper horizontal cabling jacket.
 - 4. Jacket Rating:
 - a. CMP (listed for use in a plenum).
- D Networked Security Device
- 1. Quantity:
 - a. One (1) for each terminated jack.
 - 2. Length:
 - a. 3 feet.
 - 3. Color:
 - a. Jacket color shall match color of copper horizontal cabling jacket.
 - 4. Jacket Rating:
 - a. CMP (listed for use in a plenum).
- E Provide patch cords which comply with manufacturer's warranty.
- F Final quantities of each length to be confirmed with the Owner prior to ordering.

PART 3 – EXECUTION

3.1 APPLICATION

- A Use cabling identified above for runs between telecommunications spaces and work area outlets.

3.2 INSTALLATION

- A Provide quantity of horizontal cables as indicated on the drawings. Install cables continuously from the jack on the communications outlet faceplate to the telecommunications space serving the area.
- B Do not install bruised, kinked, scored, deformed, or abraded cables. Remove and discard cabling if damaged during installation and replace it with new cabling.
- C Splicing of horizontal cables is not allowed.
- D Intermediate cross-connects or other termination of horizontal cables is not allowed unless specifically detailed and specified otherwise.
- E Terminate cables in accordance with ANSI/TIA-568-B, observing industry standards for terminating various types of color-coded cables within a building.
- F Route cables in a direct path between termination points. Neatly arrange cables in cable trays cable ladder runways, and telecommunications spaces. Provide distribution rings spaced a maximum of 12 inches on center to support cables run on the face of any wall containing a plywood backboard.
- G Install cables in cable trays, cable ladder runways, conduits, sleeve, and other pathways provided.

- H Hook-and-loop ties shall be used where appropriate or where specifically indicated in the contract documents. Where required, ties shall be spaced 5 feet to 6 feet in cable tray or cable ladder runway.
- I Where cables must be installed between devices and primary pathways, continuously support all cables from building structure in such a manner that the cables will not be damaged by normal building use.
- J Run all cabling parallel and perpendicular to building structural elements unless specifically noted otherwise, or as necessary where end-to-end lengths would otherwise exceed 295 feet.
- K Provide strain relief for cables above suspended ceilings and where any continuous cable support system is interrupted. Use mechanical fasteners as necessary to maintain cable Category rating of J-hooks and other necessary devices to support cables from the structure or ceiling support. Do not use suspended ceiling support wires or the ceiling grid to support telecommunications cabling. Space cable supports 4 feet to 5 feet apart. Where cable runs exceed 100 feet and metallic J-hook supports are utilized, place supports at differential intervals. Even spacing of metallic J-hooks for runs exceeding 100 feet are not permitted.
- L Do not attach to or support cabling by fire sprinkler heads, delivery systems, or any environmental sensor located in the ceiling space.
- M Plan cabling installation and cabling routes such that the capacity of the conduit, cable tray, and cable ladder runway is used most efficiently. Fill conduits and sleeves to maximize capacity and minimize crossover of future cabling installations.
- N Do not exceed manufacturer's recommended pulling tensions. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.

3.3 HORIZONTAL CABLES

- A Allow adequate slack for cable termination.
 - 1. Work Area Outlets:
 - a. 3 feet.
 - 2. Systems Furniture:
 - a. As necessary to reach the farthest point on each desktop using the furniture raceways plus 12 inches at the jack location.
 - 3. Telecommunications Spaces:
 - a. As necessary to reach the most distant patch panel or punch-down block, plus a length equal to two (2) times the room height.
- B Neatly arrange cables in cable trays, cable ladder runways, conduits, sleeves, and in telecommunications spaces.
- C For areas and locations that are close to TIA distance limits, run a length test on proposed routing to said area or location. Inform Owner and Architect of any jacks beyond TIA distance limits.

Owner and Architect shall not be responsible for out-of-distance outlets that are not tested prior to installation.

3.4 PATCH PANELS

- A Provide patch panels wired in T568B scheme in each telecommunications space to terminate copper twisted-pair cables.
- B Mount patch panels on equipment racks or network cabinets. Refer to drawings.
- C Group connecting hardware for cables into separate logical fields.

3.5 HORIZONTAL PATHWAYS

- A Horizontal cables between telecommunications spaces and work area outlets shall be no longer than 295 feet. If a location is identified which appears to exceed the distance limitation, it shall be the responsibility of the Contractor to field-verify the actual distance prior to installing the horizontal cable. Upon discovery of an over-length cable, the Contractor shall cease installation of the cable and immediately notify the Owner and Architect. The Contractor shall follow this notification with a formal request for information (RFI). The Contractor shall consult with the Owner and Architect to resolve the problem. There shall be no additional payment to the Contractor for rerouting of over-length cables which are discovered after installation.

3.6 GROUNDING

- A If applicable, bond horizontal cable shields and drain wires at each end.
- B Comply with Division 26 and Section 270527.

3.7 PERFORMANCE TESTING

- A The horizontal cabling system shall comply with transmission standards in ANSI/TIA-568-B.1 when tested according to test procedures of this standard.
- B After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all conductors installed. Remove temporary connections when tests have been satisfactorily completed.
- C Provide certification reports printed electronically on 8-1/2 inch x 11 inch digital sheets. Provide a separate section for each group of cables served from a common telecommunications space. Present cable testing results in a sequenced or otherwise orderly matrix format.
- D Twisted-Pair Copper Cabling Testing:
 - 1. Test horizontal cables from the punch-down blocks, patch panels, or other termination equipment to the jacks, unless noted otherwise.
 - 2. Utilize cable testing equipment capable of generating a report for each cable tested. Provide a report per ANSI/TIA-568-B.
 - 3. Inspect for physical damage and test each conductor signal path for continuity and shorts. Test for faulty connectors, splices, and terminations.

- E Field Test Requirements for a Category 6 Balanced Twisted-Pair Cabling System:
1. Test every cabling link in the installation in accordance with ANSI/TIA-568B.
 2. The installed twisted-pair horizontal links shall be tested from the telecommunications space to the work area outlet against the “permanent link” performance limits specification as defined in ANSI/TIA-568-B.
 3. Test one-hundred percent (100%) of the installed cabling links. All cable links must pass the requirements of the standard(s) mentioned above and as further detailed below. Any failing link shall be diagnosed and corrected. Follow corrective action with a new test to prove that the corrected link meets the performance requirements. Provide the final and passing result of the tests for all links in the test results documentation in accordance with this section.
 4. Trained technicians who have successfully attended an appropriate training program and have obtained certification as proof thereof shall execute the tests. These certificates shall have been issued by any of the following organizations, or an equivalent organization.
 - a. The manufacturer of the twisted-pair copper cabling and/or the twisted-pair copper connectors.
 - b. The manufacturer of the test equipment used for the field certification.
 - c. Training organizations authorized by BICSI or by the CCA.
 5. The test equipment (tester) must comply with or exceed the accuracy requirements for Level III field testers as defined in ANSI/TIA-568-B. The tester, including the appropriate interface adapter, must meet the specified accuracy requirements.
 6. The tester must be within the calibration period recommended by the manufacturer in order to achieve the manufacturer specified measurement accuracy.
 7. The tester interface adapters must be of high quality and the cable must not show any twisting or kinking resulting from coiling and storing of the tester interface adapters. Provide proof that the interface has been calibrated within the period recommended by the manufacturer.
 8. Determine the pass or fail condition for the link-under-test by the results of the required individual tests as detailed below. Any fail result yields a fail for the link-under-test. In order to achieve an overall pass condition, the results for each individual test parameter must pass (pass* is not accepted).
- F 4-Pair Unshielded Twisted-Pair Performance Test Parameters:
1. Test all horizontal twisted-pair copper cables according to the parameters in the ANSI/TIA-568-B standard. The test of each link must contain the following parameters as detailed below. In order to pass the link test, all measurements at each frequency in the range from 1 MHz through 250 MHz must meet or exceed the limit value determined in the above-mentioned standard.
 2. Perform the following tests as defined in ANSI/TIA-568-B:
 - a. Wire map.
 - b. Length.
 - c. Insertion loss (attenuation).
 - d. NEXT loss.
 - e. Pair-to-pair PSNEXT loss.
 - f. ELFEXT loss.
 - g. Pair-to-pair PSELFEXT loss.
 - h. Return loss.
 - i. ACR.
 - j. PSACR.

- k. Propagation delay.
 - l. Delay skew.
- G Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Horizontal Twisted-Pair Copper Test Equipment:
 - a. Agilent.
 - b. Fluke.
 - c. Ideal Industries.
 - d. Or pre-approved equivalent.
- H Test Result Documentation:
 - 1. Record the test results information for each link in the memory of the field tester upon completion of the test.
 - 2. Transfer the test results records saved by the tester into a Windows-based database utility that allows for the maintenance, inspection, and archiving of these test records. Guarantee these results are transferred to the PC unaltered; i.e., "as saved in the tester", at the end of each test and that these results cannot be modified at a later time.
 - a. "CSV" (comma separated value) format does not provide adequate protection and will not be acceptable.
 - 3. Store and deliver the database for the completed job, including optical fiber cabling links if applicable, by electronic means. Include the software tools required to view, inspect, and print any selection of test reports.
 - 4. Provide a paper copy of the test results that lists all the links that have been tested with the following summary information.
 - a. The identification of the link in accordance with the naming convention defined in the overall system documentation.
 - b. The overall pass/fail evaluation of the link-under-test, including the NEXT headroom (overall worst case) number.
 - c. The date and time that the test results were saved in the memory of the tester.
 - 5. General information to be provided in the electronic database containing the test result information for each link.
 - a. The identification of the project site as specified by the end user.
 - b. The overall pass/fail evaluation of the link-under-test.
 - c. The name of the standard selected to execute the stored test results.
 - d. The cable type and the value of NVP used for length calculations.
 - e. The date and time the test results were saved in the memory of the tester.
 - f. The manufacturer, model, and serial number of the tester.
 - g. The revision of the tester software and the revision of the test standards database in the tester.

END OF SECTION

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SECTION 271533**COMMUNICATIONS COAXIAL CABLING****PART 1 – GENERAL****1.1 SECTION INCLUDES**

- A This section includes cabling requirements and installation methods for copper coaxial cabling systems to be used as signal transmission media for master antenna television (MATV), community antenna television (CATV), or satellite earth station systems.
- B Coaxial cabling communications systems shall include the installation of copper coaxial cabling, connecting hardware, supports, faceplates, patch cords, cable terminations, cable testing, and cutover to form a complete and functioning system.

1.2 SUBMITTALS

- A As specified in Section 270501.
- B Product Data:
 - 1. Copper coaxial cabling.
 - 2. Termination equipment.
 - 3. Patch cords.
- C Shop Drawings:
 - 1. Cabling interconnection diagram(s) and work area outlet locations.
 - 2. Connector and termination hardware layouts.
- D Maintenance Data.
- E Qualifications:
 - 1. Documentation of certification from the cabling manufacturer.
- F Warranty.
- G Test Reports:
 - 1. Documentation of the test results, test equipment, equipment certification, and calibration of test equipment utilized.

1.3 QUALITY ASSURANCE

- A Coordinate layout and installation of communications equipment with the Owner as directed.
- B Coordinate entrance arrangements with the Owner's service provider(s) as directed.
- C The Contractor shall be responsible for verifying that all conduits and raceways are ready for cabling placement.

- D Coordinate with pathway installer to ensure that TIA distance limits and installation tolerances are maintained. Outlets that are beyond TIA distance shall be brought to the attention of the Owner and the Architect as soon as possible. Owner and Architect shall not be responsible for outlets beyond distance limits as a result of deviation from the plans and/or incorrectly routed sleeves and/or pathways.
- E Comply with 47 CFR: Part 15, Part 17, and Part 76.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Coaxial Cabling:
 - a. Belden.
 - b. CommScope.
 - c. Proterial Cable America.
 - d. Prysmian Group (General Cable).
 - e. Superior Essex.
 - f. West Penn Wire.
 - g. Windy City Wire.
 - h. Or pre-approved equivalent.
 - 2. Coaxial Termination Equipment:
 - a. Belden.
 - b. CommScope.
 - c. Hubbell.
 - d. Ortronics.
 - e. Panduit.
 - f. Siemon.
 - g. West Penn Wire.
 - h. Or pre-approved equivalent.

2.2 MATERIALS

- A Series-6 Cabling (Horizontal):
 - 1. Fire-retardant PVC jacket.
 - 2. Tinned copper-braid shielding.
 - 3. #14 AWG solid copper-clad steel conductor.
 - 4. 75-ohm impedance.
 - 5. Plenum-rated.
 - 6. 75-ohm self-terminating type "F" connector compression-style fittings.
- B Coaxial cabling elements shall be one-hundred percent (100%) factory-sweep tested to meet or exceed requirements of NFPA 70, Articles 725, 800, and 820.
- C Rated for use in indoor (inside plant) environments, and rated for use in outdoor (outside plant) environments where noted. Refer to drawings.

PART 3 – EXECUTION**3.1 EXAMINATION**

- A Examine pathway elements intended for cabling. Check raceways, cables trays, cable ladder runways, conduits, sleeves, and other elements for compliance with space allocations, installation tolerances, hazards to cabling installation, and other conditions affecting installation.
- B Examine walls, floors, roofs, equipment bases, and roof supports for suitable conditions where equipment is to be installed.
- C Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Provide quantity of coaxial cables as indicated on the drawings. Install cables continuously from the jack on the communications outlet faceplate to the telecommunications space serving the area.
- B Do not install bruised, kinked, scored, deformed, or abraded cables. Remove and discard cabling if damaged during installation and replace it with new cabling.
- C Splicing of coaxial cables is not allowed.
- D Intermediate cross-connects or other termination of horizontal cables is not allowed unless specifically detailed and specified otherwise.
- E Route cables in a direct path between termination points. Neatly arrange cables in cable trays cable ladder runways, and telecommunications spaces. Provide distribution rings spaced a maximum of 12 inches on center to support cables run on the face of any wall containing a plywood backboard.
- F Install cables in cable trays, cable ladder runways, conduits, sleeve, and other pathways provided.
- G Hook-and-loop ties shall be used where appropriate or where specifically indicated in the contract documents. Where required, ties shall be spaced 5 feet to 6 feet in cable tray or cable ladder runway.
- H Where cables must be installed between devices and primary pathways, continuously support all cables from building structure in such a manner that the cables will not be damaged by normal building use.
- I Run all cabling parallel and perpendicular to building structural elements unless specifically noted otherwise.
- J Provide strain relief for cables above suspended ceilings and where any continuous cable support system is interrupted. Use mechanical fasteners as necessary to maintain cable rating of J-hooks and other necessary devices to support cables from the structure or ceiling support. Do not use suspended ceiling support wires or the ceiling grid to support telecommunications cabling. Space cable supports 4 feet to 5 feet apart. Where cable runs exceed 100 feet and metallic J-hook

supports are utilized, place supports at differential intervals. Even spacing of metallic J-hooks for runs exceeding 100 feet are not permitted.

- K Do not attach to or support cabling by fire sprinkler heads, delivery systems, or any environmental sensor located in the ceiling space.
- L Plan cabling installation and cabling routes such that the capacity of the conduit, cable tray, and cable ladder runway is used most efficiently. Fill conduits and sleeves to maximize capacity and minimize crossover of future cabling installations.
- M Install surge suppressors where AC-power-operated devices are not protected against voltage transients by integral surge suppressors specified in UL 1449. Install surge suppressors at the devices' power-line terminals. Comply with Division 26.
- N Do not exceed manufacturer's recommended pulling tensions. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
- O Neatly arrange cables in cable trays, cable ladder runways, conduits, sleeves, and in telecommunications spaces.
- P Install exposed cabling parallel to building lines, follow surface contours, and support the cable according to manufacturer's written instructions. Do not run adjacent and parallel to power or data cables.
- Q Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.3 IDENTIFICATION

- A As specified in Section 270553.01.

3.4 FIELD QUALITY CONTROL

- A After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all conductors installed. Remove temporary connections when tests have been satisfactorily completed.
- B Provide certification reports printed electronically on 8-1/2 inch x 11 inch digital sheets. Provide a separate section for each group of cables served from a common telecommunications space. Present cable testing results in a sequenced or otherwise orderly matrix format.
- C Coaxial Cabling Testing:
 - 1. Test coaxial cables from the punch-down blocks, patch panels, or other termination equipment to the jacks, unless noted otherwise.
 - 2. Utilize cable testing equipment capable of generating a report for each cable tested. Provide report.
 - 3. Inspect for physical damage and test each conductor signal path for continuity and shorts. Test for faulty connectors, splices, and terminations.

D Field Test Requirements for a Coaxial Cabling System:

1. Test every cabling link in the installation.
2. The installed coaxial links shall be tested from the telecommunications space to the work area outlet.
3. Test one-hundred percent (100%) of the installed cabling links. Provide results of the tests for all links in the test results documentation as specified in this section.
4. Trained technicians who have successfully attended an appropriate training program and have obtained certification as proof thereof shall execute the tests. These certificates shall have been issued by any of the following organizations, or an equivalent organization.
 - a. The manufacturer of the coaxial cabling and/or the coaxial connectors.
 - b. The manufacturer of the test equipment used for the field certification.
 - c. Training organizations authorized by BICSI or by the CCCA.
5. The tester must be within the calibration period recommended by the manufacturer in order to achieve the manufacturer specified measurement accuracy.
6. The tester interface adapters must be of high quality and the cable must not show any twisting or kinking resulting from coiling and storing of the tester interface adapters. Provide proof that the interface has been calibrated within the period recommended by the manufacturer.
7. Determine a pass or fail result for each parameter by comparing the measured values with the specified test limits for that parameter. Mark with an asterisk (*) the test result of a parameter when the result is closer to the test limit than the accuracy of the field tester. Provide documentation as an aid to interpret results marked with asterisks.

E Coaxial Performance Measurements:

1. Length.
2. Insertion loss (attenuation).
3. Propagation delay.
4. Impedance.

F Approved Test Equipment Manufacturers:

1. Agilent.
2. Fluke.
3. Ideal Industries.

G Test Result Documentation:

1. Record the test results information for each link in the memory of the field tester upon completion of the test.
2. Transfer the test results records saved by the tester into a Windows-based database utility that allows for the maintenance, inspection, and archiving of these test records. Guarantee these results are transferred to the PC unaltered; i.e., "as saved in the tester", at the end of each test and that these results cannot be modified at a later time.
 - a. "CSV" (comma separated value) format does not provide adequate protection and will not be acceptable.
3. Store and deliver the database for the completed job by electronic means. Include the software tools required to view, inspect, and print any selection of test reports.
4. Provide a paper copy of the test results that lists all the links that have been tested with the following summary information.
 - a. The identification of the link in accordance with the naming convention defined in the overall system documentation.
 - b. The test parameter values for each link.

- c. The date and time that the test results were saved in the memory of the tester.
- 5. General information to be provided in the electronic database containing the test result information for each link.
 - a. The identification of the project site as specified by the end user.
 - b. The identification of the link in accordance with the naming convention defined in the overall system documentation.
 - c. The cable type and the value of NVP used for length calculations.
 - d. The date and time the test results were saved in the memory of the tester.
 - e. The manufacturer, model, and serial number of the tester.
 - f. The revision of the tester software and the revision of the test standards database in the tester.

END OF SECTION

SECTION 271543

COMMUNICATIONS FACEPLATES AND CONNECTORS

PART 1 – GENERAL

1.1 SECTION INCLUDES

- A This section includes the provision and installation of jacks, faceplates, copper twisted-pair cabling termination, labeling, and associated hardware recognized as necessary and as described in the drawings and in these specifications.

1.2 SUBMITTALS

- A As specified in Section 270501.
- B Product Data:
 - 1. Jacks.
 - 2. Faceplates.
 - 3. Connectors and terminated hardware.
- C Shop Drawings:
 - 1. Cabling interconnection diagram(s) and work area outlet locations.
 - 2. Connector and termination hardware layouts.
- D Maintenance Data.
- E Qualifications:
 - 1. Documentation of certification from the cabling manufacturer.
- F Warranty.
- G Test Reports:
 - 1. Documentation of the test results, test equipment, equipment certification, and calibration of test equipment utilized.

1.3 QUALITY ASSURANCE

- A Coordinate with pathway/box installer to ensure that faceplates are installed plumb and level, flat to wall, and without gaps.
- B In situations where communications device mounting heights vary from the adjacent electrical devices, match the electrical device mounting heights.

PART 2 – PRODUCTS**2.1 MANUFACTURERS**

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
1. Belden.
 2. CommScope Uniprise.
 3. Corning.
 4. Hubbell.
 5. Legrand.
 6. Leviton.
 7. Panduit.
 8. Siemon.
 9. Or pre-approved equivalent.

2.2 SYSTEM REQUIREMENTS

- A Coordinate the features of materials and equipment so that they form an integrated system.
- B Match components and interconnections for optimum future performance.
- C All materials and products specified herein are to be new, unused, of first quality and delivered to site in original packaging or shipping containers unless otherwise indicated on the drawings.

2.3 MATERIALS

- A Standard Communications Faceplate:
1. Single-gang.
 2. Number of outlet positions shall be four (4).
 3. Provide blanking fillers as required for unused jack openings.
 4. Material shall match adjacent electrical receptacles.
 5. Color shall match adjacent electrical receptacles.
- B Modular Communications Jack:
1. Mounting within modular faceplate.
 2. Category 6.
 3. Eight (8) pins.
 4. T568B termination.
 5. Color shall match color of copper horizontal cabling jacket.
- C Coaxial Connector:
1. Mounting within modular faceplate.
 2. Flush F-type connector.
 3. Less than 0.1 dB attenuation.
- D Type 106 Duplex Modular Frame:
1. Mounting behind NEMA 106 openings or faceplates.

2. Number of outlet positions shall be two (2) or four (4).
3. Material shall be plastic.
4. Color shall match adjacent electrical receptacles.

E Surface-Mount Box:

1. Number of outlet positions shall be two (2).
2. Plenum-rated.
3. Material shall be plastic.
4. Color shall match adjacent electrical receptacles.

PART 3 – EXECUTION

3.1 EXAMINATION

- A Verify that outlet boxes are installed at proper height.
- B Verify that wall openings are neatly cut and will be completely covered by wall plates.
- C Verify that floor boxes are adjusted and installed properly.
- D Verify that furniture openings and furniture outlet faceplates are coordinated.

3.2 PREPARATION

- A Provide extension rings to bring outlet boxes flush with finished surface.
- B Clean debris from outlet boxes.

3.3 INSTALLATION

- A Provide faceplates and jacks as indicated on the drawings.
- B Plate configurations shall be as indicated on the drawings.
- C Provide a blanking filler for each unused faceplate opening.
- D Coordinate faceplate requirements for furniture with furniture manufacturer.
- E Install devices, such as (but not limited to) faceplates and jacks, plumb and level.
- F Provide faceplates for all active and blank (spare) outlet locations.
- G Install devices securely and in a neat and workmanlike manner.
- H For all work area outlets, follow manufacturer's procedures for termination of the specific products installed and performance required.
- I All coaxial cables shall be terminated using the matching connector and tool assembly for compression-type connectors. Follow manufacturer's procedures for termination.

3.4 INTERFACE WITH OTHER WORK

- A Coordinate locations of outlet boxes with other trades to obtain unified and consistent location and mounting heights specified.

3.5 FIELD QUALITY CONTROL

- A Inspect each wiring device for defects.
- B Test each communications port.
- C Label each wall plate and communications port.

3.6 ADJUSTING

- A Adjust devices and wall plates to be flush and level.

3.7 CLEANING AND PROTECTION

- A Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

SECTION 274100
AUDIOVISUAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Requirements for the visual display, processing, routing, interface, audio support, control, and other peripheral and support equipment for audiovisual (AV) systems.

1.2 SUBSTITUTIONS

- A Requests for substitution of equipment/materials shall comply with Section 01300 regarding the proposed substitute item(s), specifications, and front/rear views.

1.3 REFERENCES

- A InfoComm International, "Basics of Audio and Visual Systems Design".
- B InfoComm 10:2013, "Audiovisual Systems Performance Verification".
- C InfoComm 2M-2010, "Standard Guide for Audiovisual Systems Design and Coordination Processes".
- D AVIXA, F501.01:2015 "Cable Labeling for Audiovisual Systems".

1.4 DEFINITIONS

- A The term "OFE" shall refer to "Owner Furnished Equipment" which will be provided by the Owner to the Installer. This equipment will be integrated as required.
- B The term "shall" is mandatory; the term "will" is informative; the term "should" is advisory; and the term "provide" means furnish and install.

1.5 SYSTEM DESCRIPTION

- A Provide all equipment, materials, associated hardware, power supplies, labor, transportation and incidentals, and all work needed for the installation and testing of the AV systems.
- B The AV systems equipment will be installed at display locations indicated within these specifications, associated drawings, and within the Owner provided areas associated with the specified systems. It is the responsibility of the AV Contractor to verify space behind displays, rooms, and cabinetry prior to installation as a portion of the Submittal Documents.
- C The work shall be in accordance with this specification and in conformity with the designs, layouts and descriptions shown on the drawings.

- D Any and all structural, mounting, or rigging details within this package is strictly conceptual. It is the responsibility of the AV Contractor to coordinate with design team Structural Engineer as necessary. Calculations shop drawings, and details of any structural modifications or additions shall be submitted to the Architect for approval.
- E Unless stated otherwise on the drawings, the work shall include everything necessary or incidental to complete the installation EXCEPT wire raceway (including conduit), raceway fittings, outlet boxes, pull boxes, terminal cabinets, 120 volt AC power circuits, lighting systems, and insulated ground cables.

1.6 DESIGN REQUIREMENTS

- A Except when plenum rated cabling is used above finished ceilings, it is required that cabling for microphone and line inputs, wideband RGBHV, video, control and other AV related cabling be routed inside the comprehensive system of conduit indicated on the drawings and installed by others. Floor and wall boxes shall serve as the primary interface points to the AV system.
- B Provide and install cover plates, connectors and associated cabling to link all floor and wall boxes to all affiliated local and remote AV components. The Owner will provide no additional conduit, power or workboxes. If additional infrastructure is required, include provisions for what is additionally required in the proposal. No wiremold or surface mounted raceway will be permitted.
- C All touch panel layouts are to comply with the applicable Owner's standards for touch panel layouts in both aesthetic and programing types.

1.7 PERFORMANCE REQUIREMENTS

- A Performance Standards: Unless restricted by the published specification of a particular piece of equipment, or unless otherwise required, the following minimum performance standards shall be met by the AV system:
 - 1. Audio:
 - a. S/N (including crosstalk and hum): 75dB minimum.
 - b. Total Harmonic Distortion: 0.5% maximum from 30 Hz to 15,000 Hz.
 - c. Frequency Response: Flat within +1.0 dB, 30 Hz to 15,000 Hz.
 - 2. Display:
 - a. Minimum 150:1 contrast ratio.
 - 3. Video:
 - a. S/N (peak to RMS), unweighted DC to 4.2 MHz: 45 dB minimum.
 - b. Crosstalk, unweighted DC to 4.2 MHz: 45 dB minimum.
 - c. Line and Field Tilt: 2% maximum.
 - d. Differential Gain: 3% maximum.
 - e. Differential Phase: 2 degrees maximum.
 - 4. Performance Test Signal Paths: The signal paths for the above Performance Standards shall be as follows:
 - a. Audio: From any and all source inputs (microphones, audiotape units, videotape units, etc.) through all audio mixers, switchers, distribution amplifiers, codec's, etc., to all signal destinations.
 - b. Video: From all source inputs (cameras, computers, videotape units, etc.) through all switchers, processors, distribution amplifiers, etc., to all signal destinations.

1.8 SUBMITTALS

- A Comply with the requirements of project General Conditions. Verify with the Architect, the quantity of copies required for each submittal package to allow copies to be: retained by the AV Engineer (and, as applicable, any other reviewing party); distributed to the Architect (and, as applicable, the Owner, Design Team members, and General Contractor or Construction Manager); and returned to the AV Contractor. Quantity shall be minimized by limiting distribution only to persons having a need-to-know.
- B Submittals shall comply with the overall project schedule. Failure to make timely, complete submittals is considered to be a lack of substantial progress of the work in the section.
- C For the first submittal, also referred to as Shop Drawings, the AV Contractor shall provide the following:
 - 1. A complete list of all equipment and materials intended for the project, and with the list arranged in the same order as in the specifications. The material and equipment lists shall be submitted and reviewed before any equipment and material is purchased.
 - 2. The equipment list shall be accompanied by manufacturer's specification sheets on all MAJOR pieces of equipment, including: video projectors, amplifiers, mixers, program source equipment, signal processing, loudspeakers, control system, and other MAJOR components of the audiovisual system. Unless directed otherwise in the front-end portion of the contract documents, cut sheets for minor items such as headphones, audio and video adapters, and audio and video connectors shall not be included. However, complete cut sheets shall be required for all substitutes or other equipment not specified herein.
 - 3. Shop drawings are drawings, diagrams, schedules and other data specifically prepared for this project by the Contractor, Manufacturer, Supplier, or Distributor to illustrate some portion of the work that includes necessary components, connectors, cabling and connectivity.
- D Sufficiently prior to installation of each respective portion of work, the AV Contractor shall submit the following:
 - 1. All panel and plate layouts (such as for wall boxes and for rack/cart-mounting) indicating locations of connectors, engraving, labeling, nomenclature, panel material, and finish.
 - 2. All Equipment racks, cabinets, consoles, tables and cart front elevations showing equipment and panel layout.
 - 3. Control system button/panel/screen layouts.
 - 4. All non-factory equipment modifications.
 - 5. All cable labeling plans
 - 6. For any permanent exposed cable applications, written authorization from the Architect (or Architect's designated Engineer) as to which locations are approved in addition to cable pathway being utilized
 - 7. Shop drawings as indicated elsewhere in these specifications and/or on the project drawings.
- E Copies of all reviewed submittals shall be kept at the project site during the construction of the project, for reference.
- F If the submittal is technically disapproved, the Engineer will return necessary copies to the PM with written explanation attached indicating the areas the submittal deviated from the system specifications.

G EQUIPMENT MANUALS

1. At the completion of the project, the AV Contractor shall compile a minimum of three (or quantity as described under the General Conditions, plus one copy) complete, identical copies (sets) of the items listed below.
 - a. All shop drawings of physical details (corrected to take into account any submittal review notations).
 - b. Original copies of manufacturers' catalogue sheets on ALL supplied equipment;
 - c. Original copies of manufacturers' engineering data sheets on ALL supplied equipment;
 - d. Original copies of ALL literature supplied with each item of equipment, including operating instructions and maintenance manuals. Manuals not routinely supplied with an item of equipment will not be required;
 - e. Other "as installed" Contractor-generated or vendor-generated drawings of the system which are not otherwise reflected in the project drawings.
2. CD ROM's shall include the programming files for each of the systems within the project. These files shall be utilized to return the systems to the base line of operation established at the time of Final Systems Test and Equivalentization. Source Code files shall become property of the Owner with no license limitations.

H AS-INSTALLED WIRING DIAGRAMS

1. Five working days prior to the proof of performance test, the Contractor shall deliver to the Owner, two complete sets of as-installed wiring diagrams of the system. The diagrams shall show all inputs and outputs of electronic and passive equipment correctly identified according to the markers installed on the interconnecting cables, equipment and room/area locations.

I SYSTEM OPERATION MANUAL

1. Produce this manual specifically for the system detailed herein. The manual shall describe all procedures necessary to activate the system to provide for the functional requirements, except as specifically excluded by the Owner. This section shall provide a non-technical graphic and narrative "how-to" users guide for the procedures needed to operate the system. The document shall contain a section on operating the system's equipment in the event of control system failure. Control system touchpanel layouts shall be accompanied by narrative text describing step-by-step function engagement.

1.9 QUALITY ASSURANCE**A Contractor Qualifications:**

1. Work in this section shall be performed by a AV Contractor who: complies with the requirements of Division 01, and is licensed to perform work of this type in the project jurisdiction.
2. The Contractor's AV Technicians assigned to the systems shall be fully trained, qualified, and carry valid and current industry certifications regarding the engineering, installation, operation, and testing of AV technologies. At least one (1) CTS-D or CTS-I shall be assigned to oversee the complete design and installation of the system. The Contractor shall provide formal written evidence of current industry certifications for the designer(s) and installer(s) dedicated to this project as a part of their submittal or to the AV Engineer before being allowed to commence work on the system.
 - a. The AV Contractor shall include, with his bid, a list of credentialed staff who will be actively involved in this project including specific tasks each will perform.

- b. The AV Contractor shall have a minimum of one full-time staff member, who is a factory certified programmer on most recent version of the specified control system software and technology. This individual shall be the same throughout the execution of the work unless illness, loss of personnel, or other reasonable circumstances intervene. The replacement shall be approved by the AV Engineer
- B Maintenance Proximity: Not more than 2 hours normal travel time from Installer's place of business to Project site.
- C Source Limitations: Obtain display equipment through a single source authorized by manufacturer to distribute each product.
- D CERTIFICATIONS
 - 1. After the system has been provided, pretested, and found to meet the requirements of this specification, the Contractor shall submit a letter to the AV Engineer certifying that the system is ready for the formal proof of performance test to be accomplished in the presence of the Engineer or Engineers' representative.
 - a. In the interim, the systems shall be left operating to "burn-in".
 - b. A copy of each recorded system pretest measurements shall be submitted to the AV Engineer with the certification. The Contractor shall submit one copy of the measurements to the Engineer for review 15 working days prior to the test.
- E TEST EQUIPMENT LIST
 - 1. Each Contractor is responsible for furnishing all test equipment required to test the system in accordance with the parameters specified. Unless otherwise stated, the test equipment shall not be considered part of the system. Each Contractor shall furnish test equipment of accuracy better than the parameters to be tested.
 - 2. The test equipment furnished by each Contractor shall have a calibration tag of an acceptable calibration service dated not more than 12 months prior to the test. As part of the submittal, a test equipment list shall be furnished that includes the make and model number of the following type of equipment as a minimum. A sample of each of the following items shall be furnished to the AV Engineer for approval prior to installation. The samples may be returned to each Contractor at the discretion of the Owner:
 - a. Two foot section of each cable and/or wire to be used with connectors installed and original equipment manufacturer's cable sweep compliance and/or certification tags as specified herein.
 - b. Back Boxes and junction boxes.
 - c. Cover plates used for wall and floor boxes.
 - d. AV outlets with back box, cover plate, and outlets installed.
 - e. UPS equipment (if required by system design).

1.10 DELIVERY, STORAGE AND PROTECTION

- A The AV Contractor shall protect all work, materials and equipment from damage due to any cause. He shall provide for the safety and new condition of the equipment and materials until final acceptance by the Owner. The AV Contractor will replace all damaged or defective materials and/or equipment as directed by the Architect or AV Engineer.

- B Equipment racks and other exposed equipment shall be kept covered and protected from airborne contaminants. The AV Contractor shall clean all debris from the equipment room(s) and control console area, and shall clean all equipment and the interior rack floor, prior to system commissioning activities.

1.11 PROJECT CONDITIONS

- A During the course of project construction, the AV Contractor shall personally examine the site of the proposed work and verify the conditions which involve his work.
- B Prior to equipment installation all AV equipment that requires an IP address shall be turned over to the owner for IP registration. The owner shall be setting up an onsite area for this IP registration.
- C By the act of submitting a bid, the AV Contractor will be deemed to have made reasonable allowances for site examinations and site conditions, and included all costs in his proposal. Failure to verify site conditions will not be considered a basis for the granting of additional compensation.
- D The AV Contractor shall comply with all applicable national and local codes, ordinances, and obtain all required permits. The AV Contractor shall be held responsible for any violations of the law within the scope of his work.
- E All equipment shall be new and in proper operating condition. All workmanship shall be of the finest quality by experienced installation technicians.
- F The AV Contractor shall contact Architect, in writing, regarding the selection of colors for all equipment such as loudspeaker grilles, exposed loudspeaker boxes, wall plates, millwork, laminate, and other items specific to the project prior to ordering equipment.
- G In addition to a complete set of the system project drawings and specifications, the AV Contractor shall maintain at the job site a complete set of manufacturer's original operation, instruction, installation, and service manuals for each equipment item, for reference.
- H The AV Contractor shall schedule and sequence the AV system rough-in work to coordinate with the established general construction sequence as updated from time to time by Architect.
- I Once the AV Contractor begins work at the project site, the company shall maintain a project manager for the duration of the work to supervise the work force and to provide coordination with other trades and/or Architect.
- J The project manager shall attend any regularly scheduled construction progress meetings. These meetings will include, but not be limited to Owner Architect Meetings, walk through meetings with the Owner and Engineer, and weekly construction meetings.
- K The AV Contractor shall conform to all site policies regarding safety, job site hours, and any additional policy which may affect site conditions.

1.12 WARRANTY

- A The AV Contractor shall warrant all work executed under this contract, including all in-shop and onsite material, parts and labor, for a period of twelve months.
- B Warranty period to start after the date of final acceptance of the system by Owner.
- C The Contractor shall provide original equipment manufacturer's equipment warranty documents, to the Owner (or Facility Contracting Officer if the Facility has taken possession of the building), that certifies each item of equipment installed conforms to each original equipment manufacturer's published specifications.
- D The Owners maintenance personnel shall have the ability to contact the AV Contractor and original equipment manufacturers for emergency maintenance and logistic assistance, remote diagnostic testing, and assistance in resolving technical problems. This contact capability shall be provided by the Contractor and each original equipment manufacturer at no additional cost to the Owner.
- E All AV Contractor maintenance and supervisor personnel shall be fully qualified by the original equipment manufacturers and must provide copies of current and qualified original equipment manufacturer training certificates and original equipment manufacturer certification upon request.
- F The warranty services are limited to normal business hours, unless additional agreements are made between the Owner and the AV Contractor.
- G The AV Contractor shall visit the job just prior to the end of the warranty period to check all equipment for proper system operation. Any defective equipment found shall be replaced or repaired under the terms of the system warranty.
- H The AV Contractor shall provide alternate pricing for second year and third year on-site services, and supply specific detail of the services and warranties that would be provided.
- I **RESPONSE TIME DURING THE ONE YEAR WARRANTY PERIOD**
 - 1. The Owner or Facility Contracting Officer is the AV Contractor's reporting and contact official for system trouble calls, during the warranty period.
 - a. A standard work week is considered 8:00 A.M. to 5:00 P.M., Monday through Friday.
 - 1) The Contractor shall respond and correct on-site trouble calls, during the standard work week to:
 - 2) Trouble call within one working day of its report. A routine trouble is considered a trouble which causes a single interface, projector or loudspeaker component to be intermittent or inoperable.
 - 3) An emergency trouble call within four hours of its report. An emergency trouble is considered a trouble which causes the entire display or audio system to be inoperable at anytime.
- J **WORK NOT INCLUDED**
 - 1. Maintenance and repair service shall not include the performance of any work due to improper use; accidents; other vendor, Contractor, or Owner tampering or negligence, for which the Contractor is not directly responsible and does not control. The Contractor shall immediately notify the Owner or Facility Contracting Officer upon the discovery of these

incidents, in writing. The Owner or Facility Contracting Officer will investigate all reported incidents and render findings concerning any AV Contractors responsibility.

1.13 MAINTENANCE SERVICE

- A The AV Contractor shall visit the job just prior to the end of the warranty period to check all equipment for proper system operation. Any defective equipment found shall be replaced or repaired under the terms of the system warranty.

PART 2 PRODUCTS

2.1 MATERIALS

A GENERAL

1. Passive and electronic components and cabling shall be provided under the original equipment manufacturer's recommendations and guidance, to prevent damage to any system equipment from electrostatic discharges. The Contractor shall contact the Engineer for technical review and approval for this requirement in case of system redesign or change of technical approved system equipment that may require substitution.
2. It is the intention of these specifications to form a guide for complete and properly operating AV systems. These specifications' equipment and hardware listings herein represent only some of the major items of the systems' prerequisites. The major items of equipment shall be furnished in the quantity indicated by the one-line diagrams on the drawings or in the quantity as specified herein. However, where an item of equipment or hardware that may not be specifically shown on the single line drawings or specified herein this general and/or a specific section, but is required for complete and properly operating AV systems operation or installation, it shall be furnished by the AV Contractor.
3. Any item necessary for the operation of the systems within this document but not specifically listed or drawn shall be included by the bidder to the bidders pricing which includes pricing for all incidentals and labor necessary to complete the installation.
4. In any case, where a specific specification has not been included herein or shown on the drawings for any item that is required, the AV Contractor shall furnish only the highest quality equipment or material consistent with the quality of other specified equipment and material.
5. Unless otherwise designated, the AV Contractor shall provide all of one type of equipment from one manufacturer; for example, power amplifiers of one type to be provided by one manufacturer; all loudspeakers of one type by one manufacturer.
6. All major components of technical system equipment shall be provided and installed by a qualified AV Contractor as outlined in Part 1 of this section.
7. All equipment shall be of professional quality. All electronic audio devices shall have electronic or transformer balanced inputs and outputs except for specific program source equipment and. specific mixing console inputs and/or outputs. If an electronic device specified or furnished has an unbalanced input and/or output, the AV Contractor shall make provisions to balance said input/output (i.e., outboard line-level transformer as approved) unless other arrangements have been agreed upon with Architect.
8. Some items listed in these specifications are custom-made products. Ensure when pricing and ordering equipment that the exact part number called out is used. If there is a discrepancy, the AV Contractor shall contact the Architect for clarification.
9. Each item of equipment to be supplied under this specification shall be new and the current model of a standard product of an original equipment manufacturer of record.

10. Specifications of equipment as set forth in this document are salient and minimum requirements, unless otherwise stated, and shall not be construed as limiting the overall quality, quantity, or performance characteristics of items furnished in the system. When the Contractor furnishes an item of equipment for which there is a specification contained herein, that item of equipment shall meet or exceed the specification for that item of equipment.
11. The systems shall be provided so that the installation, integration, and combination of equipment actually employed does not produce any undesirable visual effects such as keystoning, banding and shimmering as well as any undesirable aural effects such as signal distortion, noise pulses, glitches, audio hum, poling noise, voltage or spike transients, etc.
12. While individual items of equipment may meet the equipment specifications, and in fact, meet the system specifications; when electrically associated with other equipment, the total system shall be designed and installed so that the installation, interfacing, integration, combining, and/or consolidation of equipment actually employed does not produce any undesirable visual or aural effects such as signal distortions, noise pulses, glitches, audio or video hum bars, transients, ghosting, etc.
13. The Contractor shall produce verification, in writing to Architect at time of installation, that the type of wire/cable actually being provided is recommended and approved by the original equipment manufacturers and will provide a total system free of undesirable effects. The Contractor is responsible for the providing the correct protection cable duct and/or conduit and wiring even though the actual item installation may be by another subcontractor.
14. The Contractor is responsible for interfacing the systems with each required sub-system. The Contractor shall continually employ interfacing methods that are approved by the original equipment manufacturer and industry best practices. At a minimum, the acceptable interfacing method requires not only a physical and mechanical connection; but a matching of signal, voltage, and processing levels, with regard to signal quality and impedance.
15. Active electronic component equipment shall consist of solid state components and be rated for continuous duty service in the areas where provided.
16. All passive equipment and cables shall meet or exceed -80 dB radiation shielding specifications.
17. All signaling and communication circuits shall be solid state except for projection screen relays.
18. Each system shall utilize microprocessor components for all signaling and programming circuits and functions. Program memory shall be non-volatile or protected from erasure from power outages for a minimum of five minutes.
19. All voltages, except for the primary power to the power supply circuits, shall not exceed 70.7 VAC Root Mean Squared (RMS) or 100 V direct current (DC).
20. Color code all distribution wiring to conform to the respective system industry standard, TIA/EIA, and this document, which ever is the more stringent. At a minimum, all equipment, cable duct and/or conduit, enclosures, wiring, terminals, and cables shall be clearly and permanently labeled according to and using the provided as-installed drawings, to facilitate installation and maintenance. Reference Specification Sections 16127, CABLES LOW VOLTAGE 600 VOLTS AND BELOW.
21. All equipment face plates utilized in the system shall be stainless steel, anodized aluminum, or ABS plastic for the areas where provided.
22. Noise filters and surge protectors shall be provided for the AV system including equipment racks and display devices to ensure protection from input primary AC power surges and noise glitches are not induced into low voltage data circuits.

2.2 LOUDSPEAKERS

- A Manufacturers: subject to compliance with requirements, provide products by one of the following:
1. JBL
 2. Atlas/IED
 3. QSC
 4. Or pre-approved equivalent.
- B Refer to loudspeakers models on schematic drawings.

2.3 AMPLIFIERS

- A Manufacturers: subject to compliance with requirements, provide products by one of the following:
1. QSC
 2. Crestron
 3. Extron
 4. Or pre-approved equivalent.
- B Power Amplifier Type 1:
1. Channels: Two
 2. Mounting: Display mount
 3. Watts Per Channel: 200W
 4. Power Distribution: 70V
 5. Input Signal Type: Analog
 6. Design Basis Manufacturer: QSC
 7. Design Basis Series: MP-A20V

2.4 AUDIO PROCESSORS

- A Manufacturers: subject to compliance with requirements, provide products by one of the following:
1. QSC
 2. Or pre-approved equivalent.
- B Fixed Digital Signal Processor Type 1:
1. Input/Output: 12x12
 2. Network Audio: Dante
 3. USB Audio: Yes
 4. Phone Interface: SIP/VoIP
 5. Control: RS-232 (Serial) and Ethernet
 6. Rack Mount: 1U
 7. Manufacturer: QSC
 8. Model: Core 24f

2.5 WIRED MICROPHONES

- A Manufacturers: subject to compliance with requirements, provide products by one of the following:
1. Shure
 2. Audio-Technica
 3. Sennheiser

4. Or pre-approved equivalent.

B Networked Microphone Type 1:

1. Type: Array, 8 coverage lobes
2. Polar Pattern: Programmable
3. Connector Type: RJ-45 (8P8C)
4. Interface: Dante (PoE)
5. Mounting Type: Flush Ceiling
6. Manufacturer: Shure
7. Model: MXA910
8. Quantity: See floor plans.

2.6 WIRELESS MICROPHONES

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

1. Shure
2. Audio-Technica
3. Sennheiser
4. Or pre-approved equivalent.

B Wireless Handheld Microphone:

1. Frequency Range: 20 Hz to 20kHz
2. Polar Pattern: Unidirectional (Cardiod)
3. Batteries: Rechargeable
4. Minimum Battery Life: 9 hours
5. Accessories:
 - a. Windscreen

C Wireless Bodypack Transmitter:

1. Frequency Range: 20 Hz to 20kHz
2. Connector Type: 4-Pin Male Mini Connector
3. Batteries: Rechargeable
4. Minimum Battery Life: 9 hours
5. Accessories:
 - a. Microphone: Lavailer
 - b. Windscreen

D Wireless Receiver:

1. Frequency Range: X MHz Band
2. Encryption: Advanced Encryption Standard (AES) 256-bit
3. System Channels: 17 Channels per 6 MHz Band; 22 Channels per 8 MHz Band
4. Output Connector: XLR
5. Antenna(s): Integrated
6. Accessories:
 - a. Antenna Combiner
 - b. Active Directional Antenna
 - c. Rack Mount Kit

E Charging Station:

1. Charging Station Ports: 2
2. Network Connected: Yes
3. Manufacturer: Shure
4. Model: SBC200

2.7 VIDEO DISPLAYS

- A Manufacturers: subject to compliance with requirements, provide products by one of the following:
1. Samsung
 2. Sharp
 3. LG
 4. Or pre-approved equivalent.
- B Refer to display schedule on detail drawings.

2.8 CAMERAS

- A Manufacturers: subject to compliance with requirements, provide products by one of the following:
1. Vaddio
 2. HuddleCam
 3. ClearOne
 4. Panasonic
 5. Or pre-approved equivalent.
- B Camera Type 1:
1. Minimum Resolution: 1920x1080
 2. Horizontal Field of View: 73 degrees
 3. Zoom ratio: 12x
 4. Type: Pan Tilt Zoom (PTZ)
 5. Video Signal Type: HDBaseT and H.264
 6. Control Interface: Ethernet
 7. Power Type: PoE+
 8. Finish: White
 9. Manufacturer: Q-SYS
 10. Model: NC 12x80
 11. Accessories:
 - a. Mount: Wall Mount

2.9 VIDEO BAR APPLIANCES

- A Video Bar Appliance Type 1:
1. Camera Minimum Resolution: 1920x1080
 2. Camera Horizontal Field of View: 113 degrees
 3. Camera Zoom Ratio: 4x (8x Dig)
 4. Camera Type: Auto-Framing
 5. Camera Automatic Framing: Yes
 6. Microphone: Integrated, 5 element beamforming
 7. Speaker: Integrated (Stereo)
 8. Conferencing Appliance: Integrated

9. Conferencing Appliance Platform: Zoom Rooms w/ BYOD option for Teams on TAP
10. Video Input Signal Type: (1) HDMI
11. Video Output Signal Type: (2) HDMI
12. USB Interfaces: (1) USB-C
13. USB Device Mode Support: No
14. Bluetooth Audio Interface: No
15. Network Interface: Gigabit Ethernet
16. Power Type: 120VAC Local Power Supply
17. Finish: Black
18. Manufacturer: Logitech
19. Model: Rally Bar
20. Accessories:
 - a. Mount: Wall Mount Bracket
 - b. Remote: Touch control panel interface

2.10 CONFERENCING SYSTEMS

- A Conferencing System Type 1:
1. Conferencing Appliance: Components
 2. Conferencing Appliance Platform: Zoom/Teams/BYOM
 3. Video Input Signal Type: (2) HDMI
 4. Video Output Signal Type: (1) HDMI
 5. USB Interfaces: (1) USB-B 3.0
 6. USB Device Mode Support: Yes
 7. Bluetooth Audio Interface: Yes
 8. Network Interface: Gigabit Ethernet
 9. Power Type: 120VAC Local Power Supply
 10. Finish: White
 11. Manufacturer: Logitech
 12. Model: Rally Plus w/Room Mate
 13. Accessories:
 - a. Microphone:
 - 1) Type: Pod, (1) microphones with 8 beamforming elements
 - 2) Mute Button: Yes, with indicator light
 - 3) Model: Rally Pod Mic
 - b. Cables:
 - 1) As required to connect system accessories.
 - c. Misc:
 - 1) Sub-system components as required for a complete and functional system.
 - d. Mount:
 - 1) Wall mount bracket.
 - e. Control Panel: Tap

2.11 NETWORK TRANSPORT VIDEO DEVICES

- A Manufacturers: subject to compliance with requirements, provide products by one of the following:
1. Crestron
 2. Extron
 3. AMX

4. Or pre-approved equivalent.

B Network Video Encoder/Decoder Type 1:

1. Maximum Resolution: 4096x2160
2. Input Signal Type: HDMI
3. Output Signal Type: HDMI
4. HDCP Compliance: Yes
5. Video Compression Type: JPEG 2000
6. Power Type: 120VAC Local Power Supply
7. Network Interface: Gigabit Ethernet
8. Mounting Type: Surface Mount
9. Design Basis Manufacturer: Q-Sys
10. Design Basis Model: NV-21-HU

C Network Video Encoder/Decoder Type 2:

1. Maximum Resolution: 4096x2160
2. Input Signal Type: HDMI
3. Output Signal Type: HDMI
4. HDCP Compliance: Yes
5. Video Compression Type: JPEG 2000
6. Power Type: Chassis Power
7. Network Interface: Gigabit Ethernet
8. Mounting Type: Chassis Card
9. Design Basis Manufacturer: Q-Sys
10. Design Basis Model: NV-32

2.12 CONTROL PROCESSORS

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

1. Q-SYS
2. Or pre-approved equivalent.

B Control Processor Type 1:

1. Communications Connector Types and Quantities:
 - a. RS-232: 2
 - b. I/O: 8
 - c. Ethernet: 1
 - d. Control Subnet: 1
 - e. Manufacturer: Q-SYS
 - f. Control Processor Model: Core 24f
 - g. Accessories: Rack mount kit

2.13 CONTROL PANELS

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

1. Q-SYS
2. Or pre-approved equivalent.

B Touch Panel Type 1:

1. Minimum Resolution: 1280x720
2. Aspect Ratio: 16:9
3. Touch Technology: Projective Capacitive
4. Hard Buttons: No
5. Power Type: PoE
6. Screen Size: 10"
7. Mounting Type: Wall mount
8. Manufacturer: Q-SYS
9. Touch Panel Model: TCS-101-G3

2.14 ROOM SCHEDULERS

- A Manufacturers: subject to compliance with requirements, provide products by one of the following:
1. Crestron
 2. Extron
 3. Logitech
 4. Or pre-approved equivalent.
- B Room Scheduler Type 1:
1. Minimum Resolution: 1920x1200
 2. Aspect Ratio: 16:10
 3. Touch Technology: Projective Capacitive
 4. Hard Buttons: Yes
 5. Power Type: PoE+
 6. Screen Size: 10"
 7. Firmware Type: Room scheduling firmware.
 8. Mounting Type: Refer to detail drawings.
 9. Manufacturer: Logitech
 10. Room Scheduler Model: TAP IP
 11. Accessories:
 - a. Multisurface Mount Kit

2.15 DISPLAY WALL MOUNTS

- A Manufacturers:
1. Legrand
 2. Or pre-approved equivalent.
- B Wall Mount Type 1:
1. Installation Type: Wall - spanning (2) studs
 2. Equipment Capacity: (2) 15x10 Lever Lock panels
 3. Extension: 12.6" for service
 4. Color: Black
 5. Accessories:

2.16 WIRE AND CABLES

- A Manufacturers: subject to compliance with requirements, provide products by one of the following:
1. Belden

2. West Penn
3. Commscope
4. Liberty
5. Or pre-approved equivalent.

B General Requirements:

1. Wire and cables shall include all connectors and terminals, spade lugs, barrier straps, punch blocks, wire wrap strips, heat shrink tubing, tie wraps, solder, hangers, clamps, labels etc., required to accomplish a neat and orderly installation.
2. Refer to schematics for equipment interconnect requirements.

C Audio Cables:

1. Multi-conductor 16 AWG loudspeaker cable:
 - a. Type: Unshielded loudspeaker cable
 - b. Conductors: 16 AWG, Bare Copper
 - c. Quantity of Pairs: 1
 - d. Jacket: Plenum rated CMP 50
 - e. Jacket Color: Gray
 - f. Manufacturer: Belden

D Digital Video Cable:

1. HDMI Cable:
 - a. Type: Shielded HDMI Cable
 - b. Conductors: 24 AWG, Copper
 - c. Quantity of Pairs: 9
 - d. Jacket: Plenum rated CMP 50
 - e. Jacket Color: Black
 - f. Manufacturer: Belden

E Control Cable:

1. Serial Control Cable:
 - a. Type: Serial Control Cable
 - b. Conductor: 20AWG Shielded twisted pair copper
 - c. Quantity of Pairs: 2
 - d. Jacket: Plenum Rated CMP 50
 - e. Jacket Color: Blue
 - f. Manufacturer: Extron

F Data Network Cable:

1. Refer to specification Section 271513.

G Patch Cables:

1. For each faceplate audio and video connection provide (1) 8ft long patch cable with connectors that interface with the faceplate connector on each faceplate unless noted otherwise on the detail drawings.
2. Video Adapters:
 - a. For each HDMI patch cord and retractor cable, provide the following clamp-on pigtail HDMI adapters as part of a secured adapter ring affixed to the patch cord:
 - 1) Mini DisplayPort

- 2) DisplayPort
- 3) USB-C
- 4) Lightning

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify all conduits, back boxes and pathways.
- B Verify correct power requirements have been supplied based on equipment load and device requirements.
- C Verify video installation sightlines and possible obstructions.

3.2 PREPARATION

- A Coordinate with low voltage Electrical Contractor for required location of junction boxes, outlets, and conduit.
- B Carefully inspect areas where equipment will be installed. Notify the Architect of any conditions that would adversely affect the installation and subsequent operation of the system.
- C Coordinate with Architect for requirements for locations where AV equipment is mounted in millwork or cabinetry.

3.3 INSTALLATION

- A New Wiring: Install wiring in raceways except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum-board partitions where cable wiring method may be used. Use plenum cable in environmental air spaces including plenum ceilings. Where possible for all audio cabling except microphone cables, microphone cables shall be installed in conduit. Conceal cables and raceways except in unfinished spaces. Cable shall be installed continuous with no splices or cuts.
- B Install exposed cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings so designed and installed to avoid damage to cables. Secure cable at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, or fittings.
- C Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess. Use lacing bars in cabinets and racks.
- D Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches for speaker microphones and adjacent parallel power and telephone wiring.
- E Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

- F Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
- G Wall-Mounting Outlets: Flush mounted.
- H Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
- I All terminations shall be installed per manufacturer's specifications and recommendations
- J All audio circuits shall be two-wire circuits, with a separate grounding shield conductor, unless noted otherwise. All circuits shall have either the red or white wires as the "high" side of the line and connect to pin 2 of microphone-type XLR audio connectors and the tip of 3-conductor phone connectors. The black wire of the two-wire circuit shall be the "low" side of the line and connect to pin 3 of microphone connectors and the ring of 3-conductor phone connectors. The shield conductor shall connect to pin 1 of microphone connectors or to the sleeve of phone connectors. In the case of unbalanced lines, the low side shall connect to the shield connection.
- K Identify all audio and video wire and cable clearly with permanent labels wrapped about the full circumference within one (1) inch of each connection. Indicate the number designated on the associated field or shop drawing or run sheet as applicable. Assign wire or cable designations consistently throughout a given system. Each wire or cable shall carry the same labeled designation over its entire run, regardless of intermediate terminations.
- L Each conduit shall include a minimum of one spare cable or 10%, whichever is greater for each type of cable pulled including line-level, microphone-level, intercom, loudspeaker, control, video, and control system. Neatly bundle a minimum of 10-feet of cable at each end of each spare circuit. All spare circuits shall be labeled and noted on the AV Contractor's field drawings for inclusion into the record drawings.
- M Where the design location requires that products, materials, or equipment are visible to the public, no manufacturer's logos shall be visible. Unless otherwise directed, neatly remove or permanently paint out such logos.
- N GROUNDING
 1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
 2. Signal Ground Terminal: Locate at all equipment display locations. Isolate from power system and equipment grounding.
 3. Shields shall be connected at each end of each wire to the pin 1 of each XLR, shield connection for each electronic device, etc. No shield wires shall be left unconnected except where noted on the drawings, nor shall any shield come in contact with conduit, pullboxes, or other building steel. Audio line-level circuit shield wires shall be grounded to rack sheet metal only via rack-mounted equipment. Shields shall be electrically isolated in multiconductor cables. Shields for audio line-level circuits connected to audio transformers shall be connected to transformer electro-static shields and case ground. In the case of unbalanced audio lines the shield wire shall connect to the low side of the line (black wire).

4. Equipment rack ground shall be only via the insulated ground wire provided by the Electrical Contractor for technical system ground. Equipment racks shall be isolated from other ground paths such as building steel and from ground via conduit.
5. Each equipment rack within a row of racks shall be electrically bonded to each other using a minimum 1/4-inch diameter unfinished bolt and nut with star washers. Bolts shall fasten to each equipment rack unpainted sheet metal. Each row of equipment racks shall be electrically bonded to adjacent row(s) via a No. 6 AWG insulated ground wire. This work shall be performed by the AV Contractor.

O CIRCUIT ROUTING

1. All audio circuits shall be separated according to function; e.g. microphone circuits shall be separated from line-level circuits which are separated from video circuits which are separated from loudspeaker circuits. Where audio and video circuits are installed in conduit or other raceway, separate conduits are required for the various circuit functions.
2. Control and intercom circuits, and video circuits can be routed with line-level circuits, if separate conduit is not furnished for these circuits.
3. Where circuits are exposed in the equipment racks or large junction or pull boxes, the circuits shall be bundled according to function. Use plastic cable ties to bundle cables and provide as much separation as reasonable.

P WIRE SPLICING

1. Audio and video circuits shall not be spliced except as shown on approved shop drawings.
2. All solder connections shall be made with soldering iron and rosin core solder. All solder connections shall be checked for "cold" solder joints by the AV Contractor.
3. All audio circuits terminating to screw-type connectors shall be installed with non-insulated brazed seam spade lugs of the proper size for wire and screw connection.
4. All crimped audio connections shall be installed with a Thomas & Betts WT111 M or Klien 1006 crimping tool with the notch opposite the barrel seam. All crimped video connections shall be installed with a ratchet style crimper such as the West Penn TL-SNS (screw-on BNC connectors will not be accepted). Ensure crimper is sized for connectors and cabling that is being installed.

Q LABELING AND PLACARD

1. All labeling of equipment shall be engraved plastic laminate plates or metal-photo plates.
2. All labeling of wiring within equipment racks, consoles, or other areas obscured from direct view shall be of adhesive backed strips comprised of numbers and letters as required. Wire markers shall be near both ends of wire termination.
3. All labeling of exposed wiring, such as found at the rear of the mixing console shall be typewritten identifying each cable and covered with clear heat shrink tubing near the cable end.
4. Embossed plastic tape labeling, such as DYMO, shall not be acceptable.
5. All equipment in equipment racks shall be labeled front and rear for ease of identification. Equipment shall be labeled as indicated within quotation marks shown on technical system drawings. Labels shall be of a contrasting color with that of equipment color to promote visibility.
6. Within each rack and at other remote locations for technical system equipment, label all associated AC power receptacles reflecting the appropriate circuit breaker. Ensure that the circuit breakers are labeled as to the rack or remote equipment location.

7. At all connection points for all types of cable, pressure sensitive label strips of the appropriate letters and numbers shall be wrapped around each cable near its termination. Each label shall be of sufficient length that the written portion is covered with a transparent portion of the label or clear heat shrink of the appropriate size shall be utilized in order to protect the ink. The written portion shall be typed in sufficient quantity to allow viewing of the numbering from any angle. Hand written labels shall not be utilized.
8. Each rack mounted device shall be labeled with engraved labels as to room, type, and function. Each adjustment point on each rack mounted device shall be labeled with engraved label as to function.
9. In instances of multiple systems within a single equipment rack, care shall be taken to assure appropriate allowance for system growth. In addition, each system type shall have an engraved blank panel inserted in the top rack unit for the system describing the room and functionality of the system.

R CABLING

1. Cable within equipment racks, and where service loops are indicated, shall be separated and routed in neat groups according to function: microphone circuits, intercom circuits, line level audio circuits, loudspeaker circuits, video circuits, control circuits, and 120 volt AC power circuits. Cable shall be neatly arranged, but tight bundling, which makes modifications difficult, shall be avoided. two sided hook and loop wrap ties shall be used for grouping of circuits.
2. Cable in conduit or other raceway — microphone circuits, intercom circuits, line level audio circuits, loudspeaker circuits, control circuits, video circuits shall be separated from any 120 volt AC power circuits.
3. Care shall be exercised in wiring so as not to damage cables and equipment. Circuits shall not be spliced.
4. Allow adequate slack for cable termination.
 - a. Wall outlets: 12 inches.
 - b. Systems furniture: as necessary to reach the farthest point on each desktop using the furniture raceways plus 12 inches at the jack location.
 - c. Telecommunications Spaces: as necessary to reach the most distant patch panel or punch-down block plus a length equal to 2 times the room height.

S AUDIO INSTALLATION

1. Equipment:
 - a. All antennas shall be installed per manufacturer's recommendations to allow for adequate signal transmission and without obstruction.
 - b. IR Emitter panels shall not be obstructed in order to provide line of site view for acceptable coverage of the designated area.
 - c. Protect during construction.
 - d. Loudspeakers shall be installed per the manufacturer's recommendations and with no obstructions to the coverage area.
 - 1) Mounting hardware shall be a minimum grade SAE 8 load rating and a safety factor of 5 times the supported weight.
 - 2) Coordinate installation of loudspeakers with location of structure and other devices, including but not limited to ductwork, sprinklers, light fixtures, and fire alarm devices.

- 3) Coordinate loudspeaker finishes with architect prior to ordering. If painting of loudspeaker is required to match architectural finishes, paint per manufacturer's recommendations.
- 4) Where back cans, in-wall loudspeaker back boxes or junction boxes are to be provided, coordinate installation and associated conduit with electrical contractor and other devices located within the wall or ceiling.
- 5) In-ceiling loudspeakers to be installed plum and level with the ceiling surface. Speaker is to be supported separately from ceiling grid with independent supports.
- 6) Pendant mount loudspeakers shall be installed so that cables are neatly dressed with pendant support cable. Coordinate support cable length with architectural ceiling elements and lighting fixtures.
- 7) Surface mounted loudspeaker installation to be coordinated with architectural plans and other wall mounted devices. Coordinate location of backing with general contractor prior to installation.
- 8) Ceiling flown loudspeakers shall be provided with the designated hardware as required by manufacturer to structurally support the weight of the speaker and allow aiming as indicated on the drawings. Installation shall be coordinated with ceiling elements and associated building infrastructure to allow for proper structural support and to avoid obstructions to provide acceptable audio coverage.
- e. Amplifiers shall be installed per manufacturer's recommendations.
 - 1) For rack or desk mounting, provide all necessary hardware to properly support from the front and rear.
 - 2) Install so that front and rear air vents are not blocked to ensure proper cooling.
 - 3) Before connecting loudspeakers, check total impedance and ensure that it is within the allowable range for the amplifier output.
 - 4) Total power for connected loudspeakers shall be below the rated power output for the connected channel.
- f. Audio Processors shall be installed per manufacturer's recommendations.
 - 1) For rack mounting, provide all necessary hardware to properly support from the front and rear.
 - 2) Provide proper ventilation of device and ensure that there are no obstructions to the unit.
 - 3) Filter shall be clean when system is turned over to owner.
- g. Wired Microphones:
 - 1) Mounts shall be installed flush with surface.
 - 2) Coordinate location and installation dimensions of ceiling microphones with architectural ceiling elements and lighting fixtures.
 - 3) Coordinate location, installation and hole cut out for tabletop microphones with architectural and furniture plans.
 - 4) Align microphone coverage pattern with intended speaker location(s) for proper pick up.
 - 5) Install logic control connectors for microphone mute indicator lights.
- h. Wireless Microphones:
 - 1) Install antennas per manufacturer's recommendations to allow for adequate signal transmission and without obstruction.
 - 2) Set band limits to ensure that system(s) are operating within FCC regulations.
 - 3) Set group and channel settings on each device accordingly.

- 4) Do not block ventilation openings and install receivers to allow for adequate ventilation.
- i. Mixers:
 - 1) Install so that ventilation slots are not obstructed and that there is adequate air movement around the equipment.
 - 2) Coordinate location, dimensions and weight with architectural and furniture plans.
 - 3) Coordinate rollout enclosure dimensions with manufacturer to provide clearances for cabling.
2. Cabling:
 - a. Use plenum cable in environmental air spaces including plenum ceilings.
 - b. Install wiring in raceways where applicable. Audio cables shall be installed in separate raceways.
 - c. Exposed cables shall be installed parallel and perpendicular to surfaces or exposed structure and secured by Velcro straps. Secure at intervals not exceeding 30 inches.
 - d. Install cable sheathing on exposed cables from floor boxes.
 - e. Provide at a minimum, a 5' slack loop on equipment end of cable.
 - f. Separate speaker-microphone, line-level, speaker-level and power wiring runs.
 - g. Match input and output impedances and signal levels at signal interfaces.
 - h. Provide power input cord for equipment.
 - i. Unless otherwise noted, all audio circuits shall be two wires with shield, with the red or white wire used for the "high" side of the line and connected to pin 2 of microphone connectors or to the "tip" of patch panel and other phone jacks. The black wire shall be used for the "low" side of the line and shall connect to pin 3 of microphone connectors or to the "ring" of phone jacks. The shield (drain) wire shall connect to pin 1 of microphone connectors or to the sleeve of phone jacks.
 - j. All audio circuits (red or white and black conductors) shall be ungrounded except as provided by single ended amplifier inputs and where grounding of unbalanced circuits is directed during system tests. Shields for line level audio circuits shall be grounded to rack sheet metal at each cable termination. Where line level audio circuits connect to audio transformers, shields shall connect to transformer electrostatic shields and case grounds. At each cable termination shield or shield drain, wire length shall be approximately equivalent to the length of the insulated conductors. Shield drain wires shall be sheathed in green PVC sleeving or clear Teflon sleeving sized appropriately for conductor gauge. Circuit shields shall not otherwise connect to each other nor ground to electrical conduit at wall boxes, etc. Microphone circuit shields shall be grounded only at mixer inputs.
 - k. Where resistors are indicated to terminate an audio circuit, install each resistor at the end of the line at the input to the following transformer or amplifier. High impedance circuits shall not extend more than 20 feet.
 - l. All wire joints and connections in the audio system shall be made with rosin core solder and a small soldering iron; or with approved mechanical connectors. Soldering shall be neat and shall not exhibit "cold" solder joints. Connections to screw type terminals shall be made with mechanically connected, un-insulated, spade type lugs selected for the particular wire size in use.
 - m. Connections made with miniature screw actuated, pressure type terminal strips shall be made by stripping approximately 1/4-inch of insulation from stranded conductor, inserting the untinned wire into the pressure terminal, and tightening the terminal screw using a small screwdriver which securely fits the screw head.

- n. All crimp type connectors, including non-insulated butt connectors for inline loudspeaker circuit connections, shall be crimped with an appropriate crimping tool. Spade tongue terminals shall be crimped with the notch on the barrel opposite the seam.
 - o. Loudspeakers shall be installed so that proper impedance matching shall be maintained between amplifiers and loudspeakers.
 - p. Tie-wrap and secure all loudspeaker line matching transformer leads and loudspeaker cable away from loudspeakers to prevent "rattling" when loudspeakers are energized.
3. Labeling:
- a. Clearly identify audio cable with permanent labels within 12 inches of each connection.
 - b. Loudspeaker cable labels shall designate type and amplifier and channel/zone number.
 - c. Microphone and line-level cable labels shall designate type and number.
 - d. Provide labels on front and rear of equipment to match labeling as indicated on the submitted shop drawing.
 - e. Label wireless devices. Provide unique color identifier for each device.
4. General Labeling Requirements:
- a. All labels shall be affixed with clear heat shrink covers.
 - b. Field labeling shall be consistent with submitted shop drawings and as-built drawings.
 - c. Labeling shall be consistent with system configuration device identifiers.
 - d. Cable numbering schematic shall match number as indicated on the submitted shop drawing.
 - e. All faceplates shall have engraved labeling to clearly identify input/output.
 - f. Audiovisual equipment requiring a network patch cable shall be labeled on each end with coordinating switch port and audiovisual equipment identifier.

T PHYSICAL INSTALLATION

1. Equipment Racks:
- a. Racks will be installed plumb and square without twists in the frames or variation in level between the racks.
 - b. Firmly secure all equipment in place unless requirements of portability dictate otherwise.
 - c. Install appropriate factory or custom rack mount adapters for all equipment installed in equipment rack, whether specifically itemized or not. Utility or one size fits all rack shelves shall not be utilized unless specifically noted on the AV construction documents.
 - d. Install rear support for any equipment that exhibits mount stress or tilt caused by the depth or weight of the equipment.
 - e. The front of the rack will have the appropriate vented blanks and grills installed to fill in areas not used for equipment mounting.
 - f. Mounting hardware used in racks will be identical in color, size, and manufacturer as dictated by function, i.e. rack screws will be from the same manufacturer with identical fiber washers.
 - g. Vertical lacing bars shall be installed in all equipment racks in order to facilitate neat wiring and proper signal separation. Horizontal lacing bars shall be utilized in sufficient quantity to ensure that cables traveling horizontally do not sag, but not in such quantity to limit access for testing and maintenance.
2. Cabling Harness:
- a. Any exposed cabling harnesses are to be concealed and neatly bundled in black expandable "Tech Flex" type harnessing sheath. Before installation sheath shall be cut

to length and ends burned to prevent unravel. When installed the ends shall be turned into itself and secured with flush-cut tie-wraps.

3. Floor and Wall Plates:
 - a. All connection plates (wall, floor, etc.) will be secured with appropriate fasteners and installed plumb and level. All plate and panel finishes shall be coordinated with the Architect prior to order entry and installation. Each connection type shall be labeled in a logical manner consistent with the organizational standards of the Owner. Labeling shall be engraved into plate material. Adhesive or mechanically fastened labels shall not be permitted.
4. Mounting To Building Structure
 - a. Building structural members shall not be modified without consultation with and approval of the Architect and Structural Engineer.
 - b. Do not fabricate or install supports that will overload the building structure. Supports shall not be installed to overhead structure not capable of supporting five times the weight of the submount, mount, and equipment combined.
 - c. All Mounting methods of each device type and mounting type shall be shown on submittal drawings and approved by the project Architect prior to installation.
 - d. Do not drill or cut concrete beams, joists or structural steel, and do not weld to structural steel.
 - e. Beam clamps are to be used to anchor strut and threaded rod to structure such as I beams, Z bar, etc.
 - f. Attachment hardware with a minimum SAE Grade 8 load rating and a safety factor of at least 5 are to be used.
 - g. Screens, wall mounted devices, projector / display mounts, or sub-mounts are to be installed plumb and level.

3.4 VIDEO INSTALLATION

- A HDBaseT Cabling:
 1. Cabling shall length shall not exceed 300 ft in length.
 2. Wire according to the TIA-568B termination scheme.
 3. Maintain a minimum bend radius of 4 times the outside diameter of the cable.
 4. Do not bend, twist or kink cable, cables with physical damage will be required to be replaced.
 5. Do not splice or bridge cable at any point.
 6. Install cable using shielded RJ-45 (8P8C) plug that does not require soldering.
 7. Provide a TIA-568 Channel Test report for each installation of HDBaseT cable using a calibrated and certified cable tester. Refer to Section 27 15 13 for cable testing requirements.
 8. Cables shall be installed a minimum of 12 inches from AC power cables.
- B Projectors and Projection Screens:
 1. Field verify projection throw distances and assure proper projection device lenses are supplied for the particular throw distance.
 2. Coordinate the power connections of projector lifts and projection screens with the Electrical Contractor.
 3. Projectors shall be placed within the rooms to properly fill projection screens.
 4. Projectors shall be installed at proper heights to the screen placements to allow for proper projection utilizing the minimum necessary horizontal and vertical keystone adjustments.

C Displays:

1. Displays shall be installed plum and level.
2. Image should be clear and static free without any artifacts.
3. Displays connected to PCs shall be set to Dot by Dot mode and not image stretch.
4. Mounting heights of displays are to the center of the equipment.

3.5 CONTROL SYSTEMS INSTALLATION**A Minimum Control Requirements**

1. At a minimum, the control system shall be programmed to include the following:
 - a. Full function control of all source components, display units, processing devices and switching electronics.
 - b. Separate program and microphone audio level control with mute function.
 - c. Audio level default button on audio page.
 - d. Panel layout to include user screens as well as password protected technician pages.
 - e. Raise and lower projection screens when system is powered on/off.
 - f. Lighting presets with independent control for the separate lighting zones.
 - g. Audio conferencing call control.
 - h. Video conferencing call control.
 - i. PTZ camera presets.
 - j. Assignment of dedicated OFE room computer as default.
 - k. Owner logo on first page.
 - l. Owner Colors to be used on all pages.
 - m. Automatic system shutdown.
 - n. Install PC-based control interface application (ie. Crestron XPanel) on designated Owner PCs for remote control of all control systems.
 - o. Intellectual property release for installing editable, uncompiled source code for the entire remote control system and associated panel layouts on OFE computer(s). Editable, uncompiled source code is intended for the Owner to make additions, modifications and changes to the remote control system after the warranty period has expired.
 - p. Provide and load onto Owner's dedicated computer, editable versions of all configuration files for any digital signal processing as well as the associated software required for editing those files. Provide editable and uncompiled versions of all master source code for the control system on Flash Drive.

B Control Interface Requirements:

1. Present on All Pages
 - a. Owner Logo
 - b. Shut down button
 - c. Admin page button
 - d. Buttons to go to Sources, Audio, Phone, Camera and Lighting Pages
 - e. Room Volume Control and mute with Graphic Representation
2. Sources Page
 - a. Drag and drop source selection
 - b. Graphic representation of each display device
 - c. Graphic representation of each source
 - d. Preset function buttons
 - e. Projector Blank
3. Audio Page

- a. Audio level slider for each source
- b. Buttons for volume up, volume down and mute for each source
- c. Default button to reset audio levels to a Default value
- d. Overall Room Volume with mute
- 4. Phone Page
 - a. Dial Pad arrangement using the international standard ITU E.161
 - b. Digits dialed with clear button
 - c. Phone Volume level Up and Down with graphic level bar
 - d. Green Dial Button
 - e. Red Hang up Button
 - f. Redial
 - g. Hold
 - h. Call State
- 5. Camera Page
 - a. Pan and Tilt controls
 - b. Zoom in/ Zoom out
 - c. Focus
 - d. Camera Selection
 - e. Minimum of 4 Presets
- 6. Lights and Shades
 - a. 5 Lighting presets
 - b. Graphic sliders for each light zone
 - c. Graphic slider for each shade zone

3.6 INTERFACE WITH OTHER WORK

- A Coordinate all required interfaces with other trades and systems as required.

3.7 FIELD QUALITY CONTROL

- A Perform the following field tests and inspections and prepare test reports:
- B Schedule tests with at least seven days' advance notice of test performance.
- C After installing display equipment and after input signals are available and calibrated after electrical circuitry has been energized, test for compliance with requirements.
- D Operational Test: Perform test and calibration video display and sound per manufacturer installation training. Verify proper signal levels and that system is free of noise and distortion with all signals provided at outlet.
- E Retesting: Correct deficiencies in video and audio display and retest. Prepare a written record of tests.
- F Inspection: Verify that units and controls are properly labeled and all interconnecting wires and terminals are identified.

3.8 STARTING EQUIPMENT AND SYSTEMS

- A Upon completing installation of each system, the Contractor shall align, balance, and completely pretest each entire system under full operating conditions.
- B Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
- C System tests and adjustments shall include but not be limited to the following:
 - 1. Functional tests of all individual audio, video and control equipment.
 - 2. Alignment, convergence and source input settings for each video monitor.
 - 3. Functional tests of all AV control system software functions
 - 4. Room equalization and audio gain structure set up providing the maximum possible dynamic range and gain before feedback. These settings shall be documented and submitted to the AV Engineer prior to Final System Tests and Equivalentization.
 - 5. All functional tests of the installed system as required assuring that the system is ready for final inspection.
- D The AV Contractor shall be responsible for notifying the Owner of any unresolved malfunctions encountered during system tests and of any equipment not at the site sufficiently prior to final system testing and inspection.
- E If troubles are encountered, the AV Contractor shall continue tests and adjustments until the system operates in a satisfactory manner.

3.9 TRAINING

- A Furnish the services of a factory-trained Engineer or technician for Two (2) four-hour periods to instruct the Facility's personnel. Instruction shall include corrective and preventive maintenance of each system's equipment. Training shall be accomplished before the system can be accepted by Owner. Additionally, training will be scheduled at the convenience of the owner for these two (2) periods.
- B Furnish the services of a representative of the systems, familiar with the functions and operation of the equipment, for two four-hour periods to train selected Facility personnel. Instructions shall be provided for staff personnel in each area where new equipment is provided under this contract. When multiple locations are involved, classes will be grouped. Periods of training shall be coordinated with Owner to ensure all shifts receive the required training. A pre-recorded video presentation shall be provided where such recording exists that is sufficient in detail to stand alone as a training aid for initial utilization and familiarization of the system. Additionally, the Contractor shall provide two copies of the video presentation to the Owner.

3.10 CLEANING AND PROTECTION

- A Jobsite to remain organized during construction. All efforts must be made to protect existing finishes and equipment. Any devices altered during construction to be brought back to existing or better condition upon completion of construction.

3.11 SCHEDULE

- A All work to be scheduled with General Contractor, Owner, and Architect

SECTION 274133**MASTER ANTENNA TELEVISION SYSTEMS****PART 1 – GENERAL****1.1 SECTION INCLUDES**

- A This section includes the headend equipment and intermediate signal distribution system components for master antenna television (MATV), community antenna television (CATV), or satellite earth station systems.

1.2 SUBMITTALS

- A As specified in Section 270501.
- B Product Data:
 - 1. Signal distribution components.
- C Shop Drawings:
 - 1. Calculations and structural analyses for installed products, including selection of seismic restraints, signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Calculations of signal attenuation budget and calculated line and equipment losses for the system based on the functional block diagram, to show that the proposed system layout can be expected to perform as outlined in specifications.
 - 3. Calculations of signal strength from sources to headend input points for each antenna, satellite dish, and CATV grouping. Allowable losses between components and user interface shall be used to determine size and type of coaxial cabling.
 - 4. Dimensioned plan and elevation views of components and enclosures, and details of control panels. Show access and workspace requirements.
 - 5. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
- D Maintenance Data.
- E Qualifications:
 - 1. Documentation of certification from the component manufacturer.
- F Warranty.
- G Test Reports:
 - 1. Documentation of the test results, test equipment, equipment certification, and calibration of test equipment utilized.

1.3 QUALITY ASSURANCE

- A Coordinate layout and installation of communications equipment with the Owner as directed.

- B Coordinate entrance arrangements with the Owner's service provider(s) as directed.
- C The Contractor shall be responsible for verifying that all conduits and raceways are ready for cabling placement.
- D Coordinate with pathway installer to ensure that TIA distance limits and installation tolerances are maintained. Outlets that are beyond TIA distance shall be brought to the attention of the Owner and the Architect as soon as possible. Owner and Architect shall not be responsible for outlets beyond distance limits as a result of deviation from the plans and/or incorrectly routed sleeves and/or pathways.
- E Comply with 47 CFR: Part 15, Part 17, and Part 76.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Signal Distribution Components:
 - a. ATX Networks.
 - b. Blonder Tongue Laboratories, Inc.
 - c. Channell Commercial Corporation.
 - d. RMS Communications, Inc.
 - e. Or pre-approved equivalent.

2.2 GENERAL PRODUCT REQUIREMENTS

- A Components:
 - 1. Modular plug-in, heavy-duty, industrial-grade or commercial-grade units.
- B Equipment:
 - 1. Silicon-based, solid-state, integrated circuit devices.
- C Power Supply Characteristics:
 - 1. Devices shall be within specified parameters for AC supply voltages within the range of 105 volts to 130 volts.
- D Protect signal cables and connected components against transient-voltage surges by suppressors and absorbers designed specifically for the purpose.
- E RF and Video Impedance Matching:
 - 1. Signal-handling components, including connecting cable, shall have end-to-end impedance-matched signal paths. Match and balance devices used at connections where it is impossible to avoid impedance mismatch or mismatch of balanced circuits to unbalanced circuits.

2.3 DISTRIBUTION COMPONENTS

- A Distribution and trunk amplifiers, couplers, splitters, connectors, taps, and outlets shall be the standard product of one manufacturer to constitute a fully compatible, complete, and operational system.
- B The headend equipment shall be the control center of the system, where incoming signals are amplified, converted, processed, and combined into a common cable along with any locally-originated television signals, for transmission to user interface points. This equipment may also be referred to as the "central retransmission facility". Units shall be consistent with specified levels of overall system performance. Include the following where necessary for indicated functional requirements, regardless of whether or not they are shown in system diagrams. House units in standard 19-inch equipment cabinet(s).
 - 1. Modulators.
 - 2. Demodulators.
 - 3. Processors.
 - 4. Scramblers.
 - 5. Descramblers.
 - 6. Encoders.
 - 7. Decoders.
 - 8. Converters.
 - 9. Power supplies.
 - 10. All other broadband and single-channel amplifier combining network components.
- C Preamplifiers:
 - 1. Coaxial-down-lead-broadband or single-channel type, inherently protected against lightning and voltage surges, and enclosed in weatherproof housings. Use antenna cable for power supply from external source.
- D Signal Traps:
 - 1. Packaged filters tuned to interference frequencies encountered on project site.
- E Signal Power Splitters and Isolation Taps:
 - 1. Metal-enclosed directional couplers with brass connector parts. Where installed in signal circuits used to supply cable-powered amplifiers, power throughput capacity shall exceed load by at least twenty-five percent (25%).
 - 2. Return loss of 17 dB.
 - 3. RFI shielding of 100 dB.
 - 4. Isolation of 25 dB.
 - 5. I/O impedance of 75 ohms.
- F Attenuators:
 - 1. Fixed to balance signal levels.
- G Terminating Resistors:
 - 1. Enclosed units rated at 0.5 W and matched for coaxial impedance.
- H Distribution Amplifiers:

1. 31 dB amplifier basis of design shall be BIDA 86A-30P by Blonder Tongue Laboratories, Inc..
 2. 43 dB amplifier basis of design shall be BIDA 86A-43P by Blonder Tongue Laboratories, Inc.
- I Trunk Amplifiers:
1. 36 dB amplifier basis of design shall be LPA-860-36G by Blonder Tongue Laboratories, Inc.
- J Carrier:
1. Pure-frequency signal that is modulated to carry information. In the process of modulation, the signal is spread out over a wider band. The carrier frequency is the center frequency on any television channel.

PART 3 – EXECUTION

3.1 EXAMINATION

- A Examine pathway elements intended for cabling. Check raceways, cables trays, cable ladder runways, conduits, sleeves, and other elements for compliance with space allocations, installation tolerances, hazards to cabling installation, and other conditions affecting installation.
- B Examine rough-in for antenna and/or satellite to verify actual locations of cable connections before antenna installation.
- C Examine walls, floors, roofs, equipment bases, and roof supports for suitable conditions where equipment is to be installed.
- D Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Install surge suppressors where AC-power-operated devices are not protected against voltage transients by integral surge suppressors specified in UL 1449. Install surge suppressors at the devices' power-line terminals. Comply with Division 26.
- B Support and anchor antenna and/or satellite towers, masts, and mountings.
1. Concrete Foundations:
 - a. Reinforced concrete, complying with general construction specifications.
 2. Steel Anchorage Components:
 - a. Galvanized-steel shapes and plates complying with general construction specifications.
- C Provide required interconnecting cabling and terminations between components provided herein for a complete and operational system.
- D Wiring Within Enclosures, Equipment Racks, and Network Cabinets:
1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

E Equalizing Video Signals:

1. Where system performance may be degraded in certain operating modes, revise component connections and install video distribution amplifiers and attenuators as required to provide a balanced signal across the system.

F Splices, Taps, and Terminations:

1. For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets, and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

G Cap all unused connectors.**H Grounding:**

1. Provide independent signal circuit grounding recommended by manufacturer.

3.3 IDENTIFICATION

- A As specified in Section 270553.01.

3.4 FIELD QUALITY CONTROL**A Manufacturer's Field Service:**

1. Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, and to supervise pretesting, testing, and adjusting of equipment.

B Inspection:

1. Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.

C Pretesting:

1. Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Replace malfunctioning or damaged items. Retest until satisfactory performance and conditions are achieved. Prepare equipment for acceptance and operational testing as follows:
 - a. For CATV sources, connect the receiver to an agile demodulator or CATV set-top converter at the CATV service entrance to the facility.
 - b. For satellite earth station system sources, adapt receiver to the output of satellite television receiver.

D Test Schedule:

1. Schedule tests after pretesting has successfully been completed and system has been in normal functional operation for at least fourteen (14) days. Provide a minimum of ten (10) days' notice of test schedule.

E Performance Tests:

1. Perform system tests to verify that the system complies with specifications. Include all modes of system operation.

2. Utilize a field-strength instrument rated for -40 dBmV, measuring sensitivity and a frequency range of 54 to 812 MHz, minimum. Provide documentation of recent calibration against recognized standards.
3. Use a field-strength meter or spectrum analyzer, and a standard television receiver to measure signal levels and check picture quality at all user-interface outlets.
 - a. Test the signal strength in dBmV at 55, 151, 547, and 750 MHz.
 - b. Minimum acceptable signal level is 10 dBmV (1,000 mV).
 - c. Maximum acceptable signal level over the entire bandwidth is 17 dBmV.
 - d. Television receiver shall show no evidence of cross-channel intermodulation, ghost images, or beat interference.
4. Perform a signal-to-noise ratio test. Use a field-strength meter to make a sequence of measurements at the output of the last distribution amplifier or of another agreed location in system. With system operating at normal levels, tune meter to the picture carrier frequency of each of the designated channels in turn and record the level. With signal removed and input to corresponding headend amplifier terminated at 75 ohms, measure the level of noise at same tuning settings. With meter correction factor added to last readings, differences from first set must not be less than 45 dB.
5. Perform qualitative and quantitative performance tests. Demonstrate reception quality of color-television program transmissions at each system outlet from each designated channel and source. Quality shall be equal to or superior than that obtained with performance checks specified below, using a standard, commercial, cable-ready, color-television receiver. If poor reception is found and cannot be resolved, the Contractor shall demonstrate that the level and quality of signal at the outlet and from each designated channel and source complies with the following specifications when tested according to 47 CFR, Part 76:
 - a. RF video carrier level between 2 and 12 dBmV.
 - b. Relative video carrier level within 3 dB to adjacent channel.
 - c. Carrier level stability (short term) does not change more than 0.5 dB during a 60-minute period.
 - d. Carrier level stability (long term) does not change more than 2 dB during a 24-hour period.
 - e. Broadband frequency response of more than the 54 to 220 MHz frequency range; signal amplitude of plus or minus 3 dB, maximum.
 - f. Channel frequency response across any 6-MHz channel in the 54 to 220 MHz frequency range, referenced to video carrier; signal amplitude is plus or minus 1 dB, maximum, unless otherwise indicated.
 - g. Carrier-to-noise ratio of 45 dB or more, unless otherwise indicated.
 - h. RF visual signal-to-noise ratio of 43 dB or more.
 - i. Cross modulation of less than -50 dB.
 - j. Carrier-to-echo ratio of more than 40 dB.
 - k. Composite triple beat of less than -53 dB.
 - l. Second order beat of less than -60 dB.
 - m. Terminal isolation TV-to-TV of 25 dB, minimum.
 - n. Terminal isolation between TV and FM of 35 dB, minimum.
 - o. Hum modulation of 2%, maximum.
 - p. RF FM carrier level of 13 to 17 dB below video carrier level.
 - q. FM frequency response of more than the 88 to 108 MHz frequency range; signal amplitude of plus or minus 0.75 dB, maximum.

- r. FM carrier-to-noise ratio of more than 24 dB.

F Record test results.

G Retest:

- 1. Correct deficiencies identified by tests and observations and retest until specified requirements are met.

3.5 CLEANING

A Clean installed items using methods and materials recommended by manufacturer.

B Clean system components, including antennas and supports, headend equipment, distribution components, and outlets.

3.6 DEMONSTRATION

A Engage a factory-authorized service representative to train the Owner to adjust, operate, and maintain equipment.

- 1. Train Owner on procedures and schedules for troubleshooting, servicing, and maintaining equipment.
- 2. Demonstrate methods of determining optimum alignment and adjustment of components and settings for system controls.
- 3. Demonstrate programming and tuning of receivers.
- 4. Review data in maintenance manuals.
- 5. Conduct training as specified in Section 270501.

3.7 ON-SITE ASSISTANCE

A Occupancy Adjustments:

- 1. When requested by the Owner within one (1) year of the date of substantial completion, provide on-site assistance in tuning and adjusting the system to suit actual occupied conditions and to optimize performance. Provide up to two (2) adjustments at the project site for this purpose, without additional cost.

END OF SECTION

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SECTION 275129.13

RESCUE ASSISTANCE SIGNAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Area of refuge/rescue assistance emergency communication system and associated call stations, control stations, and accessories.
 - 1. Includes area of refuge/rescue assistance signage.

1.2 REFERENCE STANDARDS

- A 36 CFR 1191 - Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines.
- B ADA Standards - 2010 ADA Standards for Accessible Design.
- C ICC (IBC) - International Building Code.
- D NECA 1 - Standard for Good Workmanship in Electrical Construction.
- E NFPA 70 - National Electrical Code.
- F NFPA 72 - National Fire Alarm and Signaling Code.
- G NFPA 101 - Life Safety Code.
- H UL 924 - Emergency Lighting and Power Equipment.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment or other potential obstructions within the spaces dedicated for area of refuge/rescue assistance system components.
 - 2. Coordinate the work with other installers to provide communication lines required for control station timed automatic connection to designated constantly attended monitoring location.
 - 3. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B Sequencing:
 - 1. Do not install call stations and control station(s) until final surface finishes and painting are complete.

1.4 SUBMITTALS

- A Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- B Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables. Include system interconnection schematic diagrams.
- C Design Data: Include standby battery calculations.
- D Operation and Maintenance Data: Include detailed information on system operation, equipment setup, replacement parts, and recommended maintenance procedures and intervals.
 - 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- E Maintenance contracts.
- F Project Record Documents: Record actual locations of system components and installed wiring arrangements and routing.

1.5 QUALITY ASSURANCE

- A Comply with the following:
 - 1. ADA Standards.
 - 2. ICC (IBC) (International Building Code).
 - 3. NFPA 70 (National Electrical Code).
 - 4. NFPA 72 (National Fire Alarm and Signaling Code).
 - 5. NFPA 101 (Life Safety Code).
 - 6. The requirements of the local authorities having jurisdiction.
 - 7. Applicable TIA/EIA standards.
- B Manufacturer Qualifications: Company engaged in manufacturing the products specified in this section with minimum three years documented experience.
- C Installer Qualifications: Company with minimum 10 years documented experience with similar area of refuge/rescue assistance systems and providing contract maintenance service as a regular part of their business.
 - 1. Contract maintenance office located within 100 miles of project site.
- D Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.
- E Products: Listed, classified, and labeled as suitable for the purpose intended.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

- B Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

1.7 FIELD CONDITIONS

- A Maintain field conditions within manufacturer's required service conditions during and after installation.

1.8 WARRANTY

- A Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Area of Refuge/Rescue Assistance Communication System- Other Acceptable Manufacturers:
 - 1. Alpha Communications: www.alphacommunications.com.
 - 2. Cornell Communications: www.cornell.com.
 - 3. Rath Microtech: www.area-of-refuge.com.
 - 4. Fire alarm system manufacturers listed in 284600.
 - 5. Or pre-approved equivalent
- B Source Limitations: Furnish system components and accessories produced by a single manufacturer and obtained from a single supplier.

2.2 AREA OF REFUGE/RESCUE ASSISTANCE COMMUNICATION SYSTEM

- A Provide new area of refuge/rescue assistance communication system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B System Description:
 - 1. Call Stations (Remote Units): Located at each designated area of refuge/rescue assistance as indicated on drawings, unless otherwise directed by authorities having jurisdiction.
 - 2. Master Control Station (Master Unit): New, located as indicated on drawings, unless otherwise directed by authorities having jurisdiction.
 - 3. System battery backup is required.
 - 4. Timed automatic connection to designated constantly attended monitoring location is required.
 - 5. Minimum Number of Zones Supported: As required for call stations/zones indicated, with minimum 20 percent spare capacity.
- C System Operation:
 - 1. When a call for assistance is initiated at call station:
 - a. Provide audible and visual notification at call station to confirm that call has been placed.
 - b. Provide audible and visual notification at control station(s) that call has been placed and annunciate the location of the call station/zone that initiated a call.

- c. Maintain visual notification of each call location at control station(s) until manually reset by control station operator.
 - d. Maintain audible notification at control station(s) that call(s) have been placed until call is acknowledged by control station operator.
 - e. Maintain visual notification at call station until manually reset by control station operator.
 - 2. When a call for assistance is acknowledged at control station:
 - a. Provide visual notification at control station that call has been acknowledged.
 - b. Provide visual notification at call station that call has been received.
 - c. Establish two-way voice communication between call station and control station.
 - 3. When a call has not been acknowledged during a programmed time delay to allow for local response, automatically initiate call to listed remote monitoring station under contract with facility, send signal identifying specific building, and establish two-way voice communication.
 - a. Remote monitoring station shall be approved by the authority having jurisdiction.
- D Call Station(s):
 - 1. Suitable for the environment where installed.
 - 2. Finish: Stainless steel.
 - 3. Mounting: Flush-mounted.
 - 4. Provides means to initiate call for assistance.
 - 5. Provides for distinct audible and visual notification to confirm that call has been placed and for distinct visual notification that call has been acknowledged.
 - 6. Following initial call for assistance, provides for hands-free two-way communication with control station(s).
- E Control Station(s):
 - 1. Suitable for the environment where installed.
 - 2. Mounting: Flush-mounted.
 - 3. Enclosure: Powdercoat, steel cabinet with hinged door. Door shall have glass panel with view of system controls.
 - 4. Provides visual notification that system is operational.
 - 5. Provides for distinct audible and visual notification of calls with annunciation of call station/zone locations.
 - 6. Provides for two-way communication with selected call stations.
 - 7. Provides for supervision of system wiring and provides distinct audible and visual notification of faults.
 - 8. Audible Notification Sound Level: Not less than 90 dB.
- F Accessories:
 - 1. Provide components as indicated or as required for a complete operating system.
 - 2. Wiring: Provide manufacturer's recommended cables as indicated or as required for connections between system components, and in accordance with wiring methods indicated.
 - 3. Signage:
 - a. Call Station Instruction Signs: Raised character and Braille instructions complying with ADA Standards.

PART 3 EXECUTION**3.1 EXAMINATION**

- A Verify that field measurements are as indicated.
- B Verify that characteristics of system components are consistent with the indicated requirements.
- C Verify that mounting surfaces are ready to receive system components.
- D Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A Perform work in accordance with NECA 1 (general workmanship).
- B Install products in accordance with manufacturer's instructions.
- C Mounting Heights:
 - 1. Call Stations: Comply with applicable accessibility requirements.
 - 2. Control Stations: As indicated on drawings.
- D Wiring Method:
 - 1. Use 2-hour fire-rated circuit integrity (CI) cable or 2-hour fire-rated mineral-insulated, metal-sheathed (MI) cable in accordance with NFPA 72 Level 2/Level 3 pathway survivability requirements.
 - a. Exception: Buildings of less than 2-hour fire-rated construction that are fully protected by an automatic sprinkler system, where cables are installed in metal raceway or metal armored cables are utilized in accordance with NFPA 72 Level 1 pathway survivability requirements.
 - 2. Provide Class A system wiring in accordance with NFPA 72 pathway performance requirements.
 - 3. Install wiring in conduit where required for rough-in, where required by authorities having jurisdiction, and where exposed to damage.
 - 4. Conduit: Comply with Section 260533.13.
 - 5. Conceal all cables unless specifically indicated to be exposed.
- E Provide grounding and bonding in accordance with Section 260526.
- F Install firestopping to preserve fire resistance rating of partitions and other elements.
- G Identify system wiring and components in accordance with Section 260553.
- H Identify zones at control station(s) to indicate call station locations.
- I Provide required instructional signage at each call station.

3.3 SYSTEM PROGRAMMING

- A Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions and final results.

3.4 FIELD QUALITY CONTROL

- A Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's field reports with submittals.
- B Test to verify wiring is free of shorts and grounds.
- C Prepare and start system in accordance with manufacturer's instructions.
- D Test system for proper operation.
- E Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
- F Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.5 CLEANING

- A Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.6 CLOSEOUT ACTIVITIES

- A Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- B Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Instructor: Manufacturer's authorized representative.
 - 4. Location: At project site.

3.7 PROTECTION

- A Protect installed system components from subsequent construction operations.

3.8 MAINTENANCE

- A Provide to Owner, a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of area of refuge/rescue assistance system for one year from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.

- B Conduct site visit at least once every three months to perform inspection, testing, and preventive maintenance. Submit report to Owner indicating maintenance performed along with evaluations and recommendations.
- C Provide trouble call-back service upon notification by Owner:
 - 1. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 - 2. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- D Maintain an on-site log listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced.

END OF SECTION

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SECTION 280500

COMMON WORK RESULTS FOR ELECTRONIC SECURITY

PART 1 – GENERAL

1.1 SECTION INCLUDES

- A This section describes the general electronic security systems (ESS) requirements of these specifications and applies to all phases of the work specified, indicated on the drawings, or required to provide the complete installation of ESS for this project.
- B This section contains requirements that pertain to other Division 28 security specifications, such as requirements for warranty, submittals, quality assurance, record drawings, installation, demonstrations, and operator training.
- C The term security systems (SSI) shall be synonymous with the term Contractor for the Division 28 security scope.

1.2 ALTERNATES

- A Alternates, if required, shall be as described in the “Alternates” section of this project manual, as described on the proposal form, or as indicated on the drawings.

1.3 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

- A If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Architect for clarification.
- B Any definitive interpretation or clarification of the contract documents will be published by addenda and properly issued to each person holding documents prior to the bid date.
- C Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents.
- D When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.
- E The Architect shall be the sole judge regarding interpretations of conflicts within the contract documents.

1.4 CONTRACT DOCUMENT DISCREPANCIES

- A If any ambiguities should appear in the contract documents, request clarification from the Architect before proceeding with the work.
- B If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Architect.

- C Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work, unless a written clarification from the Architect was requested and obtained before submission of proposed methods or materials.
- D The Architect shall be the sole judge regarding interpretations of conflicts within the contract documents.

1.5 DEFINITIONS

- A Furnish:
 - 1. Supply and deliver to the site, ready for use, items required to complete tasks or perform tests required to build a complete and ready-to-use system.
- B Install:
 - 1. Supply labor to construct complete system, ready for intended use.
- C Provide:
 - 1. Furnish, install, connect, and test, supplying required labor to construct a complete system, ready for the intended use.

1.6 SYMBOLS

- A Items of equipment and materials are indicated on the drawings in accordance with the symbols on the plans. Some of the symbols scheduled may not be required for the project. Because of the scale of the drawings, symbols are shown on drawings as close as possible to the installation location. Verify exact locations with the Architect and the Owner.

1.7 ABBREVIATIONS

- A The following abbreviations apply throughout the contract documents:
 - 1. ADA: Americans with Disabilities Act
 - 2. AFF: Above Finished Floor
 - 3. ANSI: American National Standards Institute
 - 4. AWG: American Wire Gauge
 - 5. BICSI: Building Industry Consulting Services International
 - 6. CCTV: Closed-Circuit Television
 - 7. CFR: Code of Federal Regulations
 - 8. DAC: Digital Alarm Communicator
 - 9. DPS: Door Position Switch
 - 10. DVR: Digital Video Recorder
 - 11. EAC: Electronic Access Control
 - 12. EMI: Electromagnetic Interference
 - 13. EMT: Electrical Metallic Tubing
 - 14. ENT: Electrical Nonmetallic Tubing
 - 15. EPT: Electrical Power Transfer
 - 16. EVS: Electronic Video Surveillance
 - 17. FACP: Fire Alarm Control Panel
 - 18. FCC: Federal Communications Commission

19. FO: Fiber Optic
20. FMC: Flexible Metal Conduit
21. FPS: Frames Per Second
22. Gbps: Gigabits Per Second
23. GbE: Gigabit Ethernet
24. GND: Ground
25. HH: Handhole
26. HVAC: Heating, Ventilation, and Air Conditioning
27. IDF: Intermediate Distribution Frame
28. IDS: Intrusion Detection System
29. IEEE: Institute of Electrical and Electronics Engineers
30. IP: Internet Protocol
31. KVM: Keyboard, Video, and Mouse
32. LAN: Local Area Network
33. LCD: Liquid-Crystal Display
34. LED: Light-Emitting Diode
35. LBM: Latch Bolt Monitor
36. Mbps: Megabits Per Second
37. MDF: Main Distribution Frame
38. MGB: Main Ground Bar
39. MH: Manhole
40. MPTL: Modular Plug Terminated Link
41. NEC: National Electrical Code
42. NEMA: National Electrical Manufacturers Association
43. NFPA: National Fire Protection Association
44. NVE: Network Video Encoder
45. NVR: Network Video Recorder
46. OFE: Owner-Furnished Equipment
47. OSHA: Occupational Safety and Health Administration
48. PBB: Primary Bonding Busbar
49. PDU: Power Distribution Unit
50. PSTN: Public Switched Telephone Network
51. PTZ: Pan-Tilt-Zoom
52. PVC: Polyvinyl Chloride
53. REX: Request-to-Exit
54. RCDD: Registered Communications Distribution Designer
55. RF: Radio Frequency
56. RFI: Radio Frequency Interference
57. RTE: Request-to-Exit
58. RQE: Request-to-Exit
59. SBB: Secondary Bonding Busbar
60. ScTP: Screened Twisted-Pair
61. SFP: Small Form-Factor Pluggable
62. SSI: Security Systems Integrator
63. STP: Shielded Twisted-Pair
64. SPD: Surge Protection Device
65. UL: Underwriters Laboratories

- 66. UPS: Uninterruptible Power Supply
- 67. UTP: Unshielded Twisted-Pair
- 68. VMS: Video Management System
- 69. WAN: Wide Area Network
- 70. WTH: Wire Transfer Hinge

1.8 CODES AND STANDARDS

- A The work shall be performed by competent craftsmen skilled in the trade involved and shall be done in a manner consistent with normal industry standards. All work shall conform to all applicable sections of currently adopted editions of the codes and standards listed below or the codes, standards, and specifications published by the organizations listed below:
- 1. American National Standards Institute (ANSI).
 - 2. American Society for Testing Materials (ASTM).
 - 3. Building Industry Consulting Service International (BICSI).
 - 4. Building Officials and Code Administrators International, Inc. (BOCA).
 - 5. Electrical Testing Laboratories (ETL).
 - 6. International Building Code (IBC)
 - 7. Institute of Electrical and Electronics Engineers (IEEE).
 - 8. National Electrical Code (NEC), latest edition.
 - 9. National Electrical Manufacturer's Association (NEMA).
 - 10. National Fire Protection Association (NFPA).
 - 11. Life Safety Code (NFPA 101).
 - 12. Independent Testing Laboratories (ITL).
 - 13. International Organization for Standardization (ISO)
 - 14. Occupational Safety and Health Standards (OSHA), National Consensus Standards and Established Federal Standards.
 - 15. Safety and Health Regulations for Construction.
 - 16. Telecommunications Industry Association (TIA).
 - 17. Uniform Building Code (UBC).
 - 18. Underwriters' Laboratories, Inc., Standards (UL).
 - 19. State and Local Codes.
- B Where there is a conflict between the code or referenced standards and the contract documents, the code or standard shall have precedence only when it is more stringent than the contract documents. Items that are allowed by the code but are less stringent than those specified shall not be substituted.

1.9 MATERIALS AND EQUIPMENT MANUFACTURERS

- A Options in selecting materials and equipment are limited by requirements of the contract documents and governing regulations. They are not controlled by industry traditions or procedures experienced on previous construction projects.
- B Materials and equipment shall be provided in accordance with the following:
- 1. Primary Design Products:
 - a. Primary design products are those products around which the project was designed in terms of capacity, performance, physical size, and quality.

- b. Primary design products are indicated by use of a single manufacturer's name, model number, or similar data on drawings or schedules, or within the specifications.
 - c. Provide primary design products unless substitutions are made in accordance with the following paragraphs.
- 2. Acceptable Equivalent Substitutions:
 - a. Acceptable equivalent substitutions are products of manufacturers other than those listed for the primary design products. Equivalent acceptable substitutions shall meet each of the following requirements.
 - b. The product shall be manufactured by one of the acceptable manufacturers listed in the project manual, drawings, or addenda.
 - c. The product shall meet or exceed the requirements of the contract documents in terms of quality, performance, suitability, appearance, and physical characteristics.
 - d. The Contractor providing the substitution shall bear the total cost of changes due to substitutions. These costs may include additional compensation to the Architect for redesign and evaluation services, increased cost of work by the Owner or other contractors, and similar considerations.
- 3. Performance Requirements:
 - a. Where the contract documents list performance requirements or describe a product or assembly generically, provide products that comply with the specific requirements indicated and that are recommended by the manufacturer for the respective application.
- 4. Compliance with Standards, Codes, and Regulations:
 - a. Where the specifications require only compliance with an imposed standard, code, or regulation, the Contractor has the option of selecting a product that complies with specification requirements, including the standards, codes, and regulations.
- 5. Proposed substitutions will be judged on the basis of quality, performance, appearance, and the governing space limitations. The reputation of the manufacturer, delivery time requirements, and the availability of repair or replacement parts may also be considered.
- 6. The Architect shall be the sole and final judge as to the suitability of substitution items.

1.10 SUBMITTALS

- A Submittal Requirements:
 - 1. Other sections in the project manual shall be adhered to if more stringent than the following paragraphs.
 - 2. When required by other sections of the project manual, submit shop drawings, product data, or samples to the Architect for review.
 - 3. Submittals deemed unnecessary by the Architect shall be returned indicating "No Action Taken".
 - 4. A completed copy of the transmittal form included with the project manual shall accompany each submittal.
 - 5. Submittals shall be numbered consecutively by specification section (i.e., 280501-01, 280501-02, etc.).
 - 6. Unless otherwise noted, submit one (1) copy electronically of shop drawings and product data for review. Review comments will be returned electronically. A hard copy of the electronic submittal will be returned if requested.

7. Each submittal shall clearly indicate proposed items, capacities, characteristics, and details in conformance with the contract documents. Equipment items shall be marked with the same item number as used on drawings or schedules. Capacities, dimensions, and special features required shall be certified by the manufacturer.
8. Submittals shall indicate manufacturer's delivery time for the item after review by the Architect.
9. When required by other sections of the project manual, the Contractor shall submit a "specification compliance review" (SCR) consisting of a paragraph-by-paragraph review of the specifications and addenda. Markings may be made in the margins of the original specification or addenda. Unless a deviation or exception is specifically noted in the SCR, it is assumed that the equipment, product, or material is in complete compliance with the contract documents. Submit the SCR with shop drawings and product data.
10. Submittals will be returned to the Contractor by the Architect with one of the following responses:
 - a. "A": Reviewed, No Exceptions Taken.
 - b. "B": Reviewed, Exceptions Taken as Noted.
 - c. "C": Revise and Resubmit.
 - d. "D": Rejected.
 - e. "E": No Action Taken.
11. The Architect shall review or take other appropriate action upon the Contractor's submittals such as shop drawings, product data, and samples, but only to determine conformance with the design concept of the work and the information given in the contract documents.
12. Contractor shall not be relieved of responsibility for any deviation from the requirements of the contract documents by the Architect's review of shop drawings, product data, or samples.
13. Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data, or samples by the Architect's review of those drawings.
14. No portion of the work requiring submission of a shop drawing, product data, or sample shall be commenced until the submittal has been reviewed by the Architect. Such portions of the work shall be in accordance with reviewed submittals.
15. The successful Contractor may, at their option, obtain DXF or AutoCAD DWG electronic files for use in preparation of shop drawings.
 - a. This information is available from IP Design Group upon written request.
 - b. The use of these drawing files is intended solely for the preparation of shop drawings as required by these contract documents.
 - c. Any other use is strictly prohibited by copyright laws.
 - d. The user of these electronic drawing files assumes full responsibility for their accuracy and scale.

B Bid Submittals:

1. The Contractor shall submit a resume with their proposal containing the following:
 - a. A list of five (5) recently completed projects of similar type and size with contact names and telephone numbers for each.
 - b. Installer qualifications.
 - c. Letter of good standing from electronic security manufacturer(s).

C Pre-Construction Submittals:

1. The Contractor shall submit shop drawings in accordance with the requirements listed below.
 - a. Shop drawings are drawings, diagrams, schedules, and other data specifically prepared for this project by the Contractor to illustrate some portion of the work. Shop drawings shall also detail fabrication and installation for metal and wood supports, and anchorage for mechanical materials and equipment. Shop drawings shall include, but not be limited to, the following:
 - 1) Functional block and wiring diagrams showing single-line interconnections between components for signal transmission and control. Show cable types, quantities, and sizes.
 - 2) Dimensioned plans and elevations of equipment racks and enclosures.
 - b. Shop drawings shall be drawn to accurate scale and of adequate size to illustrate required details.
 - c. Maximum sheet size shall be 36 inches by 48 inches. For each hard copy shop drawing sheet larger than 11 inches by 17 inches, submit one (1) drawing on reproducible media.
 - d. The Architect's action shall be indicated on the reproducible drawing and the drawing shall be returned to the Contractor.
2. The Contractor shall submit product data in accordance with the requirements listed below.
 - a. Product data are illustrations, schedules, performance charts, instruction brochures, diagrams, and other information furnished by the Contractor to illustrate a product, material, or system for some portion of the work.
 - b. Includes data on features, ratings, and performance for each component specified.
3. The Contractor shall submit programming data in accordance with the requirements listed below:
 - a. Device names and descriptions.
 - b. Complete written sequence of operations for all functions of the system.
4. A proposed test plan shall be submitted to the Owner for approval prior to commencement of testing.

D Operation and Maintenance Manuals:

1. Prepare an electronic copy of the operation and maintenance manuals for the equipment furnished. Manuals shall be submitted to the Architect for review and distribution to the Owner not less than thirty (30) days prior to substantial completion of the project. Manuals not meeting the following requirements may be rejected by the Architect.
2. Each manual shall be assembled in a three-ring binder with hard cover and plastic finish. Binders shall not exceed a 3-inch thickness. Where more than one binder is required, the manuals shall be separated into a logical grouping, i.e., "Electronic Access Control", "Electronic Video Surveillance", "Maintenance", "Operation", "Parts", "Shop Drawings", etc. Each binder shall have the following information clearly printed on its front cover:
 - a. Project name and address.
 - b. Portion of the work covered by each volume (if more than one volume in the set). Where more than one volume is required, label each volume as "Volume ____ of ____".
 - c. Name, address, and telephone number of Contractor and subcontractors, including night or emergency number.
3. Manual shall include, but shall not be limited to, the following:
 - a. A Complete Index:

- 1) Contractor may submit the index to the Architect for review prior to submittal of complete manuals, if desired.
- b. Names, Addresses, and Telephone Numbers:
 - 1) This list shall include the manufacturer(s) and local representative(s) who stocks or furnishes repair parts for all items of equipment and shall be typed on a single page in front of the binder.
- c. Startup, Operation, and Shutdown Procedures:
 - 1) Provide a written description of procedures for startup, operation, and shutdown of each electrical item or system. This description shall include switches to operate, buttons to push, etc., in proper sequence, and the location of switches, starters, and push-buttons. Description shall include item references or labels used in the contract documents, unless otherwise instructed in advance by the Owner.
- d. Equipment Accessory Schedule:
 - 1) Upon completion of the work, furnish the Owner with a complete equipment accessory schedule listing each piece of equipment and the related size, type, number required, and the manufacturer of renewable items.
- e. Emergency Procedures:
 - 1) Provide a written description of emergency operating procedures or a list of service organizations (including addresses and telephone numbers) capable of rendering emergency services to the various parts of the system.
- f. Provide all manufacturer operation and maintenance manuals and parts lists.
- g. One (1) copy of shop drawings and product data, clearly marked for each item furnished using the designation label specified or indicated on Drawings.
- h. Manufacturers' warranty information.
- i. Detailed operating instructions covering operation under both normal and abnormal conditions.
- j. Routine maintenance requirements for system components.
- k. Normal maintenance schedule: Include a listing of work to be performed at various time intervals; i.e., 30, 90, 180 days, and yearly.
- l. Lists of spare parts and replacement components recommended to be stored at the site for ready access.
- m. Software Manual:
 - 1) Describe the functions of all software and include all other information necessary to enable proper loading, testing, and operation.
 - 2) Definition of terms and functions
 - 3) System use and application software
 - 4) Initialization, startup, and shutdown
 - 5) Report generation.
 - 6) Details on forms customization and field parameters.
- n. Operator Manual:
 - 1) Fully explain all procedures and instructions for the operation of the system.
 - 2) Computers and peripherals
 - 3) System start up and shut down procedures
 - 4) Use of system, command, and applications software
 - 5) Recovery and restart procedures
 - 6) Graphic alarm presentation

- 7) Use of report generator and generation of reports
- 8) Data entry
- 9) Operator commands
- 10) Alarm messages and reprinting formats
- 11) System permissions functions and requirements

E Post-Construction Submittals:

1. Field quality-control test reports in PDF format.
2. As-built shop drawings in accordance with the requirements listed below.
 - a. Wiring and device identifiers.
 - b. Routing of cables from equipment cabinets to devices.
 - c. Routing of cables between equipment cabinets.
 - d. Revisions to construction documents (addenda and field changes)
 - e. Floor plans with all final device locations, equipment cabinet locations, and labels.
 - f. Diagrams, configurations, connections, and uplinks.
3. Cable labeling schedule(s).
4. When required, submit manufacturer's printed instructions for delivery, storage, assembly, installation, adjusting, and finishing, in quantities specified for shop drawings and equipment brochures.
5. Cable labeling schedule(s).

1.11 OPERATING TRAINING

- A Complete operating instructions for each system and item of equipment shall be provided to the Owner.
- B Operation and maintenance manuals must be reviewed and accepted by the Architect and provided to the Owner prior to operating training.
- C Training shall be scheduled at the convenience of the Owner. A minimum of four (4) hours of training shall be provided.
- D Training shall include, but not be limited to, instructions on the following:
1. Startup and shutdown procedures.
 2. Periodic maintenance.
 3. Emergency operation.
 4. Safety.
 5. Configuration and setup of software.
 6. Issuing credentials.
 7. Creating and editing user accounts.
 8. Creating and exporting reports.
 9. Setting up alerts and alarms
 10. Configuring and setup of devices.
 11. Setting up schedules.
 12. Using the software.
 13. Using the mobile application.
 14. Additional training identified in other sections.

- E In addition to the instructions required above, wherever possible, perform the operations being described in order to fully illustrate system operation.
- F At the completion of training, the Contractor shall turn over to the Owner all required keys and special tools for installed equipment. Each key or tool shall be labeled with its use.
- G Train the Owner in cable management operations, such as rerouting signals in failed cables.

1.12 QUALITY ASSURANCE

- A The Contractor shall prepare and submit all required performance warranty documentation to the manufacturer and shall deliver all complete and final warranty information to the Owner prior to project closeout.
- B The Contractor shall have an existing quality assurance and quality control plan for the installation. Upon request, the Contractor shall submit the quality assurance and control plan for the project.
- C The Contractor shall extensive experience (5+ years) with the specified manufacturer(s), hardware, software, and cabling type(s).
- D The Contractor shall:
 - 1. Employ a qualified installer to supervise the project who is experienced in the design, fabrication, installation, warranty, and contract management of systems described in these specifications.
 - 2. Be an authorized representative of the equipment manufacturer(s) with industry-accepted experience relative to the size and nature of this project.
 - 3. Allow only installers trained and certified by the manufacturer to install, terminate, and test the ESS products. Others may install or program product only if under the direct supervision of the certified installer and trained by the manufacturer of the product.
 - 4. Have the manufacturer's recommended number of employees on the job site who have completed the required training courses for the above-mentioned warranties.
 - 5. Be certified by the manufacturer for the project location to install and warranty the product specified herein.
- E The Contractor shall employ a qualified project manager (PM) who must meet the following requirements:
 - 1. Required participation in meetings and conferences.
 - 2. Be present at the project site for substantial completion inspection and final inspection.
 - 3. Approve the operation and maintenance manuals.
 - 4. Provide any additional instruction as needed to the Owner.
 - 5. Be responsible for supervision of all technical work that is part of this specification.
 - 6. Supervise preparation of shop drawings and submittals, and sign all submittals.
 - 7. Supervise the shop fabrications and field installation work to ensure strict conformance in accordance to the drawings, specifications, and the reviewed shop drawings to assure workmanship of the specified quality.
 - 8. Oversee the testing of all assemblies and all sub-assemblies prior to their delivery to the project site.

9. Lead in the specified testing of completed installation to assure the Owner that all contract requirements were met. Work with and assist the Owner in the final testing for approval and acceptance of the system by the Owner.
- F The Contractor must provide proof of registration(s) and certification(s) along with the list of planned installers prior to commencing work.

1.13 WARRANTIES

- A The Contractor shall warrant all materials, workmanship, and equipment against defects for a period of one (1) year after the date of substantial completion. Certain equipment shall be warranted beginning at the time of final acceptance or for longer periods of time as specified in those sections of the project manual. The Contractor shall repair or replace, at no additional cost to the Owner, any item which may become defective within the warranty period. Any manufacturer warranties concerning any item installed will run to the benefit of the Owner. The Contractor agrees not to void or impair, or to allow subcontractors to void or impair, any warranties regarding products or items installed as part of this project. The repair of faulty workmanship shall be considered to be included in the contract.
- B Warranty Maintenance and Service Agreement
1. General Requirements:
 - a. The Contractor shall provide all services required and equipment necessary to maintain the entire ESS in an operational state as specified for a period of one (1) year after formal written acceptance of the system, and shall provide all necessary material required for performing scheduled service or other unscheduled work.
 2. Personnel:
 - a. Service personnel shall be factory-certified in the maintenance and repair of the equipment installed under this section of the specifications. The Owner shall be advised in writing of the name of the designated service representative, and of any change in personnel.
 3. Description of Work:
 - a. The service and repair of the ESS, including all equipment provided under this specification, shall be supplied by the Contractor. The Contractor shall provide the manufacturer's required scheduled and unscheduled maintenance and all other work necessary to keep the ESS at its maximum performance.
 4. Schedule of Work:
 - a. Work shall be performed during regular working hours, Monday through Friday, excluding federal holidays.
 5. Inspections:
 - a. The Contractor shall perform two (2) minor inspections at six-month intervals (or more often if required by the manufacturer), and two (2) major inspections offset equally between the minor inspections to effect quarterly inspection of alternating magnitude.
 - b. Minor inspections shall include:
 - 1) Visual checks and operational tests of all console equipment, peripheral equipment, field hardware, sensors, and electrical and mechanical controls.
 - 2) Mechanical adjustments if required on any mechanical or electromechanical devices.
 - c. Major inspections shall include all minor inspection items, and the following:

- 1) Clean all ESS equipment, including interior and exterior surfaces.
 - 2) Perform diagnostics on all equipment.
 - 3) Check, test, and if required by the manufacturer's maintenance procedures, calibrate each sensor.
 - 4) Run all system software diagnostics and correct all diagnosed problems.
6. Operation:
 - a. Performance of scheduled adjustments and repair shall verify operation of the ESS as demonstrated by applicable tests from the proposed test plan submittal.
 7. Emergency Service:
 - a. The Owner shall have the option to initiate service calls when the ESS is not functioning properly. Qualified personnel shall be available to provide service to the complete ESS. The Owner shall be furnished with a telephone number where the service supervisor can be reached at all times. Service personnel shall be at site within twenty-four (24) hours after receiving a request for service. The ESS shall be restored to proper operating condition within twenty-four (24) hours after service personnel arrive on site.
 8. Records and Logs:
 - a. The Contractor shall keep records and logs of each task, and shall organize cumulative records for each component and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain all initial settings. Complete logs shall be kept and shall be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the ESS.
 9. Work Requests:
 - a. The Contractor shall separately record each service call request on a service request form. The form shall include the model and serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, name(s) of service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials used, the time and date work started, and the time and date of completion. The Contractor shall deliver a record of the work performed within five (5) days after work is accomplished.
 10. System Modifications:
 - a. The Contractor shall make any recommendations for system modification in writing to the Owner. No system modifications shall be made without the prior approval of the Owner. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.
 11. Software:
 - a. The Contractor shall provide all software updates during the period of the warranty and verify operation of the system. These updates shall be accomplished in a timely manner, fully coordinated with ESS operators, and shall include training for any changes or new features. Any changes or new features shall be incorporated into the operations and maintenance manuals, and other documentation affected.

1.14 REFERENCE STANDARDS

- A The Contractor's performance of work shall comply with applicable federal, state, and local laws, rules, and regulations. The Contractor shall give required notices, shall procure necessary governmental licenses, permits, and inspections, and shall pay without burden to the Owner all fees and charges in connection therewith, unless specifically provided otherwise. In the event of

violation, the Contractor shall pay all fines and penalties including attorney's fees and other defense costs and expenses in connection therewith.

- B Federal Communications Commission (FCC) registration or approval for any equipment requiring such approval shall be appropriately identified and obtained by the Contractor.
- C Design, manufacture, test, and install communications cabling per manufacturer requirements, state codes, local codes, requirements of authorities having jurisdiction, and particularly the most recent edition of the following standards:
 - 1. Guide for Premises Security (NFPA 730).
 - 2. Standard for the Installation of Premises Security Systems (NFPA 731).
 - 3. IEEE C62.41.1: Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
 - 4. EIA-310-E: Cabinets, Racks, Panels, and Associated Equipment.
 - 5. ANSI/TIA-569-A: Commercial Building Standard for Telecommunications Pathways and Spaces.
 - 6. ANSI/TIA-606-D: Administration Standard for Telecommunications Infrastructure.
 - 7. ANSI/TIA-607-D: Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
- D Install security cabling in accordance with the most recent edition of the following publications:
 - 1. BICSI Telecommunications Distribution Methods Manual (TDMM).
 - 2. BICSI Outside Plant Design Reference Manual (OSPDRM).
 - 3. ANSI/BICSI 007-2020: Information Communication Technology Design and Implementation Practices for Intelligent Buildings and Premises.
 - 4. ANSI/BICSI N1-2019: Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure.
 - 5. ANSI/BICSI N2-17: Practices for the Installation of Telecommunications and ICT Cabling Intended to Support Remote Power Applications.
 - 6. ANSI/BICSI N3-20: Planning and Installation Methods for the Bonding and Grounding of Telecommunication and ICT Systems and Infrastructure.
- E Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F The aforementioned and following additional federal, state, and local rules, regulations, and ordinances govern the work as fully a part of the specifications as if herein attached. Where requirements of the drawings or specifications are more stringent than the applicable codes, rules, regulations, and ordinances, the drawings or specifications shall apply.
 - 1. ASTM E814: Standard Test Method for Fire Tests of Penetration Firestop Systems.
 - 2. UL 1479: Standard For Fire Tests of Through-Penetration Firestops.
 - 3. Americans with Disabilities Act (ADA): Accessibility Guidelines.
 - 4. Code of Federal Regulations, Title 29, Subtitle B, Chapter XVII, Part 1910 (Occupational Safety and Health Standards).

- G If allow the Owner's installation standards unless otherwise shown on the drawings or stated herein. Where requirements of installation standards conflict with performance standards or a manufacturer's recommendations, refer to the Owner for a decision before proceeding.

1.15 COORDINATION

- A Coordinate and schedule all construction work with the General Contractor prior to beginning work. Do not interrupt building activities without strict coordination with the General Contractor. Unscheduled appearance to work without prior scheduling with the General Contractor is not allowed.
- B The Contractor shall attend all meetings as required by the General Contractor.
- C Convene a meeting at least one (1) week prior to commencing the work of this section, with the following agenda at a minimum:
1. Tour, inspect, and discuss building conditions related to the ESS.
 2. Review submittals, both completed and yet to be completed.
 3. Review plans, specifications, and proposed equipment.
 4. Review construction schedule, availability of materials, personnel, equipment, and facilities needed to proceed without delay.
 5. Review required inspections and testing.
 6. Review cable routing, cable support, primary pathways, and communications spaces, and environmental conditions.
- D The Contractor's project manager must be readily available on-site when needed.
- E Coordinate network configuration requirements for ESS equipment with the Owner.
- F Record agreements reached in meetings and distribute to other participants.
- G Coordinate security device rough-ins and conduit, as well as door and door frame prep with general construction work. Coordinate the arrangement of these items within the building structure during progress of construction to facilitate the security installations that follow.
- H Coordinate exact location(s) of ceiling-mounted equipment and devices with architectural plans, reflected ceiling plans, structural plans, and all affected trades prior to construction and installation.
- I Coordinate exact location(s) of all equipment and devices mounted to desktops and countertops with the millwork, casework, and furniture plans prior to installation.
- J Fully examine the drawings and specifications for other trades and coordinate the installation of communications work with the work of the other trades. Consult and cooperate with the other trades for determining space requirements and for determining that adequate clearance is allowed with respect to their equipment, other equipment, and the building.
- K Coordinate installation of security cabling with the raceway installer. Verify raceways are installed according to current TIA standards before installing cabling.

L Environmental Conditions:

1. Do not deliver or install ESS equipment to the installation location until areas are complete, dry, and temporary or permanent HVAC systems are operating and maintaining acceptable ambient temperature and humidity conditions for the remainder of the project. ESS equipment damaged or painted as a result of premature occupancy of the site will be replaced at the expense of the Contractor.
2. Do not deliver or install equipment cabinets or network electronics until communications rooms are enclosed, painted, water-tight, complete, dry, dust-free, and work above and in ceiling spaces is complete. ESS equipment damaged as a result of premature occupancy of the communications spaces will be replaced at the expense of the Contractor.
3. System components shall be equipped and rated for the environments where installed.
4. Rate outdoor equipment for continuous operation under specified environmental conditions, unless otherwise indicated.
 - a. Temperature range of -40 °C (-40 °F) to +70 °C (+158 °F).
 - b. Relative humidity range of five percent (5%) to one-hundred percent (100%).
 - c. Provide enclosures to prevent entry of moisture due to melting ice buildup, or driven rain or snow.
5. Rate indoor equipment for continuous operation under specified environmental conditions, unless otherwise indicated.
 - a. Temperature range of 0 °C (32 °F) to +70 °C (+158 °F).
 - b. Relative humidity range of zero percent (0%) to ninety-five percent (95%).

M Provide offsets and elevation changes in cable tray, cable ladder runway, conduit, and devices as required to complete the layout and coordination process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.

N Do not install ESS devices until final surface finishes and painting are complete.

1.16 STRUCTURAL COORDINATION

- A** In cases where the Contractor determines that superimposed loads (such as suspended or floor-mounted mechanical, electrical, plumbing systems or equipment) exist which exceed design loads indicated on the structural contract documents, the Contractor shall submit the load data to the Architect for review prior to proceeding with the work.
- B** Distribute the maximum load hung from any structural member for mechanical, electrical, plumbing, ductwork, piping, etc., over the member's tributary area in a way that the design superimposed dead loads listed in the structural contract documents are not exceeded. The Contractor shall coordinate the loads and provide additional support or distribution framing as required to achieve allowable load distribution.
- C** Connections of systems designed by the Contractor such as, but not limited to, mechanical, electrical, and plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

PART 2 – PRODUCTS**2.1 PERFORMANCE, CAPACITIES, AND CHARACTERISTICS**

- A Refer to the drawings for equipment schedules and equipment performance requirements when capacities and characteristics are not indicated in the specifications.

2.2 MATERIALS

- A Unless otherwise specified, all materials and equipment shall be new, unused, and undamaged. Materials and equipment shall be the current and standard designs of manufacturers regularly engaged in their production and shall bear the UL listing, or listing by other recognized testing laboratory when such listings are available. Materials shall be free of damage or corrosion and shall be of the best quality obtainable for the purpose intended.
- B Refer to individual specification sections for manufacturers.

2.3 COMPLETENESS OF WORK

- A The contract documents depict low voltage systems which are intended to be complete and functioning systems. All products, labor, and programming necessary to render a full and functional system to fulfill the design intent shown on the documents shall be provided by the Contractor.
- B Catalog numbers referenced throughout the drawings and specifications are intended to convey the understanding of the type and quality of the product required. Where written descriptions differ from information conveyed by a catalog number, the written description shall govern. No extra charge will be allowed because a catalog number is found to be incomplete or obsolete.

2.4 MATERIALS AND EQUIPMENT FURNISHED BY OTHERS

- A Where materials and equipment are indicated as furnished by others and installed or connected under this contract, it shall be the Contractor's responsibility to verify installation details and requirements.

2.5 QUANTITY OF SPECIFIED ITEMS REQUIRED

- A Wherever in these specifications an article, device, or piece of equipment is referred to in the singular number, such reference shall apply to as many such articles as are shown on the drawings or required to complete the installation.

PART 3 – EXECUTION**3.1 EXAMINATION**

- A Examine pathway elements intended for cables. Check raceways, cable trays, cable ladder runways, conduits, sleeves and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation. Proceed with installation only after unsatisfactory conditions have been corrected.

- B For serial communication devices that are close to distance limits of the serial protocol being used (e.g., RS-232, RS-422, RS-485, Wiegand, OSDP), run a length test on the proposed routing to the device in question. Inform the Owner and the Architect of any devices beyond the recommended distance limit for the protocol being used. The Owner and the Architect shall not be responsible for cables that exceed distance limits.
- C If applicable, the Contractor shall maintain the integrity of the existing system throughout the project. The Contractor shall coordinate any outages or downtime with the Owner prior to starting any work.
- D Examine substrates, areas, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the ESS installation.
- E Examine rough-ins to verify that they are plumb and level, and that the installation height above finished floor is correct. Immediately notify the General Contractor and the Architect of any rough-ins which are incorrectly installed.
- F Examine rough-ins for embedded and built-in anchors to verify actual locations of ESS connections prior to installation.
- G Inspect built-in and cast-in anchor installations prior to installing ESS devices to verify that anchor installations comply with manufacturer requirements.
 - 1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Re-inspect after repairs or replacements are made.
 - 2. Perform additional inspections to determine compliance of replaced or additional anchor installations.
- H Prepare a written and endorsed report listing conditions detrimental to performance of the ESS.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SYSTEM INSTALLATION

- A Provide all specified materials, installation hardware, and labor required to complete the work shown on the drawings and specified in this section and other Division 28 security specifications sections. This shall include work and miscellaneous items that are not explicitly specified, but are necessary to build a complete system installation, including all tools and test equipment, accessories, appurtenances, and all items required for testing the system. All systems shall be complete, operational, and ready for use by the Owner.
- B Bring to the attention of the Owner and the Architect conflicts between manufacturer instructions and the contract documents.
- C Systems shall be complete and operational in all respects.
- D The Contractor shall program and provision the system per the drawings, specifications, and Owner requirements.

- E ESS software shall be configured and programmed as indicated within these specifications and final programming shall be coordinated with the Owner. Programming schedules shall be utilized to configure and program the ESS software.
- F Configuration and setup of ESS servers shall be coordinated with the Owner prior to programming and installation.
- G Integrations between different portions of the ESS or to other systems indicated shall be configured to allow for the most optimal efficiency of the combined systems. Where possible, these systems shall work as a single system. Integrations shall be complete in all respects and approved in writing by the Owner.
- H Program all required licenses for ESS devices and software.
- I Configure ESS workstations to meet manufacturer recommendations and the requirements indicated on the drawings and in the specifications.
- J Comply with the manufacturer instructions and recommendations for installation of all devices and software.
- K All security equipment, junction boxes, terminal cans, etc., shall be installed utilizing tamper-proof mounting hardware. Provide a minimum of two (2) driver bits or hand tools for each type of security fastener provided.
- L If required, provide seismic restraints for all security cabinets, consoles, etc.
- M All components of the ESS shall be tested prior to installation on site.
- N Install security enclosures to plywood backboard.
- O Provide a surge protection device for all security devices located in outdoor locations, including security cameras, credent readers, and intercoms. Locate surge protection devices within security cabinets or provide rack-mountable modules.
- P Install security cables continuously from the device location to the security cabinet serving that area, or between security cabinets. If a splice is required, provide tamper-resistant "torx with peg" security fasteners for junction boxes containing security cable splices.
- Q All security devices located in exterior or wet-rated locations shall be rated as weatherproof.

3.3 WIRING AND CABLE INSTALLATION

- A Provide cabling in raceway, cable tray, cable ladder runway, conduit, and sleeves except within consoles, cabinets, desks, and counters. Conceal pathways and cabling, except in unfinished spaces.
- B Bundle, lace, and train conductors to terminal points within enclosure(s). Use lacing bars and distribution spools as needed. Separate power-limited and non-power-limited conductors as recommended in writing by the manufacturers. Install conductors parallel with or at right angles

to sides and back of enclosure(s). Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the ESS systems to terminal blocks. Mark each terminal according to system's wiring diagram(s). Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

- C Provide all system wiring between all components in accordance with manufacturer guidelines. Each cable for each device shall be home run. No splices are allowed unless otherwise noted. Provide size and pair quantities as recommended in writing by system manufacturer, unless otherwise indicated.
- D All wiring and cables shall be plenum-rated and shall be installed in conduit or approved raceway in exposed spaces unless shown otherwise on the drawings.
 - 1. If exposed, install cables parallel and perpendicular to surfaces or exposed structural members. Follow surface contours where possible.
- E Install cables without damaging conductors, shield, or jacket.
- F Use cable bundling hardware rated for the environment and application in which used. Applications include, but are not limited to, general purpose, outdoor, chemical-resistant, flame-retardant, high-temperature, and vibration.
- G Provide reusable cable management straps for bundling and securing cables. Do not use nylon cable ties.
- H Do not bend cables, in handling or in installation, to smaller radii than minimums recommended by manufacturer.
- I Pull cables without exceeding cable manufacturer's recommended pulling tensions. All cables shall be free of tension at both ends. Provide strain relief connectors at each device and junction box where cables enter.
- J For wiring within equipment rooms and enclosures, provide conductors of adequate length.
- K Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by the manufacturer.
- L Refer to drawings for conduit sizes. Where not specified on drawings, the minimum conduit size shall be 3/4".
- M Low-voltage ESS wiring and cables may share communications pathways indicated in Division 27 and shall not share pathways with any other building wiring systems.
 - 1. Where communications pathways are not provided, j-hooks anchored to structure shall be provided to support ESS cabling. J-hooks shall comply with Division 27 requirements. Cable sag at mid-span shall not exceed 6 inches (150 mm).
 - 2. Secure and support cables at intervals not exceeding 60 inches, and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, equipment racks, frames, and terminals.
- N For 120-volt AC wiring, comply with Division 26.

- O For terminal connections, comply with torque-tightening values specified in UL 486A-486B.
- P Install power supplies and other auxiliary components for ESS devices within dedicated ESS enclosures within equipment rooms. Do not install such items near the devices they serve, unless noted otherwise or required by the manufacturer.

3.4 FIRESTOPPING

- A Firestop all smoke-rated and fire-rated walls, partitions, and openings after the installation of security cabling in sleeves and pathways. Firestop material shall be approved for use with the security cables and jackets being installed.
- B Provide all services, labor, materials, tools, and equipment required for the complete and proper installation of firestopping for security cabling as called for in these specifications and related drawings.
- C Deliver firestopping products to the project site in original, unopened containers or packages with intact and legible manufacturer labels identifying project, manufacturer, date of manufacture, lot number, shelf life (if applicable), qualified testing and inspecting agency's classification marking applicable to the project, curing time, and mixing instructions for multi-component materials.
- D Creation of such openings, as necessary, for cable passage between locations as shown on the drawings shall be the responsibility of the Contractor.
- E Sealing of openings between floors, through rated fire and smoke walls, existing or created by the Contractor for cabling pass-through, shall be the responsibility of the Contractor.
- F Any openings created by or for the Contractor and left unused shall be sealed as part of this work.
- G Firestop system installation must meet requirements of ASTM E814, UL 1479, or UL 2079 tested assemblies that provide a fire rating equal to that of construction being penetrated.
- H Do not install firestopping when ambient or substrate temperatures are outside limits permitted by firestopping manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.
- I Ventilate firestopping per the firestopping manufacturer's instructions by natural means or, where this is inadequate, forced air circulation.
- J During installation, provide masking and drop cloths to prevent firestopping materials from contaminating any adjacent surfaces.
- K Do not use materials that contain flammable solvents.
- L Clean out openings and joints immediately prior to installing firestopping to comply with recommendations of the firestopping manufacturer and the following requirements:
 - 1. Remove all foreign materials from surfaces of openings and joint substrates and from penetrating items that could interfere with adhesion of firestopping.

2. Clean openings and joint substrates and penetrating items to produce clean, sound surfaces capable of developing the optimum bond with firestopping. Remove loose particles remaining from the cleaning operation.
- M When the firestop system has been installed, place a label next to the system. The label shall contain the following items:
1. UL rating and any other pertinent certification information.
 2. The date the firestop was installed.
 3. Name of contractor who installed the firestop.
- N Protect firestopping during and after the curing period from contact with contaminating substances or form damage resulting from construction operations or other causes so that they are without deterioration or damage at the time of substantial completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated firestopping immediately and install new materials to produce firestopping complying with specified requirements.
- O Keep areas of work accessible until inspection by applicable code authorities.

3.5 AS-BUILT DRAWINGS

- A As-built drawings shall include all information required for shop drawings and, in addition, shall indicate the following:
1. All construction changes posted to all portions of the documents including, but not limited to, security drawings, enlarged plans, wall and rack elevations, schematics, labeling, and installation details. As-built documents shall include and clearly show final cable labeling designations down to the individual device.
- B Final drawings shall be provided to the Architect in electronic format.
- C As-built drawings shall be complete and organized to be suitable for use as disaster recovery and cable infrastructure administration documents.
- D Post a complete set of as-built documents in the security command center or in the communications room where the headend security equipment is installed. In each communications room containing security equipment, post a final floor plan of the outlets served by the respective communications room on the wall behind a protective plexiglass wall frame.

3.6 INTERFACE WITH OTHER WORK

- A Coordinate with the electrical contractor to confirm required cabling pathways, device rough-ins, emergency power, and line-voltage power requirements.
- B Coordinate with the fire alarm contractor to confirm required modules, connections, and configuration requirements.
- C If applicable, coordinate with the elevator contractor to confirm hardware placement, cabling, and interface requirements relating to security devices mounted in elevator cabs.

3.7 GROUNDING AND BONDING

- A Comply with Division 26 section: "Grounding and Bonding".
- B Comply with Division 27 section: "Grounding and Bonding for Communications Systems".
- C Bond security cabinets with minimum #6 AWG ground wire to the telecommunications primary bonding busbar (PBB) or to the nearest telecommunications secondary bonding busbar (SBB) when cabinets are located indoors. When security cabinets are installed in outdoor locations, bond the cabinet's grounding busbar to an approved ground rod installed by the electrical contractor.

3.8 OBSERVATIONS

- A Specifications and drawings represent work to be done in view of the total project requirements. Final locations of all pathways, cables, devices, equipment cabinets, components, etc., to eliminate possible conflict with other trades is the responsibility of the Contractor. The Contractor is to provide all project management and supervision required for their personnel to ensure installation is made in accordance with the plans and specifications and that all codes, safety rules, and regulations are observed. In the event of conflicts with other trades, the Contractor is to make every reasonable effort to resolve the conflict with other trades involved, by preparation of drawings or sketches, or by other appropriate action. Only after this on-site coordination has taken place, and a resolution cannot be found, is the Contractor to request assistance. Assistance shall be requested in adherence with the request for information (RFI) process defined for this project.

3.9 PERFORMANCE VERIFICATION TESTING

- A Notify the Owner, General Contractor, and Architect in advance of testing to prevent delays in the construction schedule. Notification shall be provided in writing.
- B Testing shall be completed prior to the final punch list performed by the Owner and Architect.
- C Prior to testing, provide a summary of the proposed test plan. The test plan shall include, at a minimum, the proposed schedule, a list of tests to be completed, equipment to be utilized, expected results, and documentation. The test plan and results shall be provided to the Owner, General Contractor, Architect.
- D Equipment and personnel required for performance verification testing shall be provided by the Contractor.
- E Test and place in proper and specified working order all systems prior to demonstration of the systems.
- F Perform additional tests as directed by the authorities having jurisdiction over the site.
- G If requested, testing shall be performed in the presence of the Owner, General Contractor, Architect, and representative(s) of the authorities having jurisdiction.

H Power Connections

1. Visually inspect all wiring and plugs to ensure that they are complete and conform to the wiring patterns defined by the security equipment manufacturers.
2. Test battery backup units for complete operation. Provide test reports as required.
3. Test power connections to all security devices, including (but not limited to): electrified door hardware, credential readers, security control panels, door devices, motion sensors, security cameras, intercoms, security workstations, and security servers.

I Wiring and Devices

1. Visually inspect all cabling, splices, and termination points to ensure that they are complete and conform to the wiring patterns defined by the security equipment manufacturers.
2. Test all cables for continuity, ground faults, and line-to-line short circuits.
3. Test field hardware cables as applicable to verify resistance in both door-open and door-closed conditions. Document results on a chart that lists each door and the measured resistance of each conductor pair.
4. Visually inspect all security devices and associated equipment to ensure that they are complete and conform to manufacturer recommendations and as defined herein.

J IP Network

1. Test and verify that all networked security devices are connected to the correct IP network as designated by the Owner, including (but not limited to): EAC field hardware, security cameras, intercoms, ESS servers, and ESS workstations. Coordinate assignment of the IP address, subnet mask, default gateway, VLAN, TCP/UDP port(s), and switchport for each device with the Owner.

K ESS Software

1. Visually inspect that all functions for ESS software defined herein are complete and functional.
2. Visually inspect that the information for the ESS programming schedules as a part of the pre-construction submittal process have been completed within the ESS software.

L Test system grounds to demonstrate that the ground resistance does not exceed the requirements of UL 1449 "Surge Protection Devices (SPD)" and the National Electrical Code (NEC).**M Where systems have been expanded and/or upgraded, the Contractor shall provide the personnel and labor to completely test and demonstrate all new, existing, and upgraded software and hardware.****3.10 ACCEPTANCE TESTING**

- A** Conduct acceptance testing and system startup according to a schedule coordinated with the Owner, General Contractor, Architect, and representative(s) of the authorities having jurisdiction.
- B** Prior to testing, provide a summary of the proposed test plan. The test plan shall include, at a minimum, the proposed schedule, a list of tests to be completed, equipment to be utilized, expected results, and documentation. The test plan and results shall be provided to the Owner, General Contractor, Architect, and representative(s) of the authorities having jurisdiction.

- C Prior to acceptance of the work, the Contractor shall demonstrate to the Owner, General Contractor, Architect and representative(s) of the authorities having jurisdiction, all systems, subsystems, features and functions of the systems, and shall instruct the Owner in the proper operation and event sequences of the system. The Contractor shall check for correct connections and test for short circuits, ground faults, continuity, and insulation before energizing any cables and wires.
- D The Contractor shall furnish the necessary trained personnel to perform demonstrations and instruction, and shall arrange to have the respective manufacturer's representative(s) present to assist with the demonstrations.
- E Demonstrate each system and subsystem. Each demonstration is to consist of no less than the following:
 - 1. Designate the actual location of each component of the system or subsystem and demonstrate its function and its relationship to other components within the system or subsystem.
 - 2. Verify the final field-of-view for all security cameras.LAC
 - 3. Demonstrate operations via actual "start/stop", "on/off", and "open/close" cycling, showing how to work controls, reset devices, replace fuses, and emergency operating procedures.
 - 4. Trip all alarm and intrusion detection devices and verify response of alarm and trouble signals.
 - 5. Check installation, supervision, and operation of all intelligent addressable initiating and control devices by physically testing each device in accordance with the manufacturer's requirements.
 - 6. Each of the alarm conditions that the system is required to detect shall be introduced on the system. Verify the proper receipt and the proper processing of the signal at the front-end processing unit and the correct activation of all control points and the sequence of operations.
- F Conduct system startup testing to verify, at a minimum, the functionality of the following items (where applicable):
 - 1. Electronically controlled and/or monitored doors.
 - 2. Authentication hardware (i.e., credential readers).
 - 3. ESS server(s) shutdown and startup.
 - 4. ESS workstations.
 - 5. Management database(s).
 - 6. Recording server(s).
 - 7. Alarm notifications.
 - 8. Administrative log-in.
 - 9. System administrative diagnostic tools and services.
 - 10. Access level permissions.
 - 11. Credential management.
 - 12. Credential operations.
 - 13. Credential printers (including visitor credential printers).
 - 14. Mobile and web applications.
 - 15. Integrations with other systems.
 - 16. Video wall applications.
 - 17. Security camera configurations, labeling, and grouping.

- 18. Storage configuration.
- 19. Intrusion zones.
- G Activate each installed security device through the front-end processing unit and verify proper system operation.
- H Tag all equipment, stations, and other components for which tests have been satisfactorily completed.
- I Comply with the requirements of system demonstrations outlined in Division 01.
- J Upon completion and approval of acceptance testing and system startup, training for the Owner shall proceed.

3.11 DEMONSTRATION

- A Participate in project site observations, walkthroughs, and punch lists as requested by the Owner and/or the Architect.
- B Demonstrate completeness of work relative to completion percentages submitted for payment.

3.12 CLEANING

- A After completing system installation, including outlet fittings and devices, inspect exposed finishes.
- B Remove burrs, dirt, and construction debris, and repair damaged finishes, including chips, scratches, and abrasions.

3.13 INSPECTIONS

- A At the completion of the project and prior to final acceptance of the work, provide evidence of final inspections and approvals to the Owner as required by the authorities having jurisdiction per Division 01.

3.14 ADJUSTMENTS

- A Within one (1) year of the date of substantial completion, provide up to three (3) site visits, when requested by Owner, to adjust and calibrate components and to assist the Owner in making program changes and in adjusting equipment and controls to suit actual conditions. Visits for this purpose shall be in addition to any required by warranty.

END OF SECTION

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SECTION 281300**ELECTRONIC ACCESS CONTROL SYSTEM****PART 1 – GENERAL****1.1 SECTION INCLUDES**

- A This section includes the necessary components required to provide a complete and fully functional electronic access control (EAC) system, including (but not limited to) servers, credentials and credential readers, door hardware, peripherals, software, and installation for wiring systems to be used for connection of equipment and devices.

1.2 SYSTEM DESCRIPTION

- A The EAC system shall be an extension of the existing and will serve as the key component for managing the EAC software and hardware. The software, equipment, devices, and server specified herein shall form one integrated system.
- B The EAC system shall provide for a variety of integral functions, including (but not limited to):
1. Controlled access for authorized personnel within predetermined areas based on time and/or clearance level.
 2. Monitor, track, and interface the following alarms (at a minimum):
 - a. Access granted.
 - b. Access denied.
 - c. Door forced open.
 - d. Door held open.
 3. Capable of providing, at a minimum, a hardwired signal to the electronic video surveillance (EVS) system to begin viewing, recording, and storing video upon the activation of a selected alarm point where an event has been detected.
 4. Programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times.
 5. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance
 6. Manual control stations shall have the ability to override programmed settings.
 7. Doors containing fail-safe electronic locking hardware that is connected to the EAC system and are in the path of code-required egress or in stair towers shall be connected to the fire alarm system in accordance with national and local codes such that they automatically unlock in the event of actuation of the fire alarm system. The Contractor shall coordinate with the fire alarm installer to ensure the proper type and quantity of relays are installed and configured to achieve this functionality.
 8. All fire-rated doors shall remain positively latched when electronically unlocked.
 9. The system shall support the functions and features indicated herein.

1.3 SUBMITTALS

- A As specified in Section 280500.

- B Product Data:
 - 1. Software.
 - 2. Server.
 - 3. Workstations.
 - 4. Field hardware.
 - 5. Authentication hardware.
 - 6. Access and door devices
 - 7. Wiring and cabling.
- C Shop Drawings:
 - 1. System interconnection diagram(s) and EAC device locations.
 - 2. Enclosure and equipment rack layouts and elevations.
- D Programming Schedule:
 - 1. Programming information in spreadsheet format, to include (but not be limited to) the following information by door:
 - a. When door is scheduled to be secured.
 - b. What groups or individuals have access and when.
 - c. Holiday schedules.
 - d. Users.
- E Maintenance Data.
- F Warranty.

1.4 QUALITY ASSURANCE

- A Coordinate locations of power raceways and receptacles with locations of security equipment requiring power to operate. Coordinate with Division 26.
- B Coordinate electrified door hardware and door devices being provided with the EAC system. Coordinate door leaf and frame preparations with the door hardware provider to meet ESS requirements. Coordinate with Division 08.

PART 2 – PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A Coordinate the features of materials and equipment such that they form an integrated system. Match components and interconnections for optimum present and future performance.

2.2 SOFTWARE

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Cloud-Based:
 - a. Schlage ENGAGE or pre-approved equivalent. Must be compatible with the existing Schlage ENGAGE system.

- B The software shall be an enterprise-class networked access control solution.
- C Provide and configure software site license.
- D The software shall be capable of providing a unified platform for the electronic security systems, including the electronic video surveillance (EVS) system and security intercom system.
- E The software shall be a single intuitive interface for simplistic operations.
- F Provide software edition (e.g., "standard", "pro", "expert", "enterprise", etc.) as required to meet the requirements of the drawings, as well as the features and functions outlined within these specifications.
- G Provide all additional client, server, and reader licenses and dongles required for the system as specified herein. Provide all third-party software licenses as required for the proper operation of the system.
- H Provide a failover software module for the directory server. The software shall be capable of failing over to a secondary directory server in case of emergency or disaster recovery.
- I The software shall be capable of the following administrative functions:
 - 1. Support an unlimited number (i.e., limited only by licensing) of credential readers, input points, outputs points, and user workstation computers.
 - 2. Support an unlimited number of system events and system operator transactions in a history file, limited only by available disk space.
 - 3. Support user-defined data files, personnel records, and custom report generation. These reports shall be capable of being predefined and saved within the data for ease of exporting and documentation.
- J The following software functions and features shall be provided and configured. These features are in addition to the required setup and programming required to provide a fully functional EAC system.
 - 1. Scheduled locking and unlocking of all electronically-controlled doors.
 - 2. Creation (e.g., design, printing, programming) and management of physical credentials.
 - 3. Management of credential holders and credential holder groups.
 - 4. Complete integration with the Owner's directory service (e.g., Active Directory, Okta, Azure) with automatic updating.
 - 5. Dynamic graphical floor plan mapping for all ESS devices.
 - 6. Email and text message alerts.
 - 7. Setup and installation of mobile applications (Android and iOS) and web client (Windows).
 - 8. Native integration with the following systems (provide third-party integration when native integration is not available):
 - a. Electronic video surveillance for viewing, recording, storing, and bookmarking video upon the activation of selected alarm points where an event has been detected.
 - b. Security intercom for answering or initiating calls, viewing video feed(s), and two-way audio communication.

2.3 SERVER

- A Cloud-Based Server
 - 1. Provided as part of software platform.

2.4 FIELD HARDWARE

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Schlage.
- B All decisions regarding access, alarms, and automatically-timed functions shall be made at the controller level, independent of the server.
- C All field hardware shall be fully compatible with each other.
- D Intelligent Controller Board
 - 1. Provide intelligent controller(s) for connection to the EAC software and to all downstream credential reader, input, and output interface boards.
 - 2. Hardware and firmware shall be compatible with the EAC software.
 - 3. Capable of receiving, processing, and transmitting real-time commands from the EAC software.
 - 4. Capable of acting as a standalone system when the EAC software is down/offline.
 - 5. Connectivity:
 - a. TCP/IP to EAC software.
 - b. Serial to downstream credential reader, input, and output boards.
 - 6. Mounting:
 - a. Within EAC enclosure.
 - 7. Power:
 - a. Match EAC power supply.
- E Credential Reader Interface Board
 - 1. Provide credential reader interface board(s) for connection to all electronic door hardware/devices, authentication hardware, and activation devices.
 - 2. Connectivity:
 - a. Serial to intelligent controller board.
 - 3. Reporting:
 - a. Upstream to intelligent controller board.
 - 4. Credential Reader Inputs:
 - a. Minimum of two (2).
 - 5. Provides, at a minimum, the following inputs:
 - a. Credential reader input and power.
 - b. Door status monitoring.
 - c. Request-to-exit status monitoring.
 - d. Electronic lock relay.
 - e. Auxiliary relay.
 - 6. Mounting:
 - a. Within EAC enclosure.

7. Power:
 - a. Match EAC power supply.
- F Input Interface Board
 1. Provide input interface board(s) for all input connections.
 2. Connectivity:
 - a. Serial to intelligent controller board.
 3. Reporting:
 - a. Upstream to intelligent controller board.
 4. Inputs:
 - a. Supervised.
 5. Mounting:
 - a. Within EAC enclosure.
 6. Power:
 - a. Match EAC power supply.
- G Output Interface Board
 1. Provide output board, as required, for all output connections.
 2. Connectivity:
 - a. Serial to intelligent controller board.
 3. Reporting:
 - a. Upstream to intelligent controller board.
 4. Outputs:
 - a. Supervised.
 5. Mounting:
 - a. Within EAC enclosure.
 6. Power:
 - a. Match EAC power supply.
- H Door Interface Relay
 1. Provide door interface relay board(s), as required, for connection to all powered door auto-operators and associated actuators to the EAC system.
 2. Reporting:
 - a. Upstream to intelligent controller board.
 3. Mounting:
 - a. At door location on secure side.
 4. Power:
 - a. Match EAC power supply.
 5. Provide relay module(s) to interface powered door auto-operator actuators.
 - a. Normally closed for fail safe; normally open for fail secure.
 - b. Capable of 6, 12, or 24 VDC operation.
 - c. Contacts:
 - 1) DPDT, 1A / 120 VAC or 2A / 28 VDC.

2.5 AUTHENTICATION HARDWARE

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.

1. Credentials:
 - a. HID.
 - b. STid.
 - c. Shall be compatible with the existing system.
2. Credential Readers:
 - a. HID.
 - b. STid.
 - c. Shall be compatible with the existing system.

B Credential

1. Type:
 - a. Keycard.
2. Printable:
3. Credential Technology Compatibility:
 - a. 13.56 MHz smart card.
 - 1) MIFARE DESFire EV3.
 - 2) Shall be compatible with the existing system.
4. Provide and configure credentials as directed by the Owner.
5. Provide a quantity of one hundred (100) to the Owner.

C Credential Reader

1. Credential Technology Compatibility:
 - a. 13.56 MHz smart card.
 - 1) MIFARE DESFire EV1, EV2, and EV3.
 - 2) MIFARE Classic EV1.
 - 3) HID iClass.
 - 4) HID Seos.
 - b. 125 kHz proximity card.
 - 1) HID Proximity.
 - 2) HID Indala.
2. Credential reader shall support the specified credentials.
3. Communication:
 - a. Wiegand and Open Supervised Device Protocol (OSDP).
4. Connection:
 - a. Upstream to credential reader interface board.
5. Read Range:
 - a. Minimum of 2" away.
6. Integrated RGB LED indicates credential access.
 - a. Green: Successful authentication.
 - b. Red: Unsuccessful authentication.
7. Audible Feedback:
 - a. Single beep: Successful authentication.
8. Mounting:
 - a. Refer to drawings.
9. Form Factor:
 - a. Refer to drawings.
10. Integrated Keypad:

- a. Refer to drawings.
- 11. Finish:
 - a. Black.
- 12. Environmental Rating:
 - a. IP65.
- 13. Licensing:
 - a. Provide quantity of software licenses as required by the drawings, plus two (2) spare.

2.6 CREDENTIAL PRINTERS

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Card Credential Printers:
 - a. BadgePass.
 - b. HID Fargo.
 - c. IDP.
 - d. Magicard.
 - e. Zebra.
 - f. Or pre-approved equivalent.
- B Card Credential Printer
 - 1. Provide, program, and print credentials as required by the Owner.
 - 2. High-capacity card printing.
 - 3. Card encoding.
 - a. Smart card.
 - b. Proximity card.
 - c. EPC Gen2 UHF.
 - 4. Simultaneous printing and encoding.
 - 5. Custom card image printing.
 - a. Single-sided printing.
 - b. Dual-sided printing.
 - 6. Ethernet connection(s).
 - a. Wired.
 - b. Wireless.
 - 7. Compatible with credential specified.
 - 8. Printer(s) shall be set up in location(s) indicated by the Owner.
 - 9. Alarm Controls.
 - 10. Bosch.
 - 11. George Risk Industries (GRI).
 - 12. Honeywell.
 - 13. Potter Electric Signal.
 - 14. Safety Technology International (STI).
 - 15. Seco-Larm.
 - 16. Securitron.
 - 17. Security Door Controls (SDC).

2.7 DOOR DEVICES

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Bosch.
 - 2. George Risk Industries (GRI).
 - 3. Honeywell.
 - 4. Magnasphere.
 - 5. Seco-Larm.
 - 6. Securitron.
 - 7. Or pre-approved equivalent.
- B Provide wiring and connection to EAC interface board for each device.
- C Refer to the Security and Door Hardware Coordination Schedule for additional information.
- D Standard Door Position Switch
 - 1. Mounting:
 - a. Recessed.
 - 2. Size:
 - a. 1" diameter.
 - 3. Gap Distance:
 - a. Up to 1/2".
 - 4. Switch Type:
 - a. Double pole, double throw.
 - 5. Finish:
 - a. White.
 - 6. Function:
 - a. Generate propped door alarm in EAC software based on schedule and duration.
 - 7. UL-listed.
- E Request-to-Exit Motion Sensor
 - 1. Mounting:
 - a. Surface; centered on or directly above door frame above door opening.
 - b. Adjust sensitivity to permit operation on motion of persons within 2'-0" of door. Where possible, avoid false activation by persons passing by.
 - 2. Switch Type:
 - a. Single pole, double throw.
 - 3. Loop Type:
 - a. Open/Closed.
 - 4. Indicator:
 - a. Activation LED.
 - 5. Coverage:
 - a. 8' x 10' minimum.
 - 6. Finish:
 - a. White.
 - 7. Function:
 - a. Shunt door position switch to prevent propped door alarm.

8. UL-listed.

2.8 DOOR HARDWARE

- A Provide wiring and connection to EAC interface board for each device.
- B Refer to the Security and Door Hardware Coordination Schedule for additional information.
- C Latch Bolt Monitor (LBM)
 - 1. Furnished with door hardware. Contractor shall provide cabling and connection to EAC interface board. Coordinate connection point with door hardware supplier.
- D Magnetic Lock
 - 1. Furnished with door hardware. Contractor shall provide cabling and connection to EAC interface board, and shall coordinate connection point with door hardware supplier.
- E Electric Strike
 - 1. Furnished with door hardware. Contractor shall provide cabling and connection to EAC interface board, and shall coordinate connection point with door hardware supplier.
- F Electrified Lockset
 - 1. Furnished with door hardware. Contractor shall provide cabling and connection to EAC interface board, and shall coordinate connection point with door hardware supplier.
- G Electrified Exit Device
 - 1. Furnished with door hardware. Contractor shall provide cabling and connection to EAC interface board, and shall coordinate connection point with door hardware supplier.
- H Electric Power Transfer / Wire Transfer Hinge
 - 1. Furnished with door hardware. Contractor shall provide cabling and connection to EAC interface board, and shall coordinate connection point with door hardware supplier.

2.9 CONDUCTORS AND CABLES

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. Advanced Digital Cable (ADC).
 - 2. Belden.
 - 3. Honeywell.
 - 4. Prysmian Group (CAROL).
 - 5. West Penn Wire.
 - 6. Windy City Wire.
 - 7. Or pre-approved equivalent.
- B Access Control Composite Cable
 - 1. Type:
 - a. Overall jacket.
 - 2. Each set of conductors shall be individually labeled and colored.

- a. Lock:
 - 1) Four (4) conductors.
 - 2) #16 AWG.
 - 3) Unshielded.
 - b. Credential Reader:
 - 1) Six (6) conductors.
 - 2) #18 AWG.
 - 3) Shielded.
 - c. Door Position Switch:
 - 1) Two (2) conductors.
 - 2) #18 AWG
 - 3) Unshielded.
 - d. Request-to-Exit or Spare:
 - 1) Four (4) conductors.
 - 2) #18 AWG.
 - 3) Unshielded.
 - 3. Jacket Rating:
 - a. Plenum (CMP).
 - 4. Jacket Color:
 - a. Yellow.
 - 5. Verify final conductor sizes prior to ordering.
- C Ancillary Security Cable
- 1. Type:
 - a. Overall jacket.
 - 2. Each set of conductors shall be individually labeled and colored.
 - a. Quantity, size, and shielding shall be provided as required. Refer to drawings.
 - 3. Jacket Rating:
 - a. Plenum (CMP).
 - 4. Jacket Color:
 - a. Yellow.
 - 5. Verify final conductor sizes prior to ordering.

2.10 ENCLOSURES, POWER SUPPLIES, AND CABLE MANAGEMENT

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
- 1. EAC Enclosures:
 - a. Altronix.
 - b. LifeSafety Power.
 - c. Or pre-approved equivalent.
 - 2. EAC Power Supplies:
 - a. Altronix.
 - b. LifeSafety Power.
 - c. Or pre-approved equivalent.
- B EAC Enclosure

1. Provide an EAC enclosure(s) to house EAC field hardware and to route cabling. Enclosure(s) shall house equipment, batteries, and power supplies.
2. Construction:
 - a. High-grade steel.
 - b. Conduit knockouts at top and bottom.
3. Security:
 - a. Lock and key.
 - b. Door position switch.
4. Backplane:
 - a. #16 AWG.
5. Finish:
 - a. Black.
6. Enclosure(s) shall be sized to house all EAC field hardware, plus ten percent (10%).

C EAC Power Supply

1. Mounting:
 - a. Within EAC enclosure.
2. Power Input:
 - a. 115 volts AC @ 60 Hz.
3. Input Options:
 - a. Minimum of eight (8) normally open or open collector, or any combination of each.
4. Power Output:
 - a. 12 volts DC or 24 volts DC @ 6 amps (minimum).
5. Output Options:
 - a. Minimum of eight (8) independently-controlled fail-safe, fail-secure, or auxiliary (unswitched) power outputs.
6. Output Fuse Rating:
 - a. 3.5 amps; individually fused.
7. Power Distribution:
 - a. Dedicated for each device.
8. Supervision:
 - a. AC fail with SPDT contacts.
9. Features:
 - a. Visual Indicators.
 - b. Thermal overload protection.
 - c. Alarm output relays.
10. Battery Backup:
 - a. Built-in charger with sealed lead-acid batteries.
 - b. Automatic cutover to standby batteries upon AC power failure.
 - c. AC fail supervision relay output.
 - d. Battery fail and battery presence supervision relay output.
 - e. Provide battery capacity for four (4) hours of operation, assuming thirty (30) 1.25-amp door unlocks, per door, per hour.
11. Fire Alarm Disconnect:
 - a. Latching or non-latching.
 - b. Individually selectable for any or all outputs.
 - c. Normally open (NO) or normally closed (NC) dry contact input.

- d. Alarm output relay indication that fire alarm control panel input is triggered.

2.11 SURGE PROTECTION DEVICES

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. DITEK.
 - 2. Nitek.
 - 3. Or pre-approved equivalent.
- B Credential Reader Surge Protector
 - 1. Basis of Design:
 - a. DITEK DTK-4LVLPLV or pre-approved equivalent..
- C Door Device Surge Protector
 - 1. Basis of Design:
 - a. DITEK 2MHLP Series or pre-approved equivalent..
- D Door Hardware Surge Protector
 - 1. Basis of Design:
 - a. DITEK DTK-ESS or pre-approved equivalent..
- E Provide surge protection devices for all exterior electronically controlled and/or monitored doors, including at all exterior credential readers, exterior door devices, and exterior door hardware. Surge protection devices shall be installed within equipment room(s) where EAC cabling terminates. Refer to drawings.

PART 3 – EXECUTION

3.1 EXAMINATION

- A As specified in Section 280500.

3.2 SYSTEM INSTALLATION

- A As specified in Section 280500.
- B Install, wire, and power all devices per manufacturer recommendations.
- C Mount server within the indicated equipment rack or network cabinet. Refer to drawings.
- D Install workstation(s) on or within security desk(s) as indicated. Refer to drawings.
- E Mount all credential readers where shown on drawings. Coordinate exact placement with architectural element; refer to architectural drawings. Placement shall be in accordance with ADA requirements.
 - 1. Multiple ESS devices at a single door location shall be mounted adjacent to one another.

3.3 DOOR HARDWARE COORDINATION

- A Doors and frames shall be properly prepared to receive specified electrified hardware and door devices without additional field modifications. Coordinate requirements with the hardware, door, and frame providers.
- B Verify operation of each electronically controlled and/or monitored door and door opening to ensure proper secured operation and function. Adjust door hardware and door devices as needed to ensure proper operation. Door hardware and door devices that cannot be adjusted to operate as required shall be replaced.

3.4 WIRING INSTALLATION

- A As specified in Section 280500.
- B Route individual conductors neatly within enclosure(s). Each access control composite cable shall be neatly bundled per door and terminated at interface board. Each bundle shall be clearly identified for troubleshooting, and moves, adds, or changes.

3.5 GROUNDING AND BONDING

- A As specified in Section 280500.
- B Bond EAC field hardware and enclosures to the telecommunications primary bonding busbar (PBB) or to the nearest telecommunications secondary bonding busbar (SBB). Comply with manufacturer recommendations.

3.6 INTERFACE WITH OTHER WORK

- A As specified in Section 280500.
- B Coordinate with the Division 08 installer regarding door hardware, frames, and leaves which are associated with the ESS. Verify rough-in requirements and coordinate installation requirements for all ESS equipment which is to be mounted on or within a door frame or leaf.
- C Prior to the start of installation, schedule and facilitate a preinstallation meeting with the pertinent door hardware, frame, leaf, lock, etc., manufacturer representative(s) and related trades to coordinate materials, techniques, and to sequence complex hardware items and system installation. Proper installation and adjustment of hardware shall be reviewed. Convene at least one (1) week prior to commencement of ESS installation. Provide written documentation of the meeting, including date, list of participants, and minutes.

3.7 IDENTIFICATION AND LABELING

- A Label all installed electronic access control cabling and equipment.
- B Prior to installation, the Contractor shall provide samples of all label types planned for the project. These samples shall include examples of the lettering to be used.

- C Label equipment and cables such that they can be easily identified.
 - 1. Label field hardware with identifier of door being served.
 - 2. Label overall jacket of each access control composite cable.
 - a. Near door being served.
 - b. Just before entering the EAC enclosure.
 - 3. Label each individual bundle within each access control composite cable.
 - 4. Label each ancillary security cable.
- D Wiring and cables shall be color-coded as required by function. Maintain color-coding and labeling scheme throughout entire system.

3.8 ACCEPTANCE TESTING

- A As specified in Section 280500.

3.9 SYSTEM STARTUP

- A As specified in Section 280500.

END OF SECTION

SECTION 282300**ELECTRONIC VIDEO SURVEILLANCE SYSTEM****PART 1 – GENERAL****1.1 SECTION INCLUDES**

- A This section includes necessary components required to provide a complete and fully functional electronic video surveillance (EVS) system, including (but not limited to) servers, cameras, licenses, peripherals, software, and installation for wiring systems to be used for connection of equipment and devices.

1.2 SYSTEM DESCRIPTION

- A The EVS system shall be an extension of the existing and will serve as the key component for managing the EVS software and hardware. The system shall be capable of full video control, monitoring, and recording. The software, equipment, devices, and server specified herein shall form one integrated system.
- B The EVS system shall provide for a variety of integral functions, including (but not limited to):
1. Video capture at full camera resolution with the following frame rates:
 - a. Live video at thirty (30) FPS (nominal).
 - b. Continuous recorded video at thirty (30) FPS (nominal).
 - c. Motion-activated and/or alarm-activated recorded video at thirty (30) FPS (nominal).
 2. Thirty (30) days minimum of digital storage for all recorded video.
 3. Triggering of event-based recording parameters, with five (5) seconds pre-record and five (5) seconds post-record.
 4. Ability to archive selected video from specific incidents until manually selected for deletion.
 5. Ability to view live and recorded video from remote locations via internet connectivity.
 6. Chain of custody on recorded video files to ensure authenticity for use as evidence.
 7. PTZ control via joystick, keyboard, and workstation software with support for multiple PTZ control protocols.
 8. Multiple viewers of the same camera feed or recorded video files simultaneously.
 9. Support for either a direct connection or network connection to an external time source, including the capability of acting as either a master clock for an additional system or as a listener to allow for synchronization to a master system.

1.3 SUBMITTALS

- A As specified in Section 280500.
- B Product Data:
1. Software.
 2. Server.
 3. Workstations.
 4. Cameras.

- C Shop Drawings:
 - 1. System interconnection diagram(s) and EVS device locations.
 - 2. Enclosure and equipment rack layouts and elevations.
- D Programming Schedule:
 - 1. Programming information in spreadsheet format, to include (but not be limited to) the following information by camera:
 - a. Alphanumeric identifier.
 - b. Location.
 - c. Field(s) of view.
 - d. Manufacturer and model.
 - e. Framerate.
 - f. Resolution.
- E Maintenance Data.
- F Warranty.

1.4 QUALITY ASSURANCE

- A Coordinate locations of power raceways and receptacles with locations of security equipment requiring power to operate. Coordinate with Division 26.

PART 2 – PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A Coordinate the features of materials and equipment such that they form an integrated system. Match components and interconnections for optimum present and future performance.

2.2 SOFTWARE

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. On-Premise:
 - a. Milestone Systems XProtect or pre-approved equivalent. System shall be compatible with existing Milestone XProtect system.
- B The software shall be an enterprise-class networked video surveillance solution.
- C Provide and configure software site license.
- D The software shall be a single intuitive interface for simplistic operations.
- E Provide software edition (e.g., "standard", "pro", "expert", "enterprise", etc.) as required to meet the requirements of the drawings, as well as the features and functions outlined within these specifications.

- F Provide all additional client, server, and camera licenses and dongles required for the system as specified herein. Provide all third-party software licenses as required for the proper operation of the system.
- G Provide a failover software module for the directory server. The software shall be capable of failing over to a secondary directory server in case of emergency or disaster recovery.
- H The software shall be capable of the following administrative functions:
 - 1. Support an unlimited number (i.e., limited only by licensing) of cameras and user workstation computers.
 - 2. Support an unlimited number of system events and system operator transactions in a history file, limited only by available disk space.
 - 3. Support user-defined data files, personnel records, and custom report generation. These reports shall be capable of being predefined and saved within the data for ease of exporting and documentation.
- I The following software functions and features shall be provided and configured. These features are in addition to the required setup and programming required to provide a fully functional EVS system.
 - 1. Control and view all sources of security-related video within the facility (unless noted otherwise on drawings).
 - 2. Manage and present video in a user-friendly viewing platform.
 - 3. Single graphical user interface to monitor, control, and perform administrative functions.
 - 4. Complete integration with the Owner's directory service (e.g., Active Directory, Okta, Azure) with automatic updating.
 - 5. Dynamic graphical floor plan mapping for all ESS devices.
 - 6. Email and text message alerts.
 - 7. Setup and installation of mobile applications (Android and iOS) and web client (Windows).
 - 8. Native integration with the following systems (provide third-party integration when native integration is not available):
 - a. Electronic access control for viewing, recording, storing, and bookmarking video upon the activation of selected alarm points where an event has been detected.
 - b. Security intercom for answering or initiating calls, viewing video feed(s), and two-way audio communication.

2.3 SERVER

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. AMAG Technology.
 - 2. Axis.
 - 3. BCD.
 - 4. Bosch.
 - 5. Dell Technologies.
 - 6. Exacq Technologies.
 - 7. Hewlett Packard Enterprise.
 - 8. IBM.
 - 9. i-Pro.

10. LenelS2.
11. Lenovo.
12. Or pre-approved equivalent.

B Physical Server

1. General:
 - a. The server shall meet or exceed the following requirements or the current recommended requirements published by the EVS software manufacturer at the time of purchase, whichever is higher.
 - b. The server shall be provided as a single server to operate the EAC and EVS systems. Refer to Section 281300 for EAC system requirements.
2. Form Factor:
 - a. Rack-mountable.
3. Processor(s):
 - a. Two (2) Intel Xeon 4-core, or equivalent.
4. Operating System:
 - a. Most recent Windows Server version supported.
5. Storage Capacity:
 - a. Minimum amount to store recorded video as indicated in this section, plus ten percent (10%).
6. Storage Controller:
 - a. Hardware RAID 6 (two drive failures).
7. Hard Disk Drives:
 - a. Hot-swappable.
 - b. SAS.
8. Memory:
 - a. Minimum 16 GB RAM.
9. Network Interface(s):
 - a. Two (2) 1 GbE (RJ45).
 - b. Two (2) 10 GbE (SFP).
10. Ports:
 - a. One (1) USB 2.0.
 - b. One (1) USB 3.0 or greater.
 - c. One (1) VGA.
11. Power Supplies:
 - a. Two (2) redundant.
 - b. Hot-swappable.

2.4 CAMERAS

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
1. Axis.
 2. Bosch.
 3. Hanwha.
 4. Honeywell.
 5. i-PRO.
 6. Or pre-approved equivalent.

- B Refer to the Security Camera Schedule for exact camera types and additional information.
- C Provide all mounts, licenses, hardware, and associated equipment required to install, mount, and configure cameras. Mounts shall be in accordance with the drawings.
- D Power supplies and/or heaters shall be provided for cameras requiring such hardware to operate.

2.5 SYSTEM HARDWARE

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. KVM Consoles:
 - a. Austin Hughes CyberView.
 - b. Belkin.
 - c. Raloy.
 - d. Tripp Lite (Eaton).
 - e. Or pre-approved equivalent.
 - 2. PoE Extenders:
 - a. Axis.
 - b. DITEK.
 - c. Tripp Lite (Eaton).
 - d. Veracity.
 - e. Or pre-approved equivalent.
- B KVM Console:
 - 1. Form Factor:
 - a. Rack-mountable.
 - 2. Viewable Screen Size (Diagonal):
 - a. 17 inches minimum.
 - 3. Screen Resolution:
 - a. Refer to drawings.
 - 4. Inputs:
 - a. HDMI.
 - b. VGA.
 - c. RJ45.
 - 5. Features:
 - a. Hot-pluggable.
 - b. Flip-up/fold-down display.
 - c. Compatible with all major operating systems.
 - d. Included cabling kit.
 - e. Included ground wire. Bond to equipment rack.
 - f. Included power cord.
 - 6. Install within main equipment room near the EVS server.
- C PoE Extender
 - 1. Form Factor:
 - a. Wall-mountable.
 - 2. Range

- a. Up to 200 meters.
- 3. PoE:
 - a. Up to 90 watts.
- 4. Bandwidth:
 - a. Up to 1,000 Mbps.
- 5. Rating:
 - a. Indoor.
- 6. Provide PoE extension for all networked security devices with cable runs exceeding 295 feet.

2.6 SURGE PROTECTION DEVICES

- A Subject to compliance with requirements, provide products by one of the following pre-approved manufacturers.
 - 1. DITEK.
 - 2. Nitek.
 - 3. Or pre-approved equivalent.
- B Camera Surge Protector
 - 1. Form Factor:
 - a. Wall-mountable.
 - 2. Features:
 - a. Supports 10 GbE.
 - b. Supports 90-watt PoE.
 - c. Supports Category 6A.
- C Provide surge protection devices for all exterior cameras. Surge protection devices shall be installed within equipment room(s) where cabling terminates. Refer to drawings.

2.7 LAN EQUIPMENT

- A Provided by the Owner.

2.8 CONDUCTORS AND CABLES

- A Provided by Division 27.

2.9 CABLE TERMINATION EQUIPMENT

- A Provided by Division 27.

2.10 EQUIPMENT RACKS AND CABINETS

- A Provided by Division 27.

PART 3 – EXECUTION

3.1 EXAMINATION

- A As specified in Section 280500.

3.2 SYSTEM INSTALLATION

- A As specified in Section 280500.
- B Install, wire, and power all devices per manufacturer recommendations.
- C Mount server within the indicated equipment rack or network cabinet. Refer to drawings.
- D Install workstation(s) on or within security desk(s) as indicated. Refer to drawings.

3.3 WIRING INSTALLATION

- A Provided by Division 27.

3.4 GROUNDING AND BONDING

- A As specified in Section 280500.
- B Bond EVS system hardware to the telecommunications primary bonding busbar (PBB) or to the nearest telecommunications secondary bonding busbar (SBB). Comply with manufacturer recommendations.

3.5 INTERFACE WITH OTHER WORK

- A As specified in Section 280500.
- B Coordinate with the structured cabling contractor to confirm required cabling locations, terminations, and connections.

3.6 IDENTIFICATION AND LABELING

- A Label all installed devices.
- B Prior to installation, the Contractor shall provide samples of all label types planned for the project. These samples shall include examples of the lettering to be used.
- C Label devices such that they can be easily identified.
 - 1. Label each camera with unique identifier.
 - 2. Label each piece of equipment related to the EVS system as required.

3.7 ACCEPTANCE TESTING

- A As specified in Section 280500.

3.8 SYSTEM STARTUP

A As specified in Section 280500.

END OF SECTION

SECTION 284600
FIRE DETECTION AND ALARM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Fire alarm system and associated components, including control units, related equipment, initiating devices, and notification appliances.
- B Fire alarm system design and installation, including all components, wiring, and conduit.
- C Maintenance of fire alarm system under contract for specified warranty period.

1.2 REFERENCE STANDARDS

- A 36 CFR 1191 - Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines.
- B ADA Standards - 2010 ADA Standards for Accessible Design.
- C IEEE C62.41.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits.
- D NFPA 70 - National Electrical Code.
- E NFPA 72 - National Fire Alarm and Signaling Code.
- F NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- G UL 864 - Control Units and Accessories for Fire Alarm Systems.

1.3 DEFINITIONS

- A FACP: Fire Alarm Control Panel

1.4 SUBMITTALS

- A Comply with NFPA 72 chapter "Documentation," including noting names of installers, owners, and system classification information.
- B Submittals to Authorities Having Jurisdiction: Prior to submitting to the Architect, submit product data and shop drawings to authorities having jurisdiction. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review. Submittals received without the approval of authorities having jurisdiction will be returned with no action taken.
- C Specification Compliance Review: See Section 26 0400 - Common Requirements for Electrical, for requirements.

- D Product Data: Manufacturer's data sheets for each system component.
- E Shop Drawings: Submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, riser diagrams, and description of operation:
1. Copy (if any) of list of data required by AHJ.
- F Shop Drawings: Submit installation documentation required for plan review and permitting by AHJ, including floor plans showing locations of fire alarm system components, enlarged drawn to identified scale plan view, and riser diagrams.
1. System zone boundaries and interfaces to fire safety systems.
 2. Show locations of components, circuits, and raceways; mark components with identifiers used in control unit programming.
 3. Include elevations and details of proposed equipment arrangements.
 4. Include system interconnection schematic riser diagram showing proposed and approved cable size and type; coordinated with floor plans and describing circuit class, survivability, and application specific information required by NFPA 72.
 5. Include typical wiring diagrams for devices, notification appliances, remote indicators, annunciators, remote test stations, and EoL and power supervisory devices.
 6. Include requirements and control diagrams for interfacing with other systems.
 7. Circuit layouts; number, size, and type of raceways and conductors; conduit fill calculations; standby and spare capacity calculations; notification appliance circuit loop resistance and voltage drop calculations, including spare capacity.
 8. List of devices and notification appliances on each SLC, with spare capacity indicated.
 9. Manufacturer's detailed data sheet for each component, including wiring diagrams, installation instructions, and circuit length limitations.
 10. Description of power supplies; if secondary power is by battery include calculations demonstrating adequate battery power.
 11. Detailed drawing of graphic annunciators, displays, and interfaces.
 12. Certification by either FACU manufacturer or manufacturer of related equipment.
 13. Certification by FACU manufacturer that system design complies with Contract Documents.
 14. Certification by Contractor that system design complies with Contract Documents.
- G Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
1. System interfaces to fire safety systems.
 2. Floor plans indicating locations of components; mark components with device addresses used in control unit programming. Show interconnection of devices.
 3. Riser Diagram: Indicate circuiting, device addresses and cable types.
 4. Calculations: Battery sizing, voltage drop, and audio amplifier sizing.
 5. List of all devices on each signaling line circuit, with spare capacity indicated.
- H Inspection and Test Reports:
1. Submit inspection and test plan prior to closeout demonstration.
 2. Submit documentation of satisfactory inspections and tests.
 3. Submit NFPA 72 "Inspection and Test," filled out.

- I Operating and Maintenance Data: See Section 01 7800 for additional requirements; revise and resubmit until acceptable; have one set available during closeout demonstration:
- J Maintenance Materials, Tools, and Software: Furnish the following for Owner's use in maintenance of project.
 - 1. Furnish spare parts of same manufacturer and model as those installed; deliver in original packaging, labeled in same manner as in operating and maintenance data.
 - 2. In addition to items in quantities indicated in PART 2, furnish the following:
 - a. Remote Indicating Lamp Units: Quantity equal to 5 percent of amount installed, but not less than 1 unit.
 - b. Smoke and Heat Detectors: Quantity equal to 5 percent of amount of each type installed, but not less than 1 unit of each type.
 - c. Detector Bases: Quantity equal to 5 percent of amount of each type installed, but not less than 1 unit of each type.
 - d. Keys and Tools: One extra set.
 - e. Audible and Visual Notification Appliances: One of each type installed.
 - f. Extra Fuses: Two for each installed fuse; store inside applicable control cabinet.

1.5 QUALITY ASSURANCE

- A Designer Qualifications: NICET Level III (three) or Level IV (four) certified fire alarm technician or registered fire protection engineer, employed by FACU manufacturer, Contractor, or installer, with experience designing fire alarm systems in jurisdictional area of AHJ.
- B Manufacturer Qualifications: Company specialized in manufacturing products specified in this section with at least three years of documented experience.
- C Provide products listed and labeled by testing firm acceptable to the authority having jurisdiction as suitable for the purpose indicated.

1.6 WARRANTY

- A Provide control panel manufacturer's warranty that system components other than wire and conduit are free from defects and will remain so for 1 year after date of Substantial Completion.
- B Provide installer's warranty that the installation is free from defects and will remain so for 1 year after date of Substantial Completion.

PART 2 PRODUCTS

2.1 FIRE ALARM SYSTEM

- A General Requirements:
 - 1. Provide new fire alarm system complying with NFPA 70, NFPA 72, NFPA 90A, and consisting of required equipment, conduit, cabinets, outlet boxes, wiring, connectors, hardware, supports, accessories, components, software, and system programming as necessary for complete operating system that provides functional intent indicated.
 - 2. Comply with the following; where requirements conflict, order of precedence of requirements is as listed:

- a. 36 CFR 1191 and ADA Standards.
 - b. Requirements of AHJ.
 - c. Applicable local codes.
 - d. Contract Documents.
 - e. NFPA 72; "should" is mandatory; where conflicts between requirements require deviation, identify deviations clearly on design documents.
3. Fire Alarm System Products:
 - a. Listed, classified, and labeled as suitable for purpose intended.
 - b. Installation Environments: Provide products suitable for their respective indoor and outdoor applications.
4. Provide fire alarm circuits in accordance with NFPA 70.
 - a. Comply with methods of interconnecting FACUs in accordance with NFPA 72 and NFPA 70.
 - b. Power Sources:
 - 1) Comply with requirements for power supplies of emergency systems in accordance with NFPA 70.
 - 2) Primary: Dedicated branch circuits from facility power distribution system.
 - 3) Secondary: Storage batteries with capacity to operate system for period specified by NFPA 72.
 - c. Wiring and Wiring Methods:
 - 1) General Requirements:
 - (a) Comply with requirements for wiring and wiring methods in accordance with NFPA 70.
 - (b) Conductors and Cables Installed Exposed in Spaces Used for Environmental Air (only where specifically permitted): Plenum-rated, listed and labeled as suitable for use in return air plenums.
 - (c) Special Occupancies: Comply with NFPA 70.
 - (d) Comply with NFPA 70 for wire and cable plenum, riser, general-purpose, limited-use, undercarpet, and underground applications.
 - 2) Fire Alarm Circuits:
 - (a) Comply with NFPA 70 for conditions and types required for multiconductor cable systems.
 - (b) Non-Power-Limited Fire Alarm (NPLFA) Circuits:
 - (1) Provide dedicated NPLFA non-GFCI branch circuits for fire alarm equipment and marked by red identification in accordance with NFPA 70.
 - (c) Power-Limited Fire Alarm (PLFA) Circuits:
 - (1) Provide identification for PLFA circuits in accordance with NFPA 70.
 5. Provide pathway class designations and pathway survivability, as defined in NFPA 72.
 - a. Provide monitoring of conductors and other signaling channels for integrity and circuit performance.
 - b. Pathway Class Designations:
 - 1) Unless otherwise indicated or required, pathways to meet the following requirements:
 - (a) SLCs: Class B (star, tee-tap, multi-tap, with no return).
 - (b) IDCs: Class B (daisy-chain with EoL resistor device installed at end of circuit).

(c) NACs: Class B (daisy-chain with EoL resistor device installed at end of circuit).

B Fire Alarm System Interfaces and Control Functions:

1. UL 864 listed unless otherwise indicated.
2. Descriptions below are intended to provide means for interface. See project SOOs, narrative, and input/output matrix for execution requirements.
3. Provide initiating devices, interfaces, and control functions for emergency control function interfaces in accordance with NFPA 72.
4. Provide monitoring of interconnected systems. Coordinate notification appliance alternate markings as indicated on drawings.

2.2 MANUFACTURERS

A Edwards Systems Technology: www.edwardsfiresafety.com

B Notifier: www.notifier.com

C Siemens Building Technologies: www.usa.siemens.com

D SimplexGrinnell: www.simplexgrinnell.com

E _____

F Source Limitations: Furnish fire alarm components produced by a single manufacturer, where possible.

2.3 FIRE ALARM SYSTEM

A Fire Alarm System: Provide a new automatic fire detection and alarm system:

1. Provide all components necessary, regardless of whether shown in the contract documents or not.
2. Comply with the following:
 - a. The Americans With Disabilities Act (ADA).
 - b. The requirements of the State Fire Marshal.
 - c. The requirements of the local authority having jurisdiction .
 - d. NFPA 72 and other applicable codes.
 - e. ANSI B117.1, for elevator operation.
3. FACP Display:
 - a. Minimum of two lines
 - b. Indicate location of device initiating alarm, supervisory or trouble condition by device address and by English-language description.
4. Signal Priority, not affected by order of occurrence:
 - a. Alarm
 - b. Supervisory
 - c. Trouble
5. System Trouble or Supervisory Signal:
 - a. Sound trouble signal and indicate at FACP and remote annunciator.
 - b. Record event in system memory.

6. Alarm Signal:
 - a. Indicate at FACP and remote annunciator.
 - b. Record event in system memory.
 - c. Operate notification appliances continuously, until silenced.
 - d. Operate notification appliances throughout the building.
 7. System Silencing and Reset:
 - a. Controlled by buttons in the FACP and remote annunciator.
 - b. Subsequent alarm signals reactivate notification appliances.
 8. Fire Alarm Control Panel (FACP): New.
- B Circuits:
1. Signaling Line Circuits (SLC): Class B, Style 4.
 2. Notification Appliance Circuits (NAC): Class B, Style Y.
- C Spare Capacity:
1. Signaling Line Circuits: Minimum 25 percent spare capacity.
 2. Notification Appliance Circuits: Minimum 25 percent spare capacity.
 3. Fire Alarm Control Panel: Capable of handling all circuits utilized to capacity without requiring additional components other than plug-in control modules.

2.4 FIRE SAFETY SYSTEMS INTERFACES

- A Supervision: Provide supervisory signals in accordance with NFPA 72 for the following:
1. Sprinkler water control valves.
 2. Elevator shut-down control circuits.
- B Alarm: Provide alarm initiation in accordance with NFPA 72 for the following:
1. Sprinkler water flow.
 2. Elevator lobby, elevator hoistway, and elevator machine room smoke detectors.
 3. Manual stations.
 4. Heat detectors.
 5. Smoke detectors.
- C Elevators:
1. Elevator lobby, hoistway, and machine room smoke detectors: Elevator recall for fire fighters' service.
 2. Elevator Machine Room or hoistway Heat Detector: Shut down elevator power prior to hoistway sprinkler activation.
- D HVAC:
1. Duct Smoke Detectors: Close associated smoke dampers; shut down associated air handling equipment.
 2. General alarm condition: Close smoke dampers in ducts serving the area where the alarm is initiated. Shut down air handling equipment serving the area where the alarm is located.
- E Doors:
1. Door Magnetic Holders: Release upon general alarm condition.
 2. Electrically Locked Doors: Unlock doors in egress path.

2.5 COMPONENTS

A General:

1. Unless otherwise indicated, provide flush-mounted or semi-recessed units where installed in finished areas; in unfinished areas, surface-mounted units are acceptable.

B Fire Alarm Control Units, Initiating Devices: Analog, addressable type; listed by Underwriters Laboratories or other testing agency acceptable to authority having jurisdiction as suitable for the purpose intended.

C Fire Alarm Control Panel:

1. Cabinet: Lockable steel enclosure. Arrange interior components so operations required for testing or for normal maintenance of the system are performed from the front of the enclosure. If more than one unit is required to form a complete control panel, fabricate with matching modular unit enclosure to accommodate components and to allow ample gutter space for field wiring and interconnecting panels.
 - a. Mounting: Semi-flush.
 - b. Keys: Common to all system components.
2. Password Protection: Multi level.
3. Communication Format: Digital poll/response protocol with each addressable device. The system shall verify that the type device at each address matches the software configuration.
4. Event Storage:
 - a. The system stores and logs alarm and trouble events. Each recorded event includes the time and date of the event's occurrence.
 - b. The system has the capability of recalling alarms, [detector verifications,] trouble conditions, acknowledgments, and silencing and reset activities in chronological order for the purpose of recreating an event history.
 - c. Memory: Battery protected random access memory.
 - d. Alarm Log: 300 events.
 - e. Trouble Log: 300 events.
 - f. Available Reports:
 - 1) Alarm, trouble and test conditions including the time and date of each occurrence.
 - 2) Status of each device in the system.
5. Alarm and Supervisory Systems: Separate and independent in the FACP. Alarm-initiating zone boards consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.
 - a. Quantity of Simultaneous Alarms: Unlimited.
 - b. Maintenance Alert: Automatically warns of a contaminated detector prior to false alarm.
6. Control Modules: Include types and capacities required to perform all functions of fire alarm systems.
7. Indications: Local, visible, and audible indication of alarm, supervisory, and trouble conditions.
8. Resetting Controls: Prevent the resetting of alarm, supervisory, or trouble signals while the alarm or trouble condition still exists.
9. Alphanumeric Display and System Controls:
 - a. Display: Liquid-crystal type, two lines, 40 characters per line, minimum. Displays the following:
 - b. Alarm, supervisory and component status.

- c. Programming, display and control commands.
 - d. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
 - e. Bypass Switches: Activation of a bypass switch allows system testing without operation of the bypassed circuit. A trouble condition is generated upon operation of a bypass switch. Provide bypass switches for the following:
 - 1) Remote monitoring station notification.
 - 2) Audio/visual circuits.
 - 3) Smoke dampers.
 - 4) Elevator recall.
 - 5) Fire doors.
10. Programming:
- a. System Memory: Non-volatile, programmable.
 - b. Loading or editing of special instructions and operating sequences allowed as required.
 - c. Capable of on-site programming to accommodate and facilitate expansion, building parameter changes, or changes as required by local codes.
 - d. Provisions for disabling and enabling all addressable devices, and all monitoring, signaling and control circuits individually for maintenance and testing purposes.
11. Digital Alarm Communicator Transmitter:
- a. Listed and labeled under UL 864 and NFPA 72.
 - b. Transmits alarm, supervisory and trouble events to a central monitoring station via telephone lines. The unit supervises up to two telephone lines and reports loss of one line to the central monitoring station. If service is lost on both telephone lines, the local trouble signal is initiated.
 - c. Located within the FACP if possible. Provide integral batteries with an automatic charger if unit is located remotely from FACP.
12. Power Supply:
- a. Primary: Dedicated branch circuits of the facility power distribution system.
 - b. Secondary: Storage batteries operating without an on-site emergency generator.
 - c. Battery Capacity: Sufficient to operate entire system for period specified by NFPA 72.
 - d. Battery Charger: Solid state, automatic with variable charging rate with capacity for 150 percent of connected system load while maintaining batteries at full charge.
- D Remote Annunciator:
- 1. Lockable steel flush-mounted enclosure.
 - 2. Alphanumeric display and controls matching the FACP permit acknowledging, silencing, resetting, and testing functions for alarm, supervisory, and trouble signals.
- E Signal Circuit Remote Power Supply
- 1. General: Filtered, regulated, power limited with trouble indication; with emergency power supply.
 - 2. Cabinet: Lockable steel, surface-mounted enclosure.
- F Initiating Devices:
- 1. Manual Pull Stations:
 - a. Single-action.
 - b. Constructed of metal or plastic.
 - c. Integral addressable module.
 - d. Key-operated reset.

2. Smoke Detectors:
 - a. 24 Volt, DC
 - b. Photoelectric type.
 - c. Self-restoring.
 - d. Integral addressable module.
 - e. LED indicator to show detector status.
 - f. Plug-in mounting in fixed detector base.
 3. Duct Smoke Detectors:
 - a. Photoelectric type.
 - b. Sampling tube as required for the location where the detector is installed.
 4. Heat Detectors:
 - a. Combination fixed temperature and rate-of-rise.
 - b. Analog temperature measuring device.
 - c. Self-restoring.
 - d. Integral addressable module.
 - e. LED indicator to show detector status.
 - f. Plug-in mounting in fixed detector base.
- G Addressable Interface Devices:
1. Monitor Module: Allows individual monitoring of non-addressable points.
 2. Control Module: Provides a system address to relays for control functions.
 - a. Relay: 24 VDC coil; contacts rated 10A, 115 VAC, minimum; suitable for control function required.
- H Remote Indicators and Test Switches
1. LED indicator connected to flash when the associated detector is in an alarm or trouble condition.
 2. Combined with a keyed detector test switch where indicated.
 3. Flush-mounted in a single gang wall plate.
- I Notification Appliances:
1. Combination devices consist of audible and visual devices, factory-assembled as a single assembly. Provide low frequency devices where required by Code.
 2. Horns: Electronic, multi-tone type, 24 Volt DC, sound pressure of 90 dB measured 10 feet from the horn.
 - a. Ceiling-mounted horns: White.
 - b. Wall-mounted horns: Red.
 3. Strobes:
 - a. Xenon strobe with clear polycarbonate lens.
 - b. Rated light output: as selected by the system supplier to provide Code-required coverage of the area where the strobe is located.
 - c. Synchronized operation.
 - d. Ceiling-mounted strobes: White.
 - e. Wall-mounted strobes: Red.
- J Circuit Conductors:
1. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 degrees C, color-coded insulation.
 - a. Low-Voltage Circuits: No. 14 AWG, minimum.

- b. Line-Voltage Circuits: No. 12 AWG, minimum.
- 2. Power-Limited Circuits: Types FPL, FPLR, or FPLP, as recommended by manufacturer.
- K Surge Protection:
 - 1. Provide a listed surge protection device on the supply side of the fire alarm control panel per NEC Article 760.
 - 2. Signaling Line Circuits: Provide surge protection at each point where circuit exits or enters a building, rated to protect applicable equipment.
- L Locks and Keys: Deliver keys to Owner.

PART 3 EXECUTION

3.1 INSTALLATION

- A The locations and spacing of alarm initiating devices and notification appliances indicated on the drawings are approximate. Quantities indicated are minimum. The equipment supplier shall verify device requirements and spacing and shall add devices as required to satisfy governing authorities. It shall be the responsibility of the equipment supplier or his representative to determine the type of detector required by local authorities for each type of installation.
- B Install the fire alarm system in accordance with approved manufacturer's wiring diagrams. Furnish all conduit, wiring, outlet boxes, junction boxes, cabinets, and similar devices necessary for a complete installation. Boxes shall be installed in accessible spaces without requiring the removal of light fixtures or any other equipment.
- C Coordinate system programming with the authority having jurisdiction.
- D Provide 120 volt power to remote signal circuit power supplies.
- E Coordinate the installation of equipment and devices that pertain to the work of other trades with the appropriate contractors.
- F Install field-devices, components, FACU and related equipment, and accessories in accordance with the following:
- G Install wiring in metal raceways.
- H Conceal all wiring, conduit, boxes, and supports where installed in finished areas.
- I Raceways and Supports:
 - 1. Coordinate locations of outlet boxes as required for installation. Only install boxes and equipment at locations based on application standards indicated in NFPA 72.
 - 2. Secure and support raceways at intervals complying with NFPA 70. Provide supports where vertical rise exceeds permissible limits.
 - 3. Install firestopping to preserve fire resistance rating of partitions and other elements.
- J Wiring and Connections:
 - 1. Maintain separation of Class 1, Class 2, Class 3 remote-control, signaling, fire alarm circuits, and power-limited circuits in accordance with cable insulation class and NFPA 70.

2. Maintain circuit pathway and class designations in accordance with NFPA 72 for configuration, separation, and survivability.
3. Comply with permitted and not permitted installations for wires, cables, cable routing assemblies, communications circuits, and fire alarm circuits in accordance with NFPA 70.
4. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by AHJ. Provide independent support from building structure and suspended ceiling systems. Do not provide support from raceways, piping, ductwork, or other systems.
5. Provide grounding and bonding in accordance with Section 260526.
6. Comply with manufacturer's minimum cable sizes or ratings.
7. Do not exceed manufacturer's recommended maximum power, signal, or network cable lengths between components.
8. Provide network wiring in accordance with NFPA 70.
9. Neatly train and bundle conductors inside boxes, wireways, and cabinets.
10. See manufacturer's instructions for batteries.

K Fire Alarm System Components:

1. Install field-installed devices, components, relays, notification appliances, accessories, and when applicable EoL resistors.
 - a. Install wiring to supervisory devices and associated EoL resistors as required for supervision of hardwired connections
2. Install Wall-Mounted Equipment: Assemble component hardware within (e.g., card bays, sub-bays, expansion bays, signal cards, other card frames, networking, signal transmission, application modules, tamper monitoring devices, interconnecting modules, and auxiliary power supplies), including space for required spare capacity, and configure settings.
3. Install Interconnect Wiring: Connect system cabinets, install processor and cards, cabling, connectors, terminations, and bonding.

L Branch Power:

1. After installation confirmations, follow manufacturer instructions to connect branch circuit power cables to premises fire alarm system components; comply with NFPA 70.
2. Where accessories require auxiliary power, provide control power source and monitoring as indicated or as required to complete installation.
3. Install auxiliary power supplies, including indicated monitoring, and connections necessary for remote equipment.

M System Identification:

1. Identify devices, notification appliances, components, cables, and equipment in accordance with approved submittals. See Section 260553.
2. Confirm fire alarm system programming meets requirements of SOO and sub-system SOOs.
3. Mark location of disconnecting means for NPFLA circuits.
4. Coordinate to provide red branch power circuit protective devices or identify them accordingly as required by NFPA 72 and NFPA 70.
5. Mark date of batteries installed on inside cover of panels and formal maintenance logs.

N Troubleshooting and Installer Checks:

1. Field test connectivity periodically during installation process to avoid unexpected troubleshooting.

2. Check system operation for notification, FACU functions, circuit supervision, alarm initiating devices, supervisory initiating devices, dress panels/doors/covers, and programming before performing field tests.
- O Fire Alarm System Tests:
1. Perform required tests of NFPA 72. Record measured values during operational checks.
 2. Confirm functional testing of fire alarm system is as indicated in Contract Documents.
- P Install end-of-line resistors at farthest device from panel or module.
- Q Ground cable shields and equipment according to manufacturer's instructions.

3.2 DEVICE INSTALLATION

- A Provide devices as indicated on drawings and as required to perform specified functions.
- B Initiating Devices:
1. Smoke Detectors:
 - a. Cover all smoke detection devices immediately after installation to maintain cleanliness.
 - b. Install within five feet of each door held open by the fire alarm system.
 - c. Where adjacent to an air shaft, supply diffuser or return grille, install smoke detector 36 inches minimum from the edge of the diffuser or grille.
 - d. Provide a smoke detector within 10 feet of each remote power supply panel and each control panel or subpanel.
 2. Duct Detectors:
 - a. Provide duct type smoke detectors in the supply and return ductwork of all air handling equipment with a flow rate greater than 2000 CFM.
 - b. Provide duct type smoke detector in the return ductwork of each heat pump, fan coil unit, or similar equipment sharing a common return plenum with a combined flow rate greater than 2000 CFM.
 - c. Provide duct type smoke detectors in the return ductwork of all air handling equipment which has a flow rate greater than 15,000 CFM and which serves more than one floor. Install at each story prior to the connection to a common return and prior to recirculation or fresh air inlet connection.
 - d. Install duct detectors in accordance with NFPA 90A.
 - e. Provide a remote alarm LED indicator for each duct smoke detector which is not readily visible or which is located above a ceiling or on a roof. Mount in an easily accessible and readily visible location. Label with the name of the unit served by the detector. Indicate whether the detector is installed in the supply or return ductwork.
 - f. Provide a labeled test switch with LED indicator for each duct smoke detector. Install switch at a height between 48 inches and 72 inches above finished floor.
 3. Provide heat detectors in areas where smoke detectors would be subject to false alarm.
 4. Program address for each device as recommended by system supplier or Owner.
 5. Program device output text by address and geographic location (zone).
 6. Provide an addressable interface module for each non-addressable detector zone as indicated on drawings.
 7. Provide an addressable interface module for each non-addressable initiating device.

C Notification Appliances:

1. Where plans indicate a notification appliance installed adjacent to a manual station, install the notification appliance on the wall directly above the manual station.
2. Provide a minimum of one weatherproof audible notification appliance of the same type as other notification appliances provided with the system. Mount device on the building exterior; verify location. Provide a separate circuit for exterior audible notification appliances.
3. In sprinkled buildings, provide a 120 volt circuit to the fire sprinkler bell location.

D Control Devices:

1. Provide a control module with relay for each fan requiring fire alarm shutdown or control.
2. Elevators: Verify recall requirements with local codes, authorities, and installers prior to system programming. Provide control modules and relays as required.
3. Provide control modules and relays as required to implement the required control sequences.
4. Provide control modules and relays for remote indication of alarm and trouble conditions. Connect to nearest temperature control panel.

E Cabinets:

1. Mount FACP and remote cabinets a maximum of 72 inches above finished floor to the top of the cabinet. Provide a 4-inch space between adjacent cabinets.

3.3 INTERCONNECTION TO OTHER SYSTEMS**A Alarm Indicating:**

1. Provide 4-pair, 24 gauge, Category 3 cable in 3/4-inch conduit from control panel to main telephone terminal board for connection of Digital Alarm Communicator Transmitter. Allow adequate slack at terminal board for connection by Owner.
2. Provide 2-pair, 18 gauge, cables in 3/4-inch conduit as required from alarm and trouble contacts in fire alarm control panel to the nearest temperature control panel. Coordinate with Control Contractor.

B Fire Protection System:

1. Connect all sprinkler system flow detection devices and tamper switches, including post or wall indicator valves. Provide an addressable interface module for each device.
2. Provide RGS conduit where exposed at post or wall indicator valve.
3. Verify exact quantities and locations of devices with Fire Protection Contractor.

C Access Control / Security Systems:

1. Provide a control module and relay for each electrically locked exit door or group of exit doors. Connect so relay will interrupt power to the locking device(s) under an alarm condition.

D Lighting Control System:

1. Provide a control module containing suitable contacts for each emergency lighting relay serving egress lighting circuits or by using an alternative method approved by the authority having jurisdiction.

2. Connect output of the fire alarm control module to the auxilliary input of the emergency lighting relay. Connect to the lighting control system such that a general fire alarm will drive all emergency lighting on the egress path to full brightness.
3. Verify exact requirements and location with lighting control system submittal, refer to specification 26 0923.

3.4 IDENTIFICATION

- A Paint power-supply disconnect switch or breaker red and label "FIRE ALARM". Provide locking means.
- B Affix the name and telephone number of the local service organization to the inside of the door of the FACP and each remote cabinet.
- C Label each addressable device with its address using laminated tape. See Section 26 0553 Identification for Electrical Systems for tape requirements. Attach label to detector base shroud so it is visible without removing detector or shroud.
- D Label each control module to indicate the equipment controlled.
- E Maintain wiring color codes throughout the system.

3.5 INSPECTION AND TESTING FOR COMPLETION

- A Notify Owner 7 days prior to beginning completion inspections and tests.
- B Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- C Provide the services of a factory-authorized service representative to supervise inspection and testing, correction, and adjustments.
- D Prepare for testing by ensuring that all work is complete and correct; perform preliminary tests as required.
- E Provide all tools, software, and supplies required to accomplish inspection and testing.
- F Perform inspection and testing in accordance with NFPA 72 and requirements of local authorities; document each inspection and test.
- G Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents and applicable standards.

3.6 OWNER PERSONNEL INSTRUCTION

- A Schedule training with the Owner through the Architect, with at least seven days advance notice.
- B Provide a minimum of four hours training.
- C Provide the following instruction to designated Owner personnel:

1. Hands-On Instruction: On-site, using operational system.
- D Furnish the services of the manufacturer's factory-authorized instructors; have copies of operation and maintenance data available during instruction.

3.7 MAINTENANCE

- A Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.
- B Provide to Owner, at no extra cost, a written maintenance contract for entire manufacturer's warranty period, to include the work described below.
- C Perform routine inspection, testing, and preventive maintenance required by NFPA 72, including:
1. Maintenance of fire safety interface and supervisory devices connected to fire alarm system.
 2. Repairs required, unless due to improper use, accidents, or negligence beyond the control of the maintenance contractor.
 3. Record keeping required by NFPA 72 and authorities having jurisdiction.
- D Maintain a log at each fire alarm control unit, listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced. Submit duplicate of each log entry to Owner's representative upon completion of site visit.
- E Comply with Owner's requirements for access to facility and security.

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SECTION 312005

EARTH MOVING FOR BUILDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Excavating and backfilling for buildings and structures.
 - 2. Drainage course for concrete slabs-on-grade.
 - 3. Subsurface drainage backfill for walls.

1.3 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
- B. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- C. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- D. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 - 2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
- E. Fill: Soil materials used to raise existing grades.
- F. Structures: Buildings, footings, foundations, retaining walls, building slabs, or other man-made stationary features constructed above or below the ground surface.
- G. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following manufactured products.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
 - 1. Classification according to ASTM D 2487.
 - 2. Laboratory compaction curve according to ASTM D 698.

1.6 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
 - 1. Do not proceed with work on adjoining property until directed by Architect.
- C. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth-moving operations.
- D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified are in place.

PART 2 - PRODUCTS**2.1 SOIL MATERIALS**

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- A. Unsatisfactory Soils: Soil Classification Groups OL, CH, CL/CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.
 - 1. Unsatisfactory soils also include satisfactory soils not maintained within +/- 3 percent of optimum moisture content for granular soil and -2/+3 percent of optimum moisture content for low plasticity cohesive soil at time of compaction.
- B. General Building Fill: Satisfactory Soils shall consist of low plasticity soil or granular soil:
 - 1. Soil Classification Groups GW, GP, GM, GC, SW, SP, SM and SC according to ASTM D 2487, or a combination of these groups.
 - 2. Low plasticity soil classification groups CL, CL-ML, ML with liquid limit less than 45 and a plasticity index less than or equal to 23.
 - 3. Soil shall be free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

- C. Subbase Material: Satisfactory Soils shall consist of low plasticity soil or granular soil:
 - 1. Low plasticity soil classification groups CL, CL-ML, ML with liquid limit less than 45 and a plasticity index less than or equal to 23.
 - 2. Granular soil: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2840M; with at least 90 percent passing a 1 ½ inch sieve and at least 18 percent passing a No. 200 sieve.
- D. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and less than 6 percent passing a No. 200 sieve.
- E. Over-Excavation Fill Below Footings: Iowa DOT Section 4120.04 (Class A Roadstone).
- F. Sand: ASTM C 33/C 33M; fine aggregate.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth-moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

- A. Explosives: Do not use explosives.

3.4 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil

materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.5 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch (25 mm). If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

3.6 SUBGRADE INSPECTION

- A. Notify Architect when excavations have reached required subgrade.
- B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below the building slabs with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes) to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph (5 km/h).
 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.7 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi (17.2 MPa), may be used when approved by Architect.

3.8 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.9 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
 2. Surveying locations of underground utilities for Record Documents.
 3. Testing and inspecting underground utilities.
 4. Removing concrete formwork.
 5. Removing trash and debris.
 6. Removing temporary shoring, bracing, and sheeting.
 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.10 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
 1. Under building slabs, use engineered fill.
 2. Under footings and foundations, use engineered fill.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.11 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.12 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698:
 - 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches (300 mm) of existing subgrade and each layer of backfill or fill soil material at 95 percent.

3.13 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 - 1. Provide a smooth transition between adjacent existing grades and new grades.
 - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch (13 mm) when tested with a 10-foot (3-m) straightedge.

3.14 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
 - 1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 - 2. Place drainage course 6 inches (150 mm) or less in compacted thickness in a single layer.
 - 3. Place drainage course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
 - 4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.15 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- B. Inspections: Refer to Section 01 4500 "Special Inspections and Tests" for required verifications and inspections.

- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. (186 sq. m) or less of paved area or building slab but in no case fewer than three tests.
 - 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet (30 m) or less of wall length but no fewer than two tests.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.16 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.17 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION

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Appendix

- A. Geotechnical Engineering Report, Central Office Building, Council Bluffs, Iowa, ISG-TEAM No. 71-79, Dated January 23, 2026 (29 pages)

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Geotechnical Engineering Report

January 23, 2026

Central Office Building
Council Bluffs, Iowa
ISG-TEAM No. 71-79

Prepared for:

The Samuels Group, Inc.
2929 Westown Parkway, Suite 200
West Des Moines, IA 50266

Prepared by:

ISG-TEAM, Inc.
4722 South 135th Street
Omaha, NE 68137



January 23, 2026



The Samuels Group, Inc.
2929 Westown Parkway, Suite 200
West Des Moines, IA 50266

Attn: Jerry Dehnke

Re: Geotechnical Exploration
Central Office Building
Council Bluffs, IA
ISG-TEAM Project No. 71-79

Dear Mr. Dehnke:

We have completed the subsurface exploration for the proposed central office building project in Council Bluffs, Iowa. The accompanying geotechnical report presents the findings of the subsurface exploration and our recommendations concerning geotechnical design and construction for the proposed building.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service to you in any way, please do not hesitate to contact us.

Sincerely,
ISG-TEAM, Inc.

Nicholas Gilles, P.E.
Sr. Project Engineer

	I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.
	 1-23-2026
	Nicholas M. Gilles, P.E. License Number 21385 Date: 1/23/2026 My license renewal date is December 31, 2027. Pages covered by this seal: <u> All Pages </u> .

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PROJECT INFORMATION

Project information has been provided by Mr. Jerry Dehnke of The Samuels Group in correspondence with our Mr. Dan Snyder. A site plan with proposed boring locations was also provided. We understand the project will consist of construction of a new office building just east of the facility at 1102 9th Avenue in Council Bluffs, Iowa. Based on the provided site, it appears that the building will be slab-on-grade with a finished floor elevation of about 985.0 feet. Other details for the building had not been provided at the time of this report. For our analysis, we have assumed that maximum column and wall loads will be on the order of 75 kips and 6 klf, respectively. We have also assumed that minimal cut and fill will be required to achieve the desired final grades.

SITE CONDITIONS

The project site is located northwest of the intersection of 9th Avenue and S 10th Street in Council Bluffs, Iowa. The site is currently an open grass lot with less than 2 feet of elevation change between our boring locations based on topographic maps. Our truck-mounted drill rig was able to access the boring locations without difficulty.

FIELD EXPLORATION

A total of 5 borings were conducted at this site to depths of about 10 to 20 feet below existing grades on December 30, 2025. The boring locations were determined in the field by ISG-TEAM personnel using the provided site plan and measurements from existing site features. The final boring locations are indicated on the Boring Plan enclosed in the Appendix. Ground surface elevations at the boring locations were estimated using LiDAR elevation maps. The approximate ground surface elevations are provided on their respective Boring Logs. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

Our drilling equipment consisted of a truck-mounted auger drill rig. The borings were made by mechanically twisting a continuous flight steel auger into the soil. At assigned intervals, the auger was removed and soil samples were obtained.

Representative samples were obtained using thin walled (Shelby) tube and split barrel sampling procedures in general accordance with ASTM Specifications D 1587 and D 1586, respectively. In the thin walled tube sampling procedure, a thin walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the ground to obtain relatively undisturbed samples of cohesive or moderately cohesive soils. In the split barrel sampling procedure, a standard 2 inch outer diameter split barrel sampling spoon is driven into the ground with a 140 pound hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18 inch penetration is recorded as the standard penetration resistance value. These values are indicated on the Boring Logs at the depths of occurrence. The samples were tagged for identification, sealed and returned to the laboratory for testing and classification.

Field logs of the borings were prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling, as well as the driller's interpretation of the subsurface conditions between samples. Final Boring Logs included with this report represent an interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

LABORATORY TESTING

Based on the driller's field records and examination of the samples in the laboratory, a soil testing program was developed to collect more information about the soil conditions at the site. The following is a brief description of the specific tasks completed for this project.

Natural Moisture Content -- The natural moisture content of selected samples was determined in general accordance with ASTM D 2216. The moisture content of the soil is the ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of the soil particles. The results are presented on the Boring Logs at the depths from which the samples were obtained.

Unit Weight -- In the laboratory, selected undisturbed samples of the site soils were measured and weighed to determine gross weight and volume of the samples. Where possible, the samples are placed in a template and trimmed at each end to fit the template. The moisture content of each specimen was then determined, and the dry unit weight was calculated. The results of these tests are also presented on the Boring Logs at the appropriate sample depths.

Unconfined Compressive Strength -- Selected cohesive soil samples obtained with 3 inch diameter Shelby tubes were tested in the laboratory to determine their unconfined compressive strength in general accordance with ASTM D 2166. In this procedure, sections of the Shelby tube samples were trimmed to fit into a 2.875 inch diameter by 5.70 inch high template and placed, without any confinement, in a triaxial load frame and tested for compressive strength with a controlled rate of strain. The peak stress on the samples, in psf, is reported on the Boring Logs at the depth from which the samples were obtained. A calibrated hand penetrometer was used to estimate the approximate unconfined compressive strength of the remaining samples. The calibrated hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone.

Plasticity (Atterberg Limits) Tests -- Selected soil samples were tested for Plastic Index. The soils' Plastic Index (PI) is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL). The LL is the moisture content at which the soil will flow as a heavy viscous fluid. The PL is the moisture content at which the soil begins to crumble when rolled into a small thread. These tests are conducted in general accordance with ASTM D 4318. The results are indicated on the Boring Logs at the depth where the sample was obtained.

As part of the testing program, the samples were classified in the laboratory based on visual observation, texture and plasticity. The descriptions of the soils indicated on the Boring Logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Estimated group symbols according to the Unified Soil Classification System are given on the Boring Logs. A brief description of this classification system is attached to this report.

SUBSURFACE CONDITIONS

Subsurface conditions encountered during this exploration are indicated on the individual Boring Logs. Based on the results of the borings, subsurface conditions on the project site can be generalized as follows.

Existing fill was encountered at the ground surface of our borings. The fill consisted of lean clay and sandy lean clay with varying amounts of organic matter, sand, and gravel. The fill extended to depths of about 3 to 7 feet below existing grades.

Alluvial deposits were encountered below the existing fill in the borings. Alluvial soils have typically not experienced significant overburden pressures beyond the weight of the soil above them, below the zone of soil affected by seasonal wet/dry cycles (where some preconsolidation by desiccation has occurred). The alluvium is often near-normally consolidated and can be highly compressible under moderate to heavy loads. The cohesive alluvial soils at the site generally consisted of medium stiff to very stiff lean clay, fat clay, and silt. The granular alluvium consisted of silty sand. Borings were terminated in the alluvial deposits at depths of 10 to 20 feet below existing grades.

The above descriptions provide a general summary of the subsurface conditions encountered. The attached Boring Logs contain detailed information recorded at each boring location. These Boring Logs represent our interpretation of the field logs based on engineering examination of the field samples. The lines designating the interfaces between various strata represent approximate boundaries, and the transition between strata may be gradual. It should be noted that the soil conditions will vary between the boring locations.

GROUNDWATER CONDITIONS

The borings were monitored during drilling operations for the presence and level of groundwater accumulation. Groundwater levels observed in the borings are noted on the Boring Logs.

During drilling operations, groundwater seepage was observed at a depth of about 12 feet below existing grades. These short-term water level observations provide an approximate indication of the groundwater conditions existing on the site at the time the borings were drilled. A relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole. Longer term monitoring in cased holes or piezometers would be required for a more accurate evaluation of the groundwater conditions at the site. Based on coloring of the soils and our experience in the area, we believe that groundwater levels may be within several feet of the ground surface during some periods of the year.

Fluctuation of groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, surface drainage, subsurface drainage, site topography, irrigation practices, ground cover (pavement or vegetation), and other factors not evident at the time the borings were conducted. Normally, the highest groundwater levels occur in late winter and spring time while the lowest levels

occur in late summer and fall time. The fluctuation of the groundwater levels should be considered when developing the design and construction plans for this project.

CONCLUSIONS AND RECOMMENDATIONS

Existing Fill Considerations

Existing fill was encountered at the ground surface of our borings. The fill consisted of lean clay and sandy lean clay with varying amounts of organic matter, sand, and gravel. The fill extended to depths of about 3 to 7 feet below existing grades. Based on our field and laboratory testing, the upper 2 to 3 feet of the fill appears to be poorly to moderately compacted in some areas while the deeper fill soils appear to be moderately to well compacted. The poor surface conditions may be due to freeze/thaw cycles, weathering, or other disturbance.

It should be recognized that man-made fills have an inherently high risk of variability and careful construction inspection will be necessary to assure adequate support performance, particularly below foundations. Where fill is present below the structure following earthwork operations, we recommend that additional testing be conducted at the time of construction to further explore the suitability of the existing fill. Foundations, floor slabs, and pavements may be placed on existing fill where testing confirms suitability. If unsuitable soils are encountered, which appears likely within the upper 2 to 3 feet of our borings, these soils should be removed and replaced with engineered compacted and tested fill. It should be noted that the most conservative approach in dealing with unknowns within the existing fill would be to completely remove the fill and replace it with engineered compacted and tested fill, which eliminates the risk entirely.

Contract allowances should be made for some remedial work at the site related to subgrade preparation and foundation construction. This may include overexcavation and backfilling of unsuitable soils encountered at subgrade elevation or in the foundation excavations in accordance with the recommendations of this report or lowering of the foundations to suitable bearing materials. The amount of such work cannot be defined at this time; therefore, the owner should be informed of these cost variables.

Expansive Soil Considerations

Highly expansive fat clay alluvial soils were encountered below the existing fill in Borings 4 and 5. These expansive soils will experience volume changes with changes in soil moisture content. Therefore, structures would be susceptible to swelling pressures that can cause movement, cracking, and structural distress. To eliminate the risk associated with these expansive soils, it would be necessary to remove the expansive soils at the site and replace them with suitable, compacted and tested non-expansive engineered fill material. However, complete removal or treatment of these soils would be costly. It is our opinion that the following recommendations provide a more practical approach in dealing with the expansive soils encountered at this site.

If floor slabs bear within 24 inches of the fat clay soils, which is not anticipated based on the depths encountered in our borings and the proposed finished floor elevation, we recommend removal of these potentially expansive soils to provide a minimum of 24 inches of separation between the bottoms of floor slabs and the fat clay. We recommend that these soils be replaced using suitable compacted and tested, low plasticity cohesive fill soils or granular materials.

Fly ash, cement or lime stabilization techniques can be considered for lowering the expansive characteristics of the expansive soils at the site so they can be used as backfill within the depth of expansive soil separation. If chemical stabilization is desired, ISG-TEAM should be retained to perform additional laboratory testing to determine adequate quantities for stabilization.

In our opinion, foundations may bear within or directly above the expansive soils with no additional mitigation recommended, provided these soils meet the strength and stability requirements presented in the **Shallow Foundation Design** section of this report. The anticipated foundation loads should be high enough to resist the swelling pressures exerted by the moderately expansive soils and keep expansive movements to less than 1 inch when they have appropriate embedment as described in the **Shallow Foundation Design** section.

Although exterior pavements are typically less critical than structures, separation may be desired beneath pavement to reduce expansive soil movements. It is expected that movements caused by expansive soils would be similar in magnitude to those caused by frost heave, which are typically considered tolerable in cold weather states. If expansive soils are encountered near the pavement elevation and a reduction in expansive soil movement is desired below pavements, then 12 inches of separation could be considered.

We recommend that continuous wire mesh reinforcement or regular rebar schedule be provided for the floor slabs and that crack control joints be sawn with a regular spacing not greater than about 10 feet. Isolation joints should be provided between the floor slabs and perimeter or interior foundations so that they can move independently without damage. These measures are taken with the intent of allowing the floor slabs to deflect somewhat without experiencing large differential movements across slab joints and to channel the cracking of the floor slabs to the crack control joints so that they are not perceived as building distress. If a slab and footing are not isolated then the structural engineer should ensure that adequate reinforcement is provided such that the slab and footing will not be distressed from differential swelling pressures.

The contractor should avoid excessive drying of subgrade soils during construction. If these soils experience drying then the dried soils should be removed, moisture conditioned, and properly compacted back into place or replaced with suitable new compacted fill material, prepared in accordance with the recommendations of this report. Measures to reduce drying of these soils include following excavation rapidly with backfill or foundation, floor slab, or pavement construction, covering the site with moisture-proof plastic, and/or occasionally watering the subgrade soils during dry weather.

Site Preparation

Site preparation should begin with the removal of any organic-laden soils, vegetation and any loose, soft or otherwise unsuitable materials. Unsuitable existing fill should be removed at this time, if encountered. Expansive soils should be removed if they are encountered within 24 inches below floor slabs (not anticipated based on our borings). For planning purposes, we expect topsoil/vegetation stripping depths in the range of about 6 to 9 inches. The actual depths of stripping may vary and should be determined in the field in consultation with ISG-TEAM personnel. The site strippings and any near surface soils with organics could be used for landscaping purposes in non-critical areas where support for foundations, floor slabs and pavements is not required.

After stripping and removal of any unsuitable soils, the exposed grade should be proofrolled and inspected by ISG-TEAM personnel. Proofrolling should be performed at the lowest cut grade, prior to any fill placement. Proofrolling should be conducted with a fully loaded tandem axle dump truck having a minimum gross weight of 25 tons. Where proofrolling is not possible due to poor access or excessive disturbance to existing soils, these soils should be probed and visually inspected by ISG-TEAM to determine the suitability of the subgrade. Any unsuitable soils identified during this

process should be removed and replaced with suitable engineered compacted and tested fill which meets Class 1 Construction Application requirement in Table A in the following **Fill Placement** section.

It should be noted that initial subgrade preparation for the moist cohesive soils encountered at this site will likely not be suitable under repeated heavy construction vehicle loads and may require stabilization to greater depths or stabilization with fly ash, cement or lime. The use of crushed rock with or without geogrid could also be considered in-lieu of the additional stabilization methods. Contract allowances should be made for some remedial work at the site related to subgrade preparation. The amount of such work cannot be defined at this time; therefore, the owner should be informed of these cost variables.

Fill Placement

Fill and backfill placed for support of the proposed structure should consist of approved materials which are free of organic matter and debris. Brick, concrete, rocks or other solid pieces with a maximum dimension of 3 inches or larger should not be placed in the newly placed fill sections. We recommend that low-plasticity cohesive soil or granular soil be used for general fill placement. By our definition, low-plasticity cohesive soil would have a liquid limit of 45 or less and a plasticity index of 25 or less. In our opinion, most of the surface soils appear to meet these criteria and can be reused as engineered fill for general earthwork purposes. The highly expansive fat clay soils encountered in Borings 4 and 5 do not meet these criteria and should not be reused as fill, if excavated. Any off site potential borrow materials should be evaluated by ISG-TEAM prior to their use as engineered compacted and tested fill.

The following Table A lists recommended minimum compaction requirements for cohesive and cohesionless fill materials for specific applications. For low-plasticity (CL and ML) cohesive soils, moisture contents within a range of 0 to +4 percent of the material's optimum moisture content (as determined by Standard Proctor ASTM D 698) are necessary to achieve the desired fill qualities for general grading and utility backfill. Sometimes, cohesive subgrade soils have difficulty passing proofroll or supporting construction traffic if significantly wet of optimum. For the upper 2 feet of subgrade soils, it can be permissible to place the cohesive soils up to 2 percent dry of optimum moisture content. Granular materials with sufficient fines content to be moisture-sensitive should be placed within 3 percent of the material's optimum moisture content. Clean granular materials are not moisture sensitive.

The on-site soils can be excavated utilizing conventional excavation equipment. Compaction of granular soils can generally be suitably compacted with vibratory compaction equipment. Proper compaction of cohesive soils can be achieved with sheepsfoot or pneumatic type compactors within the above moisture content ranges. The soils should be placed in a maximum loose thickness of 12 inches and at a thickness compatible with the equipment being utilized. Sufficient density tests should be performed on each lift of engineered compacted fill placed to verify that adequate compaction is achieved.

TABLE A
RECOMMENDED DEGREE OF COMPACTION GUIDELINES

Construction Application		Standard Proctor (ASTM D698) Cohesive Soil	Standard Proctor (ASTM D698) Cohesionless Soil ²	Relative Density (ASTM D4253 & D4254) Cohesionless Soil ^{1,2}
Class 1	Subgrade preparation for structures, pavements and other critical backfill areas	95%	98%	75%
Class 2	Backfill adjacent to structures not supporting other structures or pavements. Minor subsidence possible.	90%	93%	45%
Class 3	Backfill in non-critical areas. Moderate subsidence possible.	85%	88%	20%

1. Use Relative Density technique (ASTM D4253 & D4254) where Standard Proctor technique (ASTM D698) does not result in a definable maximum dry density and optimum moisture content.
2. Clean gravel should be inspected visually during compaction by a qualified engineering technician to confirm adequate compactive effort and appropriate lift thicknesses in lieu of density testing.

The moist cohesive soils at this site are highly susceptible to disturbance. Care should be taken to prevent unnecessary disturbance of subgrade soils. Disturbed areas should be removed and replaced with new fill placed and compacted in accordance with the recommendations of this report. In order to minimize disturbance of these soils, measures should be taken to control groundwater infiltration in accordance with the **Construction Dewatering** section of this report. A layer of crushed rock may be placed to provide a working surface where excavations extend into soils that are susceptible to disturbance.

Upon completion of the filling operation, care should be taken to maintain the subgrade moisture content prior to construction of foundations or slabs if these elements are to be placed on or near

cohesive soils. If the subgrade should become desiccated, frozen or otherwise disturbed, the affected material should be removed or these materials should be scarified, moistened, recompact and retested prior to concrete or asphalt placement. As a general guideline, cohesive fills which dry to a moisture content less than 2/3 of their optimum moisture content as determined by the Standard Proctor Test (ASTM D 698) in their upper 2 inches are candidates for reconditioning as described above.

Shallow Foundation Design

It appears that foundations for the proposed home will bear in the existing fill, natural alluvial soils, or on newly placed engineered fill required to achieve the desired final grades or to replace unsuitable soils. In our opinion, foundations bearing on existing fill that is verified as suitable at the time of construction, undisturbed natural soils, and/or newly placed engineered fill extending to suitable soils may be designed for a maximum net allowable bearing pressure of 1,500 pounds per square foot. As previously discussed, the existing fill soils are variable at this site and it is likely that overexcavation and replacement will be required in some areas to mitigate unsuitable fill soils.

The net bearing pressure is the pressure in excess of the minimum adjacent overburden pressure at the foundation level. The bearing capacities discussed in the previous sections may be increased by 33% when considering transient forces such as wind. We estimate that maximum settlements will be less than 1 inch and differential settlement may be on the order of 2/3 of the total settlement.

Continuous foundations should be adequately reinforced to limit deflections caused by non-uniform soil support characteristics. All perimeter foundations and foundations in unheated areas should extend at least 42 inches below the lowest adjacent finished grade for frost protection and reduce movements associated with changes in soil moisture content. Interior footings located in permanently frost-free environments should have at least 18 inches of protective embedment below lowest adjacent finished grade. We recommend that isolated spread footings should have a minimum width of 24 inches, continuous formed footings a minimum width of 16 inches and trench footings a minimum width of 12 inches. Trench footings are not recommended where granular materials or very soft soils will be encountered in the excavation sidewalls.

Shallow Foundation Construction

We recommend that the base of all foundations and excavations beneath structural areas be observed and tested by the geotechnical engineer prior to fill placement and/or placement of concrete. Where

poorly compacted existing fill or unsuitably loose, soft, organic, or otherwise unsuitable materials are encountered, these unsuitable materials should be removed and replaced with suitable engineered compacted fill soils prepared in accordance with the recommendations in Table A in the **Fill Placement** section of this report. The following Figure 1 shows a typical cross-sectional view of this overexcavation and backfill procedure.

In general, the overexcavation is widened $\frac{2}{3}$ of a foot laterally on each side of the foundation per each foot of excavation that is below the foundation bearing elevation. The depth of overexcavation (shown as “D” in Figure 1) should be determined in consultation with the geotechnical engineer. Backfill materials should be suitable cohesive or granular soil, prepared and compacted in accordance with the recommendations in Table A in the **Fill Placement** section of this report. Another option would be to remove the unsuitable soils down to suitable soils and replace the excavated area with lean concrete (minimum 50 psi compressive strength), in which case widening of the excavation would not be required. This option is not recommended where granular soils or very soft/wet cohesive soils will be present in the excavation sidewalls.

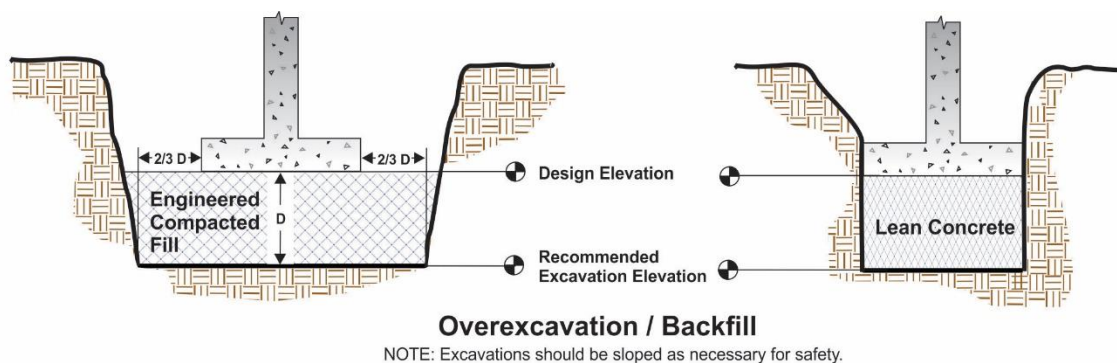


Figure 1.

Footing excavations should be kept free of water accumulation to prevent softening of subgrade soils. It should be noted that the cohesive soils at this site are highly susceptible to disturbance. Any disturbed soils or areas experiencing water seepage may require additional removal or compaction prior to concrete placement. It may be beneficial to place a 6-inch thick layer of crushed rock in the foundation excavations to provide a suitable working surface for construction of foundations. The crushed rock will also help reduce disturbance of the cohesive soils. Concrete should be placed as soon as possible after excavating to minimize bearing soil disturbance. Should the soils at bearing level become excessively dry, saturated, or otherwise disturbed, the affected soil should be removed prior to placing concrete. A working grade composed of a layer of compacted, clean gravel is recommended where disturbance from seepage, construction traffic, or precipitation is likely.

Floor Slabs

Interior floor slabs can be adequately supported on a subgrade prepared in accordance with the **Existing Fill Considerations, Expansive Soil Considerations, Site Preparation, and Fill Placement** sections of this report. As previously discussed, there are some risks associated with the undocumented existing fill soils at this site if the owner chooses to leave them in place below the structure. The risks to floor slabs can be reduced with careful construction inspections.

During building construction, the surface of the completed building pad may have been disturbed by construction equipment. Therefore, it is recommended that the building areas be proofrolled or probed and tested where proofrolling cannot be conducted to delineate zones of soft soils present near the surface which may require additional removal or compaction prior to construction of the floor slab. If the exposed subgrade has been disturbed since the original subgrade preparation, the subgrade should be scarified to a minimum depth of 12 inches, moisture conditioned (if needed), and recompact to meet or exceed the Class 1 Construction Application requirement given in Table A in the **Fill Placement** section. It should be noted that the initial subgrade preparation for the cohesive soils at this site may not be suitable under repeated heavy construction vehicle loads and may require stabilization to greater depths or stabilization with fly ash, cement or lime. The use of crushed rock with or without geogrid could also be considered in-lieu of the additional stabilization methods.

To avoid localized slab failures, it is important that interior backfill around foundations and in plumbing trenches be properly compacted. Therefore, all fill materials placed beneath the proposed floor slab are to meet or exceed the Class 1 Construction Application requirement given in Table A.

We recommend that continuous wire mesh reinforcement or a regular rebar schedule be considered for the floor slabs and that crack control joints be sawn with a regular spacing not greater than about 10 feet. Isolation joints should be considered between the floor slabs and perimeter or interior foundations so that they can move independently without damage. These measures are taken with the intent of allowing the floor slab to deflect somewhat without experiencing large differential movements across slab joints and to channel the cracking of the floor slabs to the crack control joints so that they are not perceived as structure distress.

In order to allow successful use of a variety of floor systems, measures to control vapor transmission through the floor slab are recommended where moisture sensitive floor coverings are a possibility.

This would include use of a vapor barrier/retarder with a minimum thickness of 10 mils placed between the slab and an underlying capillary break material. The vapor barrier/retarder should be strong enough to resist puncturing by the capillary break materials.

We recommend that the capillary break consist of clean manufactured sand or crushed limestone (drainable material). The capillary break should be at least 4 inches thick and contain less than 6 percent material finer than the U.S. No. 200 sieve. Floor slabs which are protected from frost action may be designed with a modulus of subgrade reaction of 150 pci when subgrade soils, subbase, and capillary breaks are constructed in accordance with the recommendations of this report.

Construction Groundwater Control

During construction activities, care should be taken to maintain positive drainage at the site to ensure that drainage is directed away from excavations. During wet weather or when groundwater levels are anticipated to be high, dewatering should be established at the site prior to excavating within 2 feet above the final excavation elevations. Enough time should be allowed for groundwater to be lowered a minimum of 3 feet below the lowest foundation elevation at all times. These proactive dewatering recommendations reduce the risk of groundwater seepage accumulation and softening of soils in critical excavations. In cohesive soils, groundwater control can be performed by digging drainage trenches leading to sump pits with pumps along the side of the excavation area, preferably, or alternatively within the excavation area. Any seepage entering the project excavations should be directed to dewatering trenches. All dewatering trenches should lead to sumps with pumps or to a free outfall. Groundwater seepage in sands can be controlled using a system of well points.

Moist cohesive soils can be susceptible to disturbance, especially when moist. During times of wet weather or groundwater seepage, the contractor should consider placing a lift of at least 6 inches of clean, crushed concrete or limestone gravel in excavations to provide a firm working surface for constructing foundations and floor slabs. The clean gravel can be well compacted in the presence of water, will drive through and reinforced shallow cohesive soils which have become softened by water exposure, and can accumulate water seepage to flow to a peripheral sump pit to be pumped out of the excavation area.

If groundwater control is lost during construction, disturbance of the upper few inches to few feet below grade is possible in the soils at the site. In these circumstances, it will be necessary to

reestablish groundwater control and remove the disturbed soils. ISG-TEAM should be consulted regarding the extent of remedial action which is necessary.

Site Drainage

Positive site drainage should be maintained along the perimeter of the structure. Final grades should be established to direct runoff away from structure foundations. Down spouts, gutters, and roof drains should discharge away from structure perimeters. Site grading should direct surface water away from excavations or completed foundations during construction and after site development is completed.

Pavement Subgrade Preparation

We expect the soils which will be encountered to support the pavement sections will consist of existing fill and natural alluvial soils in cut areas and engineered compacted and tested fill required to achieve the desired final grades in fill areas. In order to provide satisfactory pavement performance, it is important that the subgrade support be relatively uniform with no abrupt changes in the subgrade support. Therefore, we recommend that the prepared subgrade depth be at least 12 inches deep after surface stripping and fine grading or trimming and extend 2 feet beyond the edge of the pavements.

In cut areas, it is recommended that the pavement subgrade area be cut to design subgrade level or stripping depth (whichever is deeper) and that the exposed subgrade be scarified to a minimum depth of 12 inches, moisture conditioned (if needed), and compacted. In fill areas, the subgrade after stripping should be proofrolled to delineate zones of soft or loose soils present near the surface which may require additional removal or compaction, prior to fill placement. We recommend that reworked existing soils and newly placed engineered compacted non-expansive cohesive soils be placed and compacted in accordance with the **Fill Placement** section of this report. Suitable engineered compacted cohesive subgrade that passes a proofroll inspection would provide a design support capability equivalent to a CBR value of 2 or a modulus of subgrade reaction value of 70 pounds per cubic inch. A minimum of six inches of suitable engineered compacted granular subgrade placed on prepared and inspected cohesive soils would provide a design support capability equivalent to a CBR value of 3 or a modulus of subgrade reaction value of 100 pounds per cubic inch.

It should be noted that initial subgrade preparation for moist cohesive soils, which were prevalent at this site, may not be suitable under repeated heavy construction vehicle loads and may require stabilization to greater depths or stabilization with fly ash, cement or lime. The use of crushed rock with or without geogrid could also be considered in lieu of the additional stabilization methods. The subgrade preparation should be completed shortly before paving operations commence and is to be maintained in suitable condition until paved. Damage caused by construction traffic or deterioration due to adverse weather are to be repaired prior to paving. Subgrade compaction, moisture content and depth should be verified by an ISG-TEAM representative prior to paving operations.

Where construction traffic is required on the prepared subgrade, the subgrade should be proofrolled immediately prior to pavement placement with a fully loaded, tandem axle dump truck. Proofrolling is also the preferred method for evaluating the stability of surficial existing fill soils. Areas that yield should be removed and replaced with engineered compacted and tested fill.

Surface drainage around the pavement sections is important to long-term pavement performance. Curbs should be backfilled as soon as possible, once adequate pavement strength is achieved. The backfill should be compacted and sloped to prevent water from ponding and infiltrating under the pavement resulting in softening of the subgrade or subsurface erosion. Water allowed to pond adjacent to the pavement could saturate the subgrade and contribute to premature pavement deterioration.

Pavement Thicknesses

Either flexible (hot mix asphalt, HMA) or rigid pavement (Portland cement concrete, PCC) types could be constructed on the prepared cohesive subgrade as recommended in the previous section. The following Table B summarizes alternate pavement thicknesses for typical lightly-loaded and heavily-loaded paved areas constructed directly on the cohesive subgrade and on a granular base placed on the prepared cohesive subgrade. A more specific pavement evaluation can be provided if traffic volume and loading information is available.

TABLE B
TYPICAL PAVEMENT THICKNESSES

Traffic Volume	Rigid: Portland Cement Concrete ¹	Flexible: Full-Depth Hot Mix Asphalt ²			
		Full-Depth Type A HMA	Type A over Type B HMA		
			Type A	Type B Class I Base	Total HMA Thickness
Thicknesses below are based on the pavement directly on the prepared cohesive subgrade					
Lightly-Loaded ³	5"	6"	1.5"	5"	6.5"
Heavily-Loaded ⁴	7"	8"	1.5"	7"	8.5"
Thicknesses below are based on the pavement on 6” of crushed rock ⁵ base placed on prepared subgrade					
Lightly-Loaded ³	---	4.5”	1.5”	3.5”	5”
Heavily-Loaded ⁴	---	6.5”	1.5”	5.5”	7”

- 1) PCC - Flexural strength of 550 psi (compressive strength of 4000 psi).
- Structural coefficient (SC) of 0.50/inch.
- 2) Type A HMA mix with a minimum of 60% crushed aggregate
- Structural coefficient of 0.44/inch.
Type B Class I HMA mix with a minimum of 30% crushed aggregate
- Structural coefficient of 0.40/inch.
- 3) Automobile and 1 to 2 trucks average daily traffic.
- 4) Entrances, delivery areas, dumpster areas or other areas of heavier truck traffic
(25 trucks or less per day).
- 5) Crushed rock - Structural coefficient of 0.12/inch.

These pavement thicknesses are considered to be typical and would require periodic maintenance. This maintenance would consist of sealing cracks and replacement of isolated distressed areas. Thicker pavement sections would reduce maintenance and increase the pavement service life. Likewise, thinner sections would be expected to have a shorter service life that still may satisfy particular project needs but may require more maintenance. Other criteria which influence pavement service life include surface drainage, subsurface drainage, paving material quality, and joint design. Construction procedures involving placement, finishing, curing, jointing and weather protection can significantly impact pavement performance.

QUALIFICATION OF REPORT

Our evaluation of foundation support conditions has been based on our understanding of the site and project information and the data obtained in our exploration. The general subsurface conditions utilized in our foundation evaluation have been based on interpolation of subsurface data between the borings. In evaluating the boring data, we have examined previous correlations between soil properties and foundation bearing pressures observed in soil conditions similar to those at your site. Slope stability was not analyzed for this site. The discovery of any site or subsurface conditions during construction which deviate from the data outlined in this exploration should be reported to us for our evaluation. The assessment of site environmental conditions or the presence of pollutants in the soil, rock, and groundwater of the site was beyond the scope of this exploration.

Support of structures on existing fill is discussed in this report. Existing fills are potentially much more inconsistent than natural soil deposits. Support of structures and pavements upon existing fills carries with it a degree of risk that unsuitable materials may be buried within the fill and not be detected in the inspection and testing program recommended herein. Unsuitable materials in the fill may experience settlement and cause distress to structures and pavements supported on the fill. Elimination of this risk requires removal of the fill or supporting structures on suitable foundations such that the fill would not adversely affect the structures.

Potentially expansive soils were encountered in the borings at this site. These soils experience volume changes in response to soil moisture content changes. These volume changes can cause movement, cracking and other distress for structures supported above them. Measures to help reduce the degree of soil volume change have been discussed. These measures can reduce the risks associated with the potentially expansive soils, but they do not eliminate this risk. Elimination of the risks associated with expansive soils would require removal of the expansive soils and replacement with a more suitable soil type or structurally suspending the planned elements above the expansive soils. Neither of these measures is believed practical for this project. A degree of risk must be accepted to support development at this site. If movement tolerances are specified, ISG-TEAM can revisit recommendations to meet those stated tolerances.

It is recommended that the geotechnical engineer be retained to review the plans and specifications so that comments can be provided regarding the interpretation and implementation of the geotechnical recommendations in the design and specifications. It is further recommended that the

geotechnical engineer be retained for testing and observation during the foundation construction phase to help determine that the design requirements are fulfilled.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranty is provided. In the event that any changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions of this report modified or verified in writing by the geotechnical engineer.



Approximate boring location



ISG-TEAM, Inc.

4722 South 135th Street
Omaha, NE 68137

Central Office Building

Council Bluffs, Iowa

BORING PLAN

Project No. 71-79

January 23, 2026

BORING LOG No. 1

Page 1 of 1

PROJECT				SITE							
Central Office Building				Council Bluffs, IA							
GRAPHIC LOG	Approx. Surface Elevation (ft): 984 Site Datum: Drilling Method: HSA	USCS SYMBOL	DEPTH (ft.)	SAMPLES				TESTS			
				NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER
	Fill -- Lean CLAY, grayish brown 3.0 981.0	CL	0								
			1	ST		23.1		94	1500*		
	Alluvium -- Lean CLAY, trace organic matter, dark gray, stiff 7.0 977.0	CL	4	2	ST			28.2	93	2000*	
	Alluvium -- SILT, grayish brown, stiff 17.0 967.0	ML	8	3	ST			25.3	82	2000*	
	Alluvium -- Silty fine SAND, dark brown 20.0 964.0	SM	12	4	ST			44.3	79		
			16								
	Bottom of boring		20	5	ST			24	97		

Notes: * Calibrated hand penetrometer
Hammer Type:

Water Level: 12 Ft. While Drilling Ft. After Drilling Ft.	 Geotechnical and Construction Material Consultants	Boring Started: 12-30-2025 Boring Completed: 12-30-2025 Rig: 550 Foreman: JA Approved: NG Job #: 71-79

71-79.geo TSBOR16.fdt 4/25/2017

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES; IN-SITU, THE TRANSITION MAY BE GRADUAL.

BORING LOG No. 2

Page 1 of 1

PROJECT				SITE								
Central Office Building				Council Bluffs, IA								
GRAPHIC LOG	Approx. Surface Elevation (ft): 983.5 Site Datum: Drilling Method: HSA	USCS SYMBOL	DEPTH (ft.)	SAMPLES		TESTS						
				NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER	
	Fill -- Sandy lean CLAY, trace gravel, grayish brown and yellowish brown	CL	0									
			1	ST			9.7	97	4000*			
3.0	980.5	CL	4	2	ST			20.6	81		1500*	
	Alluvium -- Lean CLAY, trace organic matter, dark gray, medium stiff											
			7.0	976.5	SM	8						
	Alluvium -- Silty fine SAND, grayish brown	3	ST				13.5	97				
		12										
			16									
			20	5		ST			27.3		105	
20.0		963.5	20									
Bottom of boring												

Notes: * Calibrated hand penetrometer
Hammer Type:

Water Level: 12 Ft. While Drilling Ft. After Drilling Ft.	 Geotechnical and Construction Material Consultants	Boring Started: 12-30-2025 Boring Completed: 12-30-2025 Rig: 550 Approved: NG	Foreman: JA Job #: 71-79

71-79.geo TSBORL16.fdt 4/25/2017

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES; IN-SITU, THE TRANSITION MAY BE GRADUAL.

BORING LOG No. 3

Page 1 of 1

PROJECT				SITE								
Central Office Building				Council Bluffs, IA								
GRAPHIC LOG	Approx. Surface Elevation (ft): 983.5 Site Datum: Drilling Method: HSA	USCS SYMBOL	DEPTH (ft.)	SAMPLES				TESTS				
				NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER	
	Fill -- Lean CLAY, with sand, trace organic matter and gravek, very dark brown	CL	0									
			1	ST		7.2		81				
			4	2	ST			14.4	101			4000*
	Alluvium -- Lean CLAY, gray and brown, stiff	CL	8									
			3	ST		32.4		87	2000*			
	Alluvium -- Silty fine SAND, dark brown	SM	12									
			4	ST		24.5		95				
			16									
			20	5	ST			33.5	90			
	Bottom of boring		20									

Notes: * Calibrated hand penetrometer
Hammer Type:

Water Level:  12 Ft. While Drilling  Ft. After Drilling  Ft.	 Geotechnical and Construction Material Consultants	Boring Started: 12-30-2025 Boring Completed: 12-30-2025 Rig: 550 Approved: NG	Foreman: JA Job #: 71-79

71-79.geo TSBOR1616.fdt 4/25/2017

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES; IN-SITU, THE TRANSITION MAY BE GRADUAL.

BORING LOG No. 4

Page 1 of 1

PROJECT Central Office Building				SITE Council Bluffs, IA			

GRAPHIC LOG	Approx. Surface Elevation (ft): 984 Site Datum: Drilling Method: HSA	USCS SYMBOL	DEPTH (ft.)	SAMPLES				TESTS			
				NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER
	DESCRIPTION										
	Fill -- Sandy lean CLAY, yellowish brown and grayish brown	CL	0								
	3.0 981.0			1	ST			20.9	94		
	Alluvium -- Fat CLAY, very dark gray, very stiff	CH	4	2	ST			30.3	90	4000*	LL=67, PI=42
	7.0 977.0										
	Alluvium -- Lean CLAY, grayish brown, stiff	CL	8				11	28.3			
	10.0 974.0			3	ST						
	Bottom of boring										

Notes:								* Calibrated hand penetrometer Hammer Type:		

Water Level:  None Ft. While Drilling  Ft. After Drilling  Ft.	 Geotechnical and Construction Material Consultants	Boring Started: 12-30-2025 Boring Completed: 12-30-2025 Rig: 550 Foreman: JA Approved: NG Job #: 71-79

71-79.geo TSBOR16.fdt 4/25/2017

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES; IN-SITU, THE TRANSITION MAY BE GRADUAL.

BORING LOG No. 5

Page 1 of 1

PROJECT				SITE							
Central Office Building				Council Bluffs, IA							
GRAPHIC LOG	Approx. Surface Elevation (ft): 983.5 Site Datum: Drilling Method: HSA	USCS SYMBOL	DEPTH (ft.)	SAMPLES				TESTS			
				NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER
	Fill -- Sandy lean CLAY, trace gravel, dark brown	CL	0								
				1	ST			8.7	108		
	Alluvium -- Fat CLAY, very dark gray, very stiff	CH	4	2	ST			22.4	96	6000*	
	Alluvium -- SILT, trace sand, grayish brown	ML	8								
				3	ST			16.8	98		
	Bottom of boring										

Notes: * Calibrated hand penetrometer
Hammer Type:

Water Level:  None Ft. While Drilling  Ft. After Drilling  Ft.		 Geotechnical and Construction Material Consultants		Boring Started: 12-30-2025			
				Boring Completed: 12-30-2025			
				Rig: 550	Foreman: JA		
				Approved: NG	Job #: 71-79		

71-79.geo TSBORL16.fdt 4/25/2017

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES; IN-SITU, THE TRANSITION MAY BE GRADUAL.

UNIFIED SOIL CLASSIFICATION SYSTEM



Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A					Soil Classification	
					Group Symbol	Group Name ^B
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines ^C	$Cu \geq 4$ and $1 \leq Cc \leq 3^E$	GW	Well-graded gravel ^F	
			$Cu < 4$ and/or $1 > Cc > 3^E$	GP	Poorly graded gravel ^F	
		Gravels with Fines More than 12% fines ^C	Fines classify as ML or MH	GM	Silty gravel ^{F, G, H}	
			Fines classify as CL or MH	GC	Clayey gravel ^{F, G, H}	
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines ^E	$Cu \leq 6$ and $1 \leq Cc \leq 3^E$	SW	Well-graded sand ^I	
			$Cu < 6$ and/or $1 > Cc > 3^E$	SP	Poorly graded sand ^I	
		Sands with Fines More than 12% fines ^D	Fines classify as ML or MH	SM	Silty sand ^{G, H, I}	
			Fines classify as CL or CH	SC	Clayey sand ^{G, H, I}	
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic:	$PI > 7$ and plots on or above “A” line ^J	CL	Lean clay ^{K, L, M}	
			$PI < 4$ or plots below “A” line ^J	ML	Silt ^{K, L, M}	
		Organic:	Liquid limit – oven dried	< 0.75	OL	Organic clay ^{K, L, M, N}
			Liquid limit – not dried		Organic silt ^{K, L, M, O}	
	Silts and Clays Liquid limit 50 or more	Inorganic:	PI plots on or above “A” line	CH	Fat clay ^{K, L, M}	
			PI plots below “A” line	MH	Elastic silt ^{K, L, M}	
		Organic:	Liquid limit – oven dried	< 0.75	OH	Organic clay ^{K, L, M, P}
			Liquid limit – not dried		Organic silt ^{K, L, M, Q}	
Highly Organic Soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

^A Based on the material passing the 3-in. (75-mm) sieve.

^B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^C Gravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

^D Sands with 5 to 12% fines require dual symbols:

SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

$$Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

^F If soil contains $\geq 15\%$ sand, add "with sand" to group name.

^G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^H If fines are organic, add "with organic fines" to group name.

^I If soil contains $> 15\%$ gravel, add "with gravel" to group name.

^J If Atterberg limits plots in shaded area, soil is a CL-ML, silty clay.

^K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

^L If soil contains $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ and plots on or above "A" line.

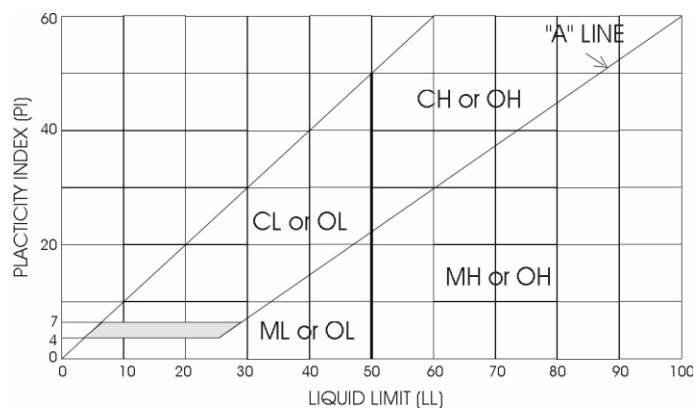
^O $PI < 4$ or plots below "A" line.

^P PI plots on or above "A" line.

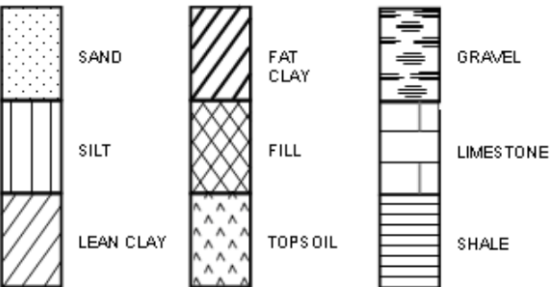
^Q PI plots below "A" line.

For classification of fine-grained soils and fine grained fraction of coarse-grained soils.

Equation of "A" Line:
Horizontal at $PI = 4$ to $LL + 25.5$.
then $PI = 0.73 (LL - 20)$



GENERAL NOTES

SOIL and ROCK TYPES	DRILLING & SAMPLING SYMBOLS
	SS Split Spoon - 1 1/2" I.D., 2" O.D., unless otherwise noted ST Thin-Walled Tube - 3" O.D., unless otherwise noted PA Power Auger HA Hand Auger DB Diamond Bit - 4", N, B AS Auger Sample HS Hollow Stem Auger WS Wash Sample RB Rock Bit BS Bulk Sample DC Dutch Cone WB Wash Bore AR Air Rotary

STRENGTH TERMS				
CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing No. 200 sieve)			RELATIVE DENSITY OF COARSE-GRAINED SOILS (50% or more retained No. 200 sieve)	
Consistency	Unconfined Compressive Strength, Qu, psf	N-Blows/ft* (Approx. Correlation)	Relative Density	N-Blows/ft. *
Very Soft	< 500	0 - 2	Very Loose	0 - 4
Soft	500 - 1,000	3 - 4	Loose	5 - 10
Medium	1,001 - 2,000	5 - 8	Medium Dense	10 - 29
Stiff	2,001 - 4,000	9 - 15	Dense	30 - 49
Very Stiff	4,001 - 8,000	16 - 30	Very Dense	50 - 80
Hard	8,001 - 16,000	31 - 50	Extremely Dense	80 +
Very Hard	> -16,000	50 +		

* Standard "N" Penetration Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch OD split spoon, except where noted.

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES		GRAIN SIZE TERMINOLOGY	
Descriptive Term(s) (of components also present in sample)	Percent of Dry Weight	Descriptive Term(s) (of components also present in sample)	Percent of Dry Weight	Major Component of Sample	Size Range
Trace With Modifier	< 15 15 - 29 > 30	Trace With Modifier	< 5 5 - 12 > 12	Boulders	Over 12 in. (300 mm)
				Cobbles	12 in. to 3 in. (300 mm to 4.75 mm)
				Gravel	3 in. to #4 sieve (75 mm to 4.75 mm)
				Sand	#4 to #200 sieve (4.75 mm to 0.075 mm)
				Silt or Clay	Passing #200 sieve (0.075 mm)

WATER LEVELS:		WD = While Drilling	AD = After Drilling
	Depth groundwater first encountered during drilling		
	Groundwater level after 24 hours (unless otherwise noted, i.e. "AD" -- after drilling)		

TERMS DESCRIBING SOIL STRUCTURE			
Parting:	paper thin in size	Fissured:	containing shrinkage cracks, frequently filled with fine sand or silt, usually more or less vertical.
Seam:	1/8" to 3" in thickness		
Layer:	greater than 3" in thickness	Interbedded:	composed of alternate layers of different soil types.
Ferrous:	containing appreciable quantities of iron	Laminated:	composed of thin layers of varying color and texture.
Well-Graded:	having wide range in grain size and substantial amounts of all intermediate sizes.	Slickensided:	having inclined planes of weakness that are slick and glossy in appearance.
Poorly-Graded:	predominately one grain size or having a range of sizes with some intermediate sizes missing.	NOTE:	Clays possessing slickensided or fissured structure may exhibit lower unconfined strength than indicated above. Consistency of such soil is interpreted using the unconfined strength along with pocket penetrometer results.

END OF VOLUME 2 OF 2