

- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls." Assist the CxA with preparation of testing plans.
- B. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in HVAC piping Sections. HVAC&R Contractor or Subcontractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - 2. Description of equipment for flushing operations.
 - 3. Minimum flushing water velocity.
 - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- C. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of gas, chilled water / ice storage, hot-water and solar systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- D. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.
- E. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

END OF SECTION 23 0800

SECTION 23 0900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 BAS SYSTEM DESCRIPTION

- A. BAS Design Criteria: An extension of the existing T.A.C. Vista system to match existing T.A.C. systems Building Management System (BMS) control equipment for HVAC systems and components, including open protocol control components for terminal heating and cooling units and includes the following:

1. HVAC Control System
2. Energy Management System
3. Lighting Control System - Monitor only
4. Fire Alarm System - Monitor only
5. Security System - Monitor only
6. Use of the ANSI 709.1 LonTalk protocol at the field bus level of the architecture and ANSI/EIA 709.1, and ISO/IEC DIS 14908 LonTalk at the TCP/IP level.

- B. The building automation binding tool will be Echelon LonMaker Turbo for Windows set up to be non-proprietary configuration and configurable.

- C. The building automation system router shall be a Linksys / Cisco Gigabit Security Router or integrated network product that utilizes

1. Virtual Private network (VPN)
2. SPI Fire Wall and integrated Intrusion Prevention System (IPS).
3. Supports 802.1Q Virtual Local Area Network (VLAN) and that has its own DHCP scope.

1.3 RELATED SECTIONS

- A. Section 01 9113 – General Commissioning Requirements
- B. Section 23 0593 – Testing, Adjusting and Balancing for HVAC
- C. Section 26 0010 – Basic Electrical Requirements
- D. Section 26 0519 – Building Wiring and Cabling
- E. Section 26 0800 – Electrical Commissioning
- F. Section 26 0926 – Low-Voltage Lighting Control

- G. Section 26 2726 – Wiring Devices
- H. Section 28 3100 – Fire Detection and Alarm

- 1.4 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION THAT REQUIRE BAS PROVIDER INTERFACE
 - A. Section 23 0900 – Instrumentation and Control for HVAC:
 - 1. Control Valves
 - 2. Air Flow Stations
 - 3. Terminal Unit Controls
 - 4. Flow Switches
 - 5. Control Dampers not part of equipment

- 1.5 PRODUCTS NOT FURNISHED OR INSTALLED BUT INTEGRATED WITHIN THE SCOPE THAT REQUIRE BAS PROVIDER INTERFACE
 - A. Section 23 7413 – Central Station Air-Handling Units:
 - 1. Discharge Air Temperature Control
 - 2. Economizer Control
 - 3. Volume Control
 - 4. Indoor Air Quality Controls
 - B. Section 23 3600 – Air Terminal Units:
 - 1. Cross Flow CFM Sensors
 - 2. Terminal Actuator Control
 - 3. Heat Exchanger Control
 - C. Section 26 0926 – Low-Voltage Lighting Control
 - D. Division 28:
 - 1. Fire Alarm System
 - E. Division 28:
 - 1. Security System

- 1.6 RELATED DOCUMENTS
 - A. Codes, Standards and References: Refer to Division 01.

- B. The publications listed below form a part of this standard to the extent referenced. The publications are referred to within the text by the basic designation only.
1. AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)
 - a. AMCA 500-D-07 - (2007) Laboratory Methods of Testing Dampers for Rating
 2. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
 - a. ANSI/ASHRAE 15 - (2007) Safety Code for Mechanical Refrigeration
 - b. ANSI/ASHRAE 55 - (2004) Thermal Environmental Comfort Standard
 - c. ANSI/ASHRAE 62 - (2007) Ventilation for Acceptable Indoor Air Quality
 - d. ANSI/ASHRAE 90.1 - (2007) Energy Efficient Design of New Buildings except Low Rise Residential Buildings
 - e. ANSI/ASME B16.34 - (2001) Valves – Flanged, Threaded, and Welded Ends
 - f. ANSI C12.1 - (2008) Code for Electricity Metering
 - g. ANSI/CEA 709.1B - (2006) Open Standard Protocol
 - h. ANSI/EIA 709.1 - (2000) Control Network Protocol Specification
 - i. ANSI/EIA 709.3 - (2003) Free-Topology Twisted-Pair Channel Specification
 - j. ANSI/FCI 70.2 - (2003) Control Valve Seat Leakage
 3. California Code of Regulations, Title 24, Latest Adopted Edition, California Building Codes.
 4. California Code of Regulations, Title 8, Latest Adopted Edition, California Industrial Relations.
 5. AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS (ASHRAE)
 - a. ASHRAE Handbook of Fundamentals
 6. ECHELON
 7. Junction Box and Wiring Guideline for Twisted Pair LONWORKS® Networks, July 2003
 8. FEDERAL COMMUNICATIONS COMMISSION (FCC)
 - a. FCC EMC - (2002) FCC Electromagnetic Compliance Requirements
 - b. FCC Part 15 - (2008) FCC Rules and Regulations Part 15: Radio Frequency Devices (Volume II)
 9. INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
 - a. IEEE C62.41 - (1991; R 2002) Surge voltages in Low-Voltage AC Power circuits
 - b. IEEE 100 - (2000) IEEE Standard Dictionary of Electrical and Electronics Terms
 - c. IEEE 142 - (1991) IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
 - d. IEEE 802.1M - (2000) Media Access Control Bridges
 - e. IEEE 802.2 - (2000) Standards for Local Area Networks: Logical Link control
 10. INSTRUMENT SOCIETY OF AMERICA - (2006) ISA Standards

11. INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)
 - a. ISO OSI Model - Open Systems Interconnection Reference Mode
 - b. ISO/IEC - (2008) DIS 14908-1 Lon Protocol
 - c. ISO/IEC - (2008) DIS 14908-2 Lon Twisted-Pair Media
 - d. ISO/IEC - (2008) DIS 14908-3 Lon Powerline Media
 - e. ISO/IEC - (2008) DIS 14908-4 Lon IP Tunneling of the Protocol
12. LONMARK INTEROPERABILITY ASSOCIATION
 - a. SNVT Master List - (2002) LonMark SNVT Master List; Version 2
 - b. LonMark XIF Guide - (2003) LonMark External Interface File Reference Guide; Revision 4.0B
13. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
 - a. NEMA 250 - (2008) Enclosures for electrical Equipment (1000 Volt Maximum)
14. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
 - a. NFPA 70 - (2008) National Electrical Code
 - b. NFPA 90A - (2009) Installation of Air Conditioning and Ventilation Systems
 - c. NFPA 262 - (2007) Test for Flame-Propagation and Smoke Density Values for Electrical and Optical Fiber Cables Used in Spaced Transporting Environmental Air
15. UNDERWRITER'S LABORATORIES (UL)
 - a. UL 1778 - (2006) Standard for Uninterruptible Power Supply Equipment
 - b. UL 60950 - (2007) Safety of Information Processing and Business Equipment
 - c. UL 916 - (2002) Energy Management Equipment
 - d. UL 1585 - (2001) Class 2 and Class 3 Transformers
 - e. UL 555 - (1999) Standard for Fire Dampers
 - f. UL 555S - (1996; R2002) Leakage Rated Dampers for Use in Smoke Control Systems
 - g. UL 94 - (1996; Rev thru July 2006) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
 - h. UL 268A - (2006) Smoke Detectors for Duct Application
 - i. UL 864 - (2007) Standard for Control Unit and Accessories for Fire Alarm Systems
16. U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)
 - a. 47 CFR Part 15 - Radio Frequency Devices
 - b. 21 CFR Part 11 - Administrative Practice and Procedure, Computer Technology, Reporting and Record Keeping Requirements

1.7 SUBMITTALS

A. Required Format for Submittals:

1. Shop Drawings and Product Data shall meet the requirements.
2. Shop drawings shall be 11 inch by 17 inch, landscape, bound on the left edge. They shall be produced with Microsoft Visio. Organize the packages by building and floors. To the maximum extent possible Adobe Acrobat shall be used to produce the documents in an X.pdf format.
3. All text based documents and product data sheets shall be 8-1/2 inch by 11 inch format bound on the left edge. To the maximum extent possible Adobe Acrobat shall be used to produce the documents in an X.pdf format.
4. Software files shall be submitted on fully labeled CDs that shall include a table of contents file in pdf format that provides a description of all of the files on the CD and or USB Drive.
5. Requirement for Shop Drawings:

a. System Architecture Design Diagram:

- 1) This is a riser diagram that shall show the IP layers and all of the field bus layers.
- 2) It shall show each computer, printer, router, repeater, controller and protocol translator that is connected to either the IP layer or any of the field busses.
- 3) This diagram shall include the existing control system that is to be integrated into the common enterprise level system.
- 4) Each component that is shown shall have a name that is representative of how it will be identified in the completed database and the manufacturer's name and model number. Example: Device A10: AHU1 Controller, XXX, IHM Model 1401Z0
- 5) The physical relationship of one component to another component shall reflect the proposed installation.
 - a) Example: If AHU-1 controller is the closest controller to the IP to LON router on the field bus, then this device shall be shown as the first device on the riser diagram just below the IP to LON router.
- 6) This diagram shall not include power supplies, sensors or end devices.

b. Layout Design Drawing for each control panel:

- 1) The layout drawing shall be with all devices shown in their proposed positions.
- 2) All control devices shall be identified by name.
- 3) All terminal strips and wire channels shall be shown and labeled
- 4) All control transformers shall be shown and labeled
- 5) All 120 VAC receptacles shall be shown and labeled
- 6) All IP connection points shall be shown and labeled

- c. Wiring Design Diagram for each control panel:
 - 1) The control voltage wiring diagram shall clearly designate devices powered by each control transformer. If the control devices use half-wave power, the diagram shall clearly show the consistent grounding of the appropriate power connection. All wire identification numbers shall be annotated on the diagram.
 - 2) The LON wiring diagram shall clearly show the use of the daisy chain wiring concept, the order in which the devices are connected to the LON and the location of end of segment termination devices. All wire identification numbers shall be annotated on the diagram.
 - 3) If shielded communication wiring is used, the grounding of the shield shall be shown.
 - 4) The terminal strip wiring diagram shall identify all connections on both sides of the terminal strip. Wiring label numbers for all wiring leaving the control panel shall be annotated on the diagram.

- d. Wiring Design Diagram for individual components (controllers, protocol translators, etc.):
 - 1) The wiring diagram for each component shall identify all I/O, power and communication wiring, and the locations on the terminal blocks to which the wires are landed. Example: Fan Status sensor is wired from terminals 5/6 on the controller to terminals 17 and 18 on the terminal strip.

- e. Installation Design Detail for each I/O device:
 - 1) Include a drawing of the wiring details for each sensor and/or end device.
 - 2) For devices with multiple quantities a standard detail may be submitted.
 - a) Note: The standard detail drawing must be accompanied by a list of the locations where the devices will be installed.

6. Requirements For Product Data:
 - a. Direct Digital Control System Hardware Technical Data.
 - 1) A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.
 - 2) Manufacturer's description and technical data for each unique device to include performance curves, product specification sheets and installation instructions. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
 - 3) This requirement applies to:
 - a) Controllers
 - b) Transducers / Transmitters
 - c) Sensors
 - d) Actuators
 - e) Valves

- f) Relays and Switches
 - g) Control Panels
 - h) Power Supplies
 - i) Batteries
 - j) Operator Interface Equipment
- b. An Instrumentation List for each system:
- 1) The list shall be in a table format.
 - 2) Include name, type of device, manufacturer, model number and product data sheet number.
- c. Binding Map:
- 1) LonMaker Turbo drawings shall be 11 inch by 17 inch, landscape, bound on the left edge. They shall be produced with Microsoft Visio. Organize the packages by building and floors. The map will not need to include the flow of data from devices to the presentation system.
- d. HMI/GUI Graphic Pages:
- 1) Submit a sample HMI/GUI graphic page for each type of page described in the specification section on graphic pages.
- B. Turnover Documents after Completion and Commissioning:
- 1. The following is a list of post construction turnover documentation 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 each control panel.
 - d. LonMaker Turbo Drawings
 - e. Wiring diagram for individual components.
 - f. System flow diagram for each controlled system.
 - g. Instrumentation list for each controlled system.
 - h. Sequence of controls.
 - i. Binding maps.
 - 2. Operation and Maintenance Manuals:
 - a. Operations and Maintenance Manuals shall consist of two parts. The information shall be in three ring binders with tabs and a table of contents. Diagrams shall be on 11" by 17" foldouts. If color has been used to differentiate information, the printed copies shall be in color.
 - b. Part I: Information common to the entire system. This shall include but not be limited to the following.
 - 1) Product manuals for the key software tasks.
 - a) Operating the system.

- b) Administrating 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.
- 2) System Architecture Diagram.
 - 3) List of recommended maintenance tasks associated with the system servers, operator workstations, data servers, web servers and web clients.
 - a) Define the task.
 - b) Recommend a frequency for the task.
 - c) Reference the product manual that includes instructions on executing the task.
 - 4) Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
 - 5) Licenses, guarantees, and warranty documents for equipment and systems.
 - 6) Submit one copy for each building, plus two extra copies.
- c. Part II: Information common to the systems in a single building.
- 1) System architecture diagram for components within the building annotated with specific location information.
 - 2) As-built wiring design diagram for each control panel.
 - 3) As-built wiring design diagram for all components.
 - 4) Installation design details for each I/O device.
 - 5) As-built system flow diagram for each system.
 - 6) Sequence of control for each system.
 - 7) Binding map for the building.
 - 8) Product data sheet for each component.
 - 9) Installation data sheet for each component.
 - 10) Description of system commissioning protocol and procedures in binder with two extra copies.
 - 11) Initial system change control log in binder.
 - 12) Submit two copies for each building and two extra copies for file.
3. Software:
- a. Submit a LICENSED COPY of all software installed on the servers and workstations.
 - b. Submit all licensing information for all software installed on the servers and workstations.
 - c. Submit a LICENSED COPY of all software used to execute the project even if the software was not installed on the servers and workstations.
 - d. Submit all licensing information for all of the software used to execute the project.
 - e. All software revisions shall be as installed at the time of the system acceptance. All submittals will include all revisions

4. Firmware Files:

- a. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.
- b. 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.
- c. Submit a LICENSED COPY of all application files that were created during the execution of the project.
- d. Submit an electronic copy on DVD of all graphic page files created during the execution of the project.
- e. Submit a copy of all secondary graphic files on DVD such as bitmaps, jpegs, etc. that were used in the creation of the graphic pages.

1.8 DEFINITION OF TERMS

- A. Appendix A to this document contains a list of terms and/or abbreviations with their definitions. These terms are used throughout this document.
- B. Additional definitions of terms or acronyms are included on the contract drawings and in other Sections of this specification.
- C. In the preparation of submittals and reports, the contractor shall use these definitions and abbreviations. Any terms or abbreviations used by the BAS provider in submittals and reports that have not been defined in this section shall be defined by the BAS provider in the first section of the submittal or report prior to their use.

1.9 OWNERSHIP OF PROPRIETARY MATERIAL

- A. The AOC shall retain all rights to any and all software and hardware used for this project.
- B. The AOC shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to the AOC as defined by the manufacturer's licensing agreement. Standard language protecting the manufacturer's rights to disclosure of Trade Secrets contained within such software is acceptable.
- C. The licensing agreement shall not preclude the use of the software by individuals under contract to the AOC 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 AOC's computers and only for the purpose of commissioning, change control, servicing, or altering the installed system.
- D. All project developed software, files and documentation shall become the property of the AOC. 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
12. All licensing

1.10 QUALIFICATIONS

- A. All work described in the plans and specifications shall be installed, wired and commissioned by factory certified BAS technicians qualified for this work and in the regular employment of the control system manufacturer's local office.
- B. A local office is defined as a corporate branch office or an independently owned office with a current contractual agreement with the system manufacturer that allows the office to purchase, install and service the manufacturer's products.
- C. The local office shall be a full service facility within 142 miles of the project site. The local office shall be staffed with BAS engineers and technicians trained on the installation, commissioning and service of energy management and control systems based on the LON Works technology.
- D. The building automation system (BAS/IP) design engineer must demonstrate expertise in the following:
 1. Six (6) years in Building Automation System (BAS) in the HVAC/Mechanical engineering field.
 2. Five (5) years of project management experience in similar types of facilities upgrade projects that involve Building Automation Systems (BAS), Energy Management (EM) and Heating, Ventilations and Air-conditioning (HVAC) systems.
 3. Four (4) years experience in the proprietary Building Automation System (BAS) Control Systems Design.
 4. Three (3) years of working experience with open industry standard, BAS control product lines.
 5. Two (2) years of project engineering experience with at least two major control system manufacturer's LonMark and LonTalk compliance standards
 6. One (1) year working experience with the California Building Energy Efficiency Standards, Nonresidential Compliance Manual.

1.11 QUALITY ASSURANCE

- A. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to receipt of bids for all of the Codes and Standards listed in Paragraph 1.6 of this specification.

- B. Performance criteria for components, collections of components, communications and system performance are described in Part 2 - Products.
- C. Key quality assurance BAS/IP Commissioning programs are described in Part 3 shall include the following
 - 1. Installation Component Verification
 - 2. Operational Testing Verification
 - 3. Performance Testing Verification
 - 4. Integrated Functional Testing Verification
 - 5. Commissioning Turnover Documentation package

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Manufacturers (Product Line):
 - a. Schneider Electric; (TAC VISTA)

2.3 EXISTING SYSTEM ARCHITECTURE

- A. The DDC system shall include system servers, operator work stations, a data server, a web server and field level devices installed in an architecture that consists of two layers, the TCP/IP layer and the field bus layer.
- B. The TCP/IP layer connects all of the buildings to the LAN and then interconnects all the buildings on a WAN or wide area network. Fixed IP addresses for connections to the LAN or local area network shall be used for each device (except workstations) that connects to the LAN or local area network.
- C. Connection points for the system servers, operator workstations, data server and web server shall be at the IP layer of the system architecture.
- D. The system architecture shall include an IP to LON third party, configurable, "Loytec Redundant, EIA 709/IP Network Translator" and or pre-approved LonMark Certified Building Controller of comparable functional capabilities to connect a field bus to the LAN. A building

control system shall have one or more IP connections to the LAN based on the number of connected devices and wiring considerations.

- E. For the new building control systems, each LON field bus shall consist of one channel with no more than 78 connected devices. If there are more than 38 connected devices, the channel shall be divided into two segments separated by a physical layer, configurable "Echelon Repeater/Router" and or approved equal of comparable functional capabilities.
- F. For the new building control systems, the programmable process controllers, supervisory logic controllers, application specific devices and protocol translators shall be installed on the field busses.

2.4 NETWORKING

- A. IP Network: All new devices that connect to the LAN shall be capable of operating at 100 megabits per second or 1000 megabits per second. A legacy device connection speed of 10 megabits shall be accommodated on a case-by-case basis.
- B. Field Bus:
 - 1. The field busses shall be FTT-10A operating at 78 kilobits per second.
 - 2. The wiring of components shall use (a preferred choice of) a properly terminated bus or daisy chain. Free topology networks (not a preferred choice) need exception preapprovals from the BAS-IP team at the time of submittal.
 - 3. The wiring type and length limitations shall conform to Echelon's Junction Box and Wiring Guideline for Twisted Pair LonWorks Networks.
- C. IP to Field Bus Router:
 - 1. These devices shall perform layer 3 routing of ANSI/EIA 709.1B packets onto the IP network.
 - 2. These devices shall be configurable locally without the use of the IP network (local cross over cable connection is acceptable) and configurable via the IP network.
 - 3. These devices shall be configurable as routers such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.
- D. Building Controller:
 - 1. These devices shall be configurable as routers such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.
 - 2. These devices shall provide the following support for the field bus devices that are connected below the building controller.
 - a. Time schedules
 - b. Trend logging
 - c. Alarm message generation and handling
 - 3. These devices may provide supervisory logic support for the field bus devices that are connected below the building controller.

4. These devices may have physical inputs and outputs and provide process control for systems using these inputs and outputs.
5. If a building controller has physical inputs and outputs, it shall also comply with all of the requirements for programmable process controllers.

E. Physical Layer Repeaters (PLR):

1. PLRs are required to connect two segments to create a channel.
2. The design of the PLRs shall conform to LONmark standards.
3. LON to LON routers configured as repeaters may be used as a PLR.
4. Physical layer repeaters shall be installed in an enclosure. The enclosure may be in an interstitial space.

2.5 FIELD BUS DEVICES

A. General Requirements:

1. Devices shall incorporate a service pin which, when pressed, will cause the device to broadcast its 48 bit node ID and its program ID over the network. The service pin shall be distinguishable and accessible.
2. Devices shall have a light indicating that they are powered.
3. Devices shall incorporate a TP/FT-10A transceiver in accordance with ANSI/EIA 709.3 and connections for TP/FT control network wiring.
4. Devices shall be locally powered. Link powered devices are not acceptable.
5. Application programs shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings.

B. Programmable Process Controllers (PPC):

1. The key characteristics of a PPC are:
 - a. They have physical input and output circuits for the connection of analog input devices, binary input devices, pulse input devices, analog output devices and binary output devices. The number and type of input and output devices supported will vary by model.
 - b. They may or may not provide support for additional input and output devices beyond the number of circuits that are provided on the basic circuit board. Support for additional I/O may be by additional circuit boards that physically connect to the basic controller or by a standalone device that communicates with the basic controller via the FTT-10A field bus.
 - c. The application to be executed by a PPC is created by an application engineer using the vendor's application programming tool.
 - d. PPCs will support embedded time schedules. When time schedules are not embedded in a PPC, an occupancy command shall be an input network variable when time based control is required by the sequence of control
 - e. PPCs will support trend data storage with periodic upload to the data server. When trend data storage is not supported, the variables to be trended shall be broadcast over the field bus to another device that does support embedded trend data storage.
 - f. PPCs will support the initiation of an alarm message to the system server. When alarm message initiation is not supported, binary alarm indication variables shall

be broadcast over the field bus to another device that does support the initiation of alarm messages to the system server.

2. Analog Input Circuits:
 - a. The electrical signals from analog sensors shall be processed by an analog to digital (A/D) converter chip. The output of the A/D chip shall then be processed mathematically to produce data within the controller that has the required engineering units.
 - b. The resolution of the A/D chip shall not be greater than 0.01 Volts per increment. For an A/D converter that has a measurement range of 0 to 10 VDC and is 10 bit, the resolution is 10/1024 or 0.00976 Volts per increment.
 - c. For non-flow sensors, the control logic shall provide support for the use of a calibration offset such that the raw measured value is added to the (+/-) offset to create a calibration value to be used by the control logic and reported to the Operator Workstation (OWS).
 - d. For flow sensors, the control logic shall provide support for the use of an adjustable gain and an adjustable offset such that a two point calibration concept can be executed (both a low range value and a high range value are adjusted to match values determined by a calibration instrument).
 - e. For non-linear sensors such as thermistors and flow sensors the PPC shall provide software support for the linearization of the input signal.
3. Binary Input Circuits:
 - a. Dry contact sensors shall wire to the controller with two wires.
 - b. An external power supply in the sensor circuit shall not be required.
4. Pulse Input Circuits:
 - a. Pulse input sensors shall wire to the controller with two wires.
 - b. An external power supply in the sensor circuit shall not be required.
 - c. The pulse input circuit shall be able to process up to 50 pulses per second.
5. True Analog Output Circuits:
 - a. The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range (Example: 0 to 100% creates 3 to 6 VDC where the full output range is 0 to 10 VDC).
 - b. The resolution of the D/A chip shall not be greater than 0.04 Volts per increment or 0.08 milliamps per increment.
6. Pulse Width Modulation Outputs with PWM Transducers:
 - a. The controller shall be able to generate incremental pulses as small as 0.1 seconds.

7. Binary Output Circuits:
 - a. Single pole single throw or single pole double throw relays with support for up to 230 VAC and a maximum current of 2 amps.
 - b. Voltage sourcing or externally powered Triacs with support for up to 30 VAC and 0.8 amps.

 8. Program Execution:
 - a. Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
 - b. The sample rate for a process control loop shall be adjustable and shall support a minimum sample rate of 1 second.
 - c. The sample rate for process variables shall be adjustable and shall support a minimum sample rate of 1 second.
 - d. The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
 - e. The application shall have the ability to determine if a power cycle to the controller has occurred, and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.

 9. Local Interface: The controllers shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
 - a. Adjust application parameters.
 - b. Edit time schedule parameters if time schedules are embedded in the controller.
 - c. Execute manual control of input and output points.
 - d. View dynamic data.
 - e. View alarm messages if alarm messaging is embedded in the controller.

 10. Each PPC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.
- C. Supervisory Logic Controllers (SLC):
1. The key characteristics of an SLC are:
 - a. The application to be executed by as SLC is created by an application engineer using the vendor's application programming tool.
 - b. SLCs will support embedded time schedules. When time schedules are not embedded in a SLC, an occupancy command shall be an input network variable when time based control is required by the sequence of control.
 - c. SLCs will support trend data storage with periodic upload to the data server. When trend data storage is not supported, the variables to be trended shall be broadcast over the field bus to another device that does support embedded trend data storage.

- d. SLCs will support the initiation of an alarm message to the system server. When alarm message initiation is not supported, binary alarm indication variables shall be broadcast over the field bus to another device that does support the initiation of alarm messages to the system server.
2. Program Execution:
 - a. Control algorithms shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
 - b. The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
 - c. The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.
 3. Local Interface: The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
 - a. Adjust application parameters.
 - b. Edit time schedule parameters if time schedules are embedded in the controller.
 - c. Execute manual control of input and output network variables.
 - d. View dynamic data.
 - e. View alarm messages if alarm messaging is embedded in the controller.
 4. Each SLC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.
 5. Programmable process controllers with un-used I/O may be used as supervisory logic controllers provided they meet all other requirements.
 6. Supervisory logic controllers shall have support a minimum of 200 input network variables and 70 output network variables.
 - a. The SNVT for each of the 200 input network variables shall be selectable.
 - b. The SNVT for each of the 70 output network variables shall be selectable.
 - c. For the input and output network variables there shall not be any limitations as to the SNVT selected. (Example: SNVT_temp_p can only be used on 10 input network variables.)
- D. Application Specific Devices (ASD):
1. ASD shall have fixed function configurable applications.
 2. If the application can be altered by the vendor's application programming tool, the device shall be considered a programmable controller and not an application specific device.
 3. All input and output network variables shall be formatted with SNVTs.
 4. All input configuration parameters shall be formatted with SNVTs or SCPTs. If UNVTs or UCPTs are used, the device resource files that allow these custom parameters to be read shall be provided to the owner.

5. The network interface shall conform to the LonMark profile for the application provided by the ASD.
6. Each ASD shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.

E. Protocol Translators:

1. Protocol translators are required to interface third party equipment items such as chillers, boilers, power monitoring equipment, etc. to the new control system via the FTT-10A field bus.
2. Protocol translators shall convert the BACnet, Modbus or proprietary variables to/from the third party device to network variables that use SNVTs.
3. The application in a protocol translator shall include minimum send time and send on delta parameters for each reported variable to avoid data storms from the protocol translator.

2.6 EXISTING DATA SERVERS, WEB SERVERS, DDC SYSTEM SERVERS AND WORKSTATIONS

A. Hardware Requirements:

1. General: The following minimum requirements apply to the system servers, data server, web server, operator workstations and appliances.
 - a. Intel 7i Processor with 6 GB of RAM
 - b. Rack Mounted Style Hewlett Packard or Dell servers with remote workstations
 - c. Intel Motherboard or pre-approved equal
 - d. Serial port, parallel port and 4 USB ports
 - e. 10/100/1000 MBPS Ethernet NIC
 - f. >750 GB Hard Disk Drive
 - g. Mirroring Hard Disk Drives (Redundant Array Independent Disks)
 - h. DVD-RW Drive
 - i. High resolution (minimum 1280 by 1024), >23.1 inch, LED flat panel wide screen display
 - j. Optical mouse and full function keyboard
 - k. Audio sound card and speakers
 - l. Surge protector / UPS with Powerchute manufactured by American Power Conversion Corporation (APC).

B. Software Requirements:

1. General: The following software with license agreements shall be provided.
2. System Servers:
 - a. Microsoft Windows Server 2003 operating system
 - b. Microsoft Office 2003 Professional Edition
 - c. DDC System Server Application, latest revision
 - d. Any other software required to deliver the specified performance.

3. Data Servers:
 - a. Microsoft Windows 2003 Server Operating System.
 - b. Microsoft SQL 2005
 - c. Microsoft Office 2003 Professional Edition
 - d. Echelon LonMaker Turbo Binding Tools
4. Web Server:
 - a. Microsoft Windows 2003 Server Operating System OR an embedded web server.
5. Operator Workstations:
 - a. Microsoft Windows Vista Professional Operating System
 - b. Microsoft Office 2003 Professional Edition
 - c. DDC System Operator Workstation Application(s) , latest revision
 - d. Any other software required to deliver the specified performance.
 - e. Echelon LonMaker Turbo

2.7 EXISTING DDC SYSTEM SOFTWARE

- A. System Servers: Software to provide the following functionality makes up the DDC System Server Application Software.
 1. The system server shall manage the collection of data from a specific set of hardware devices and make that data available to the operator workstations and web server.
 2. The system server shall manage the uploading of trend log data and transfer of this data to the data server.
 3. For large systems with multiple system servers, each managing a portion of the hardware environment, a system server shall be able to send and receive data from other system servers that are part of the total system. Example: A demand control command from a controller under System Server # 1 is uploaded by System Server # 1 and then passed to System Server # 2 over the IP. System Server # 2 shall then pass the demand control command down to the controller where the command is required to execute the sequence of control.
 4. The system architecture shall support up to 12 system servers.
 5. The system server shall receive alarm messages from the hardware environment and distribute these messages to alarm files, printers, and email accounts as programmed. The received alarm shall cause trend data to be collected and reports to be automatically generated. Operator workstation software does not have to be running for these actions to take place.
 6. The system server shall manage the execution of scheduled reports. Operator workstation software does not have to be running for reports to be written to the hard disk.
 7. The system server software shall run as a service under the operating system for automatic start up after a power cycle of the system server computer.

B. Existing Operator Workstations: Software to provide the following functionality makes up the DDC System Operator Workstation Application Software.

1. Data Presentation: Data shall be presented in the following formats:

- a. Points lists with dynamic presentation of data. The operator shall be able to create custom point lists with data that originates from multiple devices. A point may be dynamic data from a controller or a configuration parameter to be written to a controller by the BAS operator.
- b. Graphic pages with dynamic presentation of data on a visual diagram that represents a building, a floor plan, a cross section of a mechanical system or a table of data.
- c. Graphical presentation of historical trend log data plotted against time.
- d. Graphical presentation of real time trend data plotted against time.
- e. Alarm Presentation:
 - 1) Unless restricted by a reduction in viewing authority, an operator shall be able to view alarms for all systems in a single alarm list.
 - 2) Custom alarm views configured for select categories of alarms shall present only the alarms specified.
 - 3) Alarm messages shall include identifying information and the signal value or state at the time of the alarm.
- f. Event Presentation:
 - 1) Unless restricted by a reduction in viewing authority, an operator shall be able to view an event log that chronologically captures all activity created by the system and operator actions.
 - 2) Custom event views for select categories of events shall present only the events specified.
- g. Time Schedules:
 - 1) Each time schedule shall have the ability to issue a minimum of 64 start and 64 stop commands for the week. The requirements for start and stop commands may be different for each day of the week.
 - 2) Each time schedule shall also include a holiday component where a holiday is identified by the date and duration (one day, two days, etc.). The time schedule shall support a unique set of start and stop commands for each holiday. The time schedule shall support a minimum of 72 holidays per year. Holiday schedules shall take precedence over standard schedules during the holiday period. Holidays that are date specific shall roll over from year to year without operator programming action.
 - 3) There shall be a mechanism to link a master time schedule editor at an OWS to multiple time schedules in various ATS devices (or Building Controllers). Once linked, whenever the master time schedule is changed at an OWS, the new time schedule parameters shall be automatically downloaded to all of the linked time schedules. This concept shall apply to both standard schedules and holiday schedules.

- h. The system shall support a configuration that:
 - 1) Causes the system to go into standby mode (user is logged out but the current screen is still displayed) after a specific period of inactivity.
 - 2) Causes an automatic system logout after a specific period of inactivity.
- 2. Data Source:
 - a. An AOC BAS service provider operator workstation shall present data from all of the system servers.
 - b. The system architecture shall allow a minimum of 1 BAS operator workstations and 2 LED monitoring screen stations per system if so specified on the drawings.
- 3. Operator Access And Privileges:
 - a. There shall be a minimum of four privilege levels.
 - 1) BAS System Administrator:
 - a) No limitations
 - b) Only level that can assign or delete users and assign or modify privileges.
 - 2) BAS Engineer:
 - a) View data in any format.
 - b) Acknowledge alarms.
 - c) Inhibit alarms.
 - d) Exercise control actions.
 - e) Edit the presentation of data.
 - f) Modify the system.
 - 3) BAS Operator:
 - a) View data in any format.
 - b) Acknowledge alarms.
 - c) Exercise control actions.
 - 4) BAS Viewer:
 - a) View data in any format.
 - b. The level assigned to a specific user shall be the maximum level that can be used anywhere in the system. The software shall provide the capability to reduce a user's level from his or her maximum level to a lower level on a per building or system basis.
 - c. Signing on to the system shall require a user name and password. When the password is typed in, it shall not be shown on the screen.
 - d. The system shall have the capability of using Windows NT Security logons in lieu of DDC system logons.

- e. The software shall provide the capability to establish groups of users with the same privileges. Once assigned to the group, the user shall automatically have the maximum privileges and the selectively reduced privileges assigned to the group.
 - f. The software shall provide the capability to set user profiles that enable assigning a specific home graphic page, alarm view, and event view.
4. BAS Operator Actions:
- a. Given the appropriate authority, an BAS operator from an operator workstation shall be able to:
 - 1) View all data that is presented in the forms described previously.
 - 2) Acknowledge alarms.
 - 3) Manually control both physical input and physical output points.
 - 4) Edit both independent and master time schedules.
 - 5) Initiate real time trend logging.
 - 6) Manually initiate reports.
 - 7) Initiate system backups for the database and trend log data.
 - 8) Customize the layout of the operator workstation presentation which shall then be the default for that user.
 - b. The BAS operator shall be able to execute the above tasks on data from any of the system servers via a single workstation.
 - c. The system shall support the use of Electronic Signature system wide or on selective tasks (change of values, manual control, trend initiation, etc.)
 - d. All of the BAS operator workstations shall be operable simultaneously. {You will want a license for each operator workstation so that all of the workstations can be used at the same time.}
5. Engineering Actions:
- a. The software shall, as a minimum, enable the following engineering functions from each of the operator workstations. If the task is followed by the annotation (#) where # is a number, the task must be executable from any combination of the workstations up to that number of workstations simultaneously.
 - 1) Create graphic pages for the presentation of dynamic data on visual images of buildings or equipment (2).
 - 2) Create reports for the presentation of historical data in an organized format (2).
 - 3) Create time schedules (2).
 - 4) Create trend logs in any of the field level devices and assign a dynamic variable from a field bus device to be trended (2).
 - 5) Setup long term storage of trend log data on the data server computer and the automatic transfer of the trend log data to the data storage tables in the SQL database (2).
 - 6) Create alarm objects in any of the field level devices, assign an alarm variable from a field bus device to initiate the alarm and set up the alarm routing (2).
 - 7) Configure and bring on-line a newly installed IP to LON router in support of an initial or incrementally added building control system (2).

- 8) Configure and bring on-line a newly installed field level devices in support of an initial or incrementally added building control system (2).
- 9) Create and download applications for programmable devices (2).
- 10) Download firmware updates to field level devices.
- 11) Import all field level devices into the system so that all input network variables, output network variables and adjustable application parameters can be accessed from any of the operator workstations (2).
- 12) Bind variables from one field level device to a second field level device (2).
- 13) Bind data from a field bus device under one IP connection to a field bus controller under a different IP connection (2).
- 14) Configure the system to create backups of the database and all application and supporting databases on a scheduled basis (2).
- 15) Setup user groups and individual users and establish authority levels for each group and individual user (2).
- 16) Any additional tasks defined later in this document or required to deliver a fully functional system.

C. Existing Web Server Software:

1. This software shall enable BAS operators to access the system from remote computers using only Microsoft Internet Explorer. The software shall allow for a minimum of three (3) Once connected to the system, the operators shall be able to execute the following tasks.
 - a. View dynamic data in a real time environment in both point list format and in a graphical page format.
 - b. View and acknowledge alarms.
 - c. Adjust time schedule parameters.
 - d. View historical trend data in table and graph formats.
 - e. View dynamic real time trends in graph format.
 - f. Run established reports.
 - g. Manually adjust application parameters.
 - h. Manually override physical inputs (sensor values) and force a specific value as an input to control logic.
 - i. Manually override physical outputs (end devices) and force a specific value regardless of the command from the control logic.
2. Enforced acknowledgement / response and electronic signature features shall apply to web delivered information.

D. Graphic Page Creation and Editing:

1. The Graphics Editor portion of the Engineering Software shall provide the following minimum capabilities:
 - a. Create and save symbols.
 - b. Create and save pages.
 - c. Group and ungroup symbols.
 - d. Modify an existing symbol.
 - e. Modify an existing graphic page.
 - f. Rotate and mirror a symbol.

- g. Place a symbol on a page.
- h. Place analog dynamic data in decimal format on a page.
- i. Place binary dynamic data using state descriptors on a page.
- j. Create motion through the use of gif files.
- k. Place test mode indication on a page.
- l. Place manual mode indication on a page.
- m. Place links using a fixed symbol or flyover on a page.
 - 1) Links to other graphics.
 - 2) Links to web sites.
 - 3) Links to notes.
 - 4) Links to time schedules.
 - 5) Links to any .exe file on the operator work station.
 - 6) Links to .doc files.
- n. Assign a background color.
- o. Assign a foreground color.
- p. Place alarm indicators on a page.
- q. Change a symbol color as a function of an analog variable.
- r. Change a symbol color as a function of a binary state.
- s. Change symbols as a function of a binary state.
- t. All symbols used by the contractor in the creation of graphic pages shall be saved to a library file for use by the owner.

E. Event Logging:

1. The BAS system shall maintain a log of all operator activity, system messages, alarms and alarm acknowledgments.
2. Operator activity is defined as any action by an operator such as changing the value of an application parameter, modifying a program, acknowledging an alarm, logging on, logging off, etc. Any change in the system caused by operator action shall be part of the log. The log shall include the event, the time of the event, the part of the system affected and an identification of the BAS operator and the OWS from which the change was made.
3. When the event deals with a value change, both the original and new values shall be part of the event record.
4. The Event Log shall be exportable to a report format that is printable.
5. The System Administrator shall be able to archive the event log.
6. The event data log shall comply with FDA CFR 21 - Part 11 requirements for data integrity.
7. The Event Log shall have a search function with assignable criteria to identify subsets of the event log such as all points placed under manual control, etc.

F. Alarm Generation And Processing:

1. Alarm creation is a two part process. The creation of a binary alarm indication is accomplished in a field level device where a binary state of zero shall indicate a normal condition and a binary state of one shall indicate an alarm condition. The binary alarm condition is read within a PPC, SLC, AH Device or Building Controller. The PPC, SLC, AH device or Building Controller shall assign a descriptive message, a category or

- priority number and a date and time stamp to the alarm and forward the information to the system server in accordance with an alarm routing table.
2. Alarm parameters such as high limits, low limits, time to state, binary alarm conditions are setup within the programming of the field level devices. These parameters shall be viewable and editable in point lists and on configuration graphic pages.
 3. The BAS alarm message shall be descriptive.
 - a. Building identification
 - b. System identification
 - c. Device identification
 - d. Date
 - e. Time to the second
 - f. Nature of the alarm
 - 1) High value
 - 2) Low value
 - 3) Fail to start
 - g. Value or state at the time of the alarm.
 4. When the BAS operator acknowledges the alarm, there shall be an opportunity to enter a message that becomes a permanent part of the alarm record recorded in the event log.
 5. The system shall support the association of graphic pages, trend charts, reports and text documents with specific alarms.
 - a. The BAS operator shall have the ability to configure the system to auto-launch a specific graphic page when the alarm occurs.
 - b. The system shall support the assignment of wav files to alarm signals on graphic pages.
 - c. The BAS operator shall have the ability to launch a specific trend chart from the alarm window when the alarm occurs.
 - d. The BAS operator shall have the ability to launch a specific text document when the alarm occurs.
 - e. An associated report shall automatically execute and write to the hard disk on the OWS when the alarm occurs. Configurations options shall include overwriting the previous report or creating a new file.
 6. The BAS system shall use selectable multiple colors on alarm messages for each of the following conditions:
 - a. Alarm condition exists and has not been acknowledged
 - b. Alarm condition has returned to normal but was never acknowledged
 - c. Alarm condition exists and has been acknowledged.
 7. When an BAS alarm condition no longer exists and has been acknowledged, it shall no longer be displayed in the alarm viewer but it shall be permanently recorded in the event list.
 8. The Alarm Routing Table shall support the following:
 - a. Multiple operators (based on OWS login) at any time.

- b. Specific operators (based on OWS login) at particular times (to include always as a choice).
 - c. Pagers
 - d. Email addresses via simple mail transfer protocol (SMTP; RFC 821)
 - e. Permanent comprehensive system wide alarm file
 - f. Specific alarm file based on a building or equipment identification
 - g. One or more alarm printers at any time
 - h. Specific alarm printers at specific times
 - i. Rerouting of alarms to a backup receiver when an acknowledgement has not been entered into the system within a specified time.
9. The system shall have a default audible indicator generated by the computer when an alarm is received.
 10. Once an alarm is acknowledged at one OWS, it shall display as acknowledged at all operator workstations.
 11. An BAS operator shall be able to select multiple alarms for single action acknowledgement.
 12. There shall be the ability to disable alarms and display all disabled alarms in a separate alarm view.
 13. The OWS alarm viewer shall be able to display the last 100 active alarms. If there are more than 100 active alarms, as alarms are acknowledged and removed from the viewer, older alarms shall be viewable to keep the viewer showing the last 100 active alarms until there are less than 100 active alarms.

G. Trends:

1. Real Time Trends:
 - a. At each OWS the operator shall be able to initiate a real time trending instance of up to 20 variables simultaneously.
 - b. The polling interval setting shall be adjustable down to a rate of every second.
 - c. The data for each instance shall be presented on a single graphical display that automatically updates with each new data collection cycle.
 - d. The graphical presentation shall plot the variables on the Y axis and time on the X axis.
 - e. A minimum of two Y axis scales shall be available.
 - f. The operator shall have the ability to set the range on each Y axis scale or let the scales auto range to cover the range of the values being trended.
 - g. Each element of data on the graphical display must be labeled by name or by a unique color. If color is used, a color legend must be included on the graph page.
 - h. The BAS operator shall be able to open up to five instances simultaneously for a total of 100 points being trended at one time.
 - i. An BAS operator shall be able to print an instance of real time data.
 - j. The system shall be capable of trending any variable in the system.
 - k. The BAS operator shall be able to save pre-configured instances of real time trending that can be initiated with simple point and click actions.
 - l. The system shall provide the ability to expand the graphical presentation to full screen.

2. Historical Data Collection:
 - a. Historical trend data shall be collected by field level devices and periodically uploaded to the data storage PC.
 - b. The trend log objects in the field level devices shall have the capacity to store 300 samples per variable. When the 301st sample is collected, the 1st sample shall be discarded.
 - c. The field level devices shall be configured to request an upload of data when the number of samples is not greater than 180. Uploads may be configured to occur at a greater frequency.
 - d. Initiation of historical data collection shall be configurable.
 - 1) By manual operator intervention in a point and click manner.
 - 2) By a user adjustable time schedule or date.
 - 3) Triggered by a binary status variable (when the fan status is on, start the trend of the mixed air temperature).
 - 4) The system shall be capable of trending any variable in the system.
 - e. The status and capacity of the trend logs in the field devices shall be viewable from the operator workstation.
3. Historical Data Presentation:
 - a. An OWS shall have the capability to present the historical data for a variable in a tabular presentation of the values along with the date and time of the sample. The time period for the values to be presented shall be user adjustable.
 - b. An OWS shall have the capability to present the historical data for a variable in a graphical presentation of the values plotted against time and date.
 - c. The graphical presentation capabilities for historical trends shall equal those described above for real time trends.
 - d. The BAS operator shall be able to save pre-configured instances of historical trending that can be initiated with simple point and click actions.
 - e. The BAS operator shall be able to print the tabular presentations and graphical presentations of historical trend data.
 - f. The system shall provide the ability to expand the graphical presentation to full screen.
4. The data collection, storage, retrieval and presentation system shall provide the features necessary for the AOC to achieve certification under Regulation 21 CFR Part 11 of the US Food and Drug Administration. (FDA) The key issue is the integrity of the data, the ability to verify that the data has not been modified after collection by the system.

H. Application Programming:

1. The application programming tool may be based on Line Programming or Graphical Programming concepts.
2. If the application programming is object based and graphical:
 - a. There shall be an off-line simulation capability.
 - b. There shall be the ability to view dynamic data displayed on the object diagram in real time.

3. There shall be self checking for errors in programming to be used by the programmer.
4. Key functions that must be supported are:
 - a. Timer functions to include Delay Off, Delay On and Sample Rate Support
 - b. Interval timer
 - c. Math functions to include Addition, Subtraction, Multiplication, Division, Exponentiation, Trigonometric Functions and Logarithmic Functions (base 2 and base 10)
 - d. If-Then-Else Instructions (also referred to as switching logic)
 - e. Look up tables with a minimum of 100 entries, with and without extrapolation
 - f. Bit Wise Logic
 - g. Sample and hold binary
 - h. Sample and hold analog
 - i. Latch on and latch off functions with resets
 - j. Input network variable definition
 - k. Output network variable definition
 - l. Sensor measurement definition
 - m. End device control definition
 - n. Logic functions to include And, Or, Not and Exclusive Or
 - o. Detection of a power cycle
 - p. Common function support (standard objects in graphical programs and subroutines in line programs). As a minimum the common functions shall include:
 - 1) PID with analog output
 - 2) PID with tri-state outputs
 - 3) Enthalpy from temperature and relative humidity
 - 4) Optimum start stop based on occupancy schedule, temperature, set point and outside air temperature.
 - 5) Polynomial equation
 - q. Search function.

I. Report Creation:

1. The BAS operators shall be able to extract historical data from the data collection files and present the data in a Microsoft Excel format. All of the data in the log shall be exportable to include the date, time and values
2. The number of trend logs that can be inserted into a single Excel Workbook shall not be limited by the OWS software.
3. The operators shall be able to pre-configure reports for manual execution or automated execution.
4. The OWS shall be able to auto execute any report based on:
 - a. A time schedule
 - b. An alarm trigger
 - c. The status of a binary point (state=1, execute the report)

5. The BAS operators shall be able to pre-configure the destination of the report:
 - a. OWS screen
 - b. Write to file on the hard drive
 - c. Send to a printer
 6. The generation of a report shall not interrupt the use of the OWS by the operator, that is, it shall execute in the background.
- J. Network Configuration Software:
1. Network Configuration Software shall be accessible from any operator workstation.
 2. This software may be a separate software tool, multiple software tools or the functions may be integral to the engineering software.
 - a. Functions that must be supported are:
 - 1) Addressing of field level devices
 - 2) Establishing data flow from device to device
 - 3) The ability to query a field bus and identify all installed devices by domain number, subnet number and node number.
 3. If configuration of event driven communication is a function of the network configuration tool (in lieu of the application programs), the tool shall provide the capability to select the binding services used. See the definition of terms section for a discussion of binding services.

2.8 HVAC CONTROL HARDWARE IDENTIFICATION

- A. Coordinate with the requirements of Section 23 0553 "Identification for HVAC Piping and Equipment."
- B. Automatic Control Valve Tags:
 1. Use metal tags with a 2-inch minimum diameter, fabricated of brass, stainless steel or aluminum. Attach the tags with a chain of the same material.
 2. Stamp or engrave metal tags with color contrasting identification information
 3. For lubrication instructions, use plastic laminated information / instruction sheets with nylon or ploy wrap ties
 4. Tag the valves with identifying number and system information
 5. Prepare a list of all tagged valves showing location, floor level, tag number and use. Organize the list by system. Include all tag information in all maintenance manuals.
 6. Prepare a valve tag identification chart integrated with an single line diagram generated from the BAS as built drawings
- C. Panels and Control Devices:
 1. Control Panels (Enclosures) shall be labeled with stamped or engraved tags with contrasting color identification information permanently mounted on the panels.

D. HVAC Test and Balance Requirements:

1. The BAS provider shall provide the Test and Balance Contractor a single set of BAS test tools to interface with the control system for testing and balancing.
2. The BAS provider shall provide a minimum of 8 hours of training on the use of the BAS test tools.
3. The BAS provider shall provide a qualified BAS Test technician to assist with the testing and balancing of one system controlled by a programmable controller and the first ten terminal units.
4. The Test and Balance contractor is required to return the interface test tools unaltered and in working condition after completion of the testing and balancing.

2.9 GENERAL WORKMANSHIP REQUIREMENTS

- A. The BAS provider shall install equipment, conduit, and wiring / raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- B. The BAS provider shall provide sufficient slack and flexible connections to allow for vibration of piping, equipment and service loops.
- C. The BAS provider shall install all equipment in readily accessible locations as defined by Chapter 1, Article 100 and Part A of the National Electrical Code (NEC).
- D. The BAS provider shall verify the integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

2.10 FIELD QUALITY CONTROL

- A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.
- B. The BAS provider shall continually monitor the field installation for code compliance and quality of workmanship.
- C. The BAS provider shall have work inspected by local and/or state authorities having jurisdiction over the work.

2.11 WIRING

- A. All control and interlock wiring shall comply with national and local electrical codes and Division 25 of this specification. Where the requirements of this section differ from those in Division 27, the requirements of this section shall take precedence.
- B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC and Division 26 requirements.

- C. Low voltage wiring shall meet NEC Class 2 requirements. Sub-fuse low voltage power circuits as required to meet Class 2 current limits.
- D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL Listed for the intended application.
- E. All wiring in mechanical, electrical, or service rooms, or where subject to mechanical damage, shall be installed in raceway at levels below 11 feet.
- F. The BAS provider shall not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
- G. The BAS provider shall not install wiring in raceway containing tubing.
- H. Where Class 2 wiring is exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 8 foot intervals.
- I. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.
- J. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire to wire connections shall be at a terminal block.
- K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- L. Maximum allowable voltage for control wiring shall be 125 Volts. If only higher voltages are available, the contractor shall provide step-down transformers.
- M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
- N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain the fire rating at all penetrations.
- O. The size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
- P. Include one pull string in each raceway that is 1 inch in diameter or larger.
- Q. Use coded conductors throughout with conductors of different colors.
- R. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
- S. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway, to maintain a minimum clearance of 9 inches from high-temperature equipment such as steam pipes, electrical transformers or flues.

- T. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap, plumber tape or tie rods. Raceways may not be run on or attached to air distribution ductwork.
- U. Adhere to specification requirements where raceway crosses building expansion joints.
- V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
- W. The BAS provider shall terminate all control and/or interlock wiring and shall maintain updated as-built wiring diagrams with terminations identified at the job site.
- X. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 2.5 feet in length and shall be supported at each end. Flexible metal raceway less than ½ inch electrical trade size shall not be used. In areas exposed to moisture, including chiller, pumps, chemical mixing and boiler rooms, liquid-tight, flexible metal raceways shall be used.
- Y. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with coupling according to code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have protective bushings installed.

2.12 COMMUNICATION WIRING

- A. The BAS provider shall adhere to the items listed in the previous section on WIRING.
- B. The BAS provider shall install all cabling in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- C. The BAS provider shall not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
- D. When a cable enters or exits a building, the BAS provider shall install a lightning arrestor between the lines and ground. The lightning arrestor shall be installed according to the manufacturer's instructions.
- E. The BAS provider shall install all runs of communication wiring with un-spliced lengths when that length is commercially available.
- F. The BAS provider shall provide a permanent tagged label on all communication wiring to indicate origination and destination data.
- G. The BAS provider shall ground coaxial cable in accordance with NEC regulations on "Communications Circuits, Cable, and Protector Grounding."
- H. When shielded wiring is use, the BAS provider shall ground the shield only once for each continuous segment of cable. The grounding location shall be at the end of the segment that is most readily accessible.

2.13 SENSORS

- A. The BAS provider shall install sensors in accordance with the manufacturer's recommendations.
- B. The BAS provider shall mount sensors rigidly and adequately for the environment within which the sensor operates.
- C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
- D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
- E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the duct. Each bend shall be supported with a stainless steel capillary clip. Provide 1 foot of sensing element for each square foot of coil area.
- G. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in the thermal wells.
- H. Install outdoor air temperature sensors on the north wall, complete with a sun shield at the designated location.
- I. Carbon Dioxide - CO₂ - Sensors.
 - 1. CO₂ transmitter: Non-dispersive infrared (NDIR) diffusion sampling, with ABC (Automatic Baseline Calibration) which automatically adjusts the CO₂ sensor to compensate for drift.
 - 2. Housing: High impact ABS plastic.
 - 3. CO₂ sensors must be factory-certified to have an accuracy within plus or minus 75 ppm at 600 and 1000 ppm concentration when measured at sea level and 25 C (77 F), factory calibrated or calibrated at start-up, and certified by the manufacturer to require calibration no more frequently than once every 5 years.
 - 4. Each CO₂ sensor(s) reading for each zone must be displayed continuously, and recorded. The energy management control system (EMCS) may be used to display and record the sensors readings. The display(s) must be readily available to maintenance staff so they can monitor the systems performance.
 - a. When a sensor failure is detected, the system must provide a signal to reset the system to provide the minimum quantity of outside air levels required.
- J. Differential Air Static Pressure Sensors:
 - 1. For supply duct static pressure, pipe the high pressure tap to a duct probe that measures at a 90-degree angle +/- 5 degrees to flow (to measure only the static pressure and not the effects of velocity). Pipe the low-pressure port to a tee in the high-pressure tap tubing of

- the corresponding building static pressure sensor if one is installed or to the plenum if a building static pressure sensor is not installed.
2. For return duct static pressure, pipe the high pressure tap to a duct probe that measures at a 90-degree angle \pm 5 degrees to flow (to measure only the static pressure and not the effects of velocity). Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor if one is installed or to the plenum if a building static pressure sensor is not installed.
 3. For building static pressure, pipe the low-pressure port of the sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
 4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels and not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without the use of ladders or special equipment to the maximum extent possible.
 6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.
- K. Annular pilot tubes shall be installed so that the total head pressure ports are set-in-line with the pipe axis upstream and the static port facing downstream. The total head pressure ports shall extend diametrically across the entire pipe. Annular pilot tubes shall not be used where the flow is pulsating or where pipe vibration exists.

2.14 FLOW SWITCHES

A. Airflow Switches:

1. Install in horizontal duct runs whenever possible.
2. If a vertical duct run is the only option, then install in a location with an upward airflow.

B. Hydronic Switches:

1. Use the correct paddle type for the pipe diameter as described by the switch manufacturer.
2. Adjust the flow switch in accordance with the manufacturer's instructions.

2.15 ACTUATORS

- A. Damper actuators manufactured by Belimo featuring Multi-Function Technology for HVAC or approved comparable product of equal functional reliability and warrantee duration.
- B. Damper actuators shall be provided with all appropriate mounting hardware and linkages.
- C. Mount and link control damper actuators according to manufacturer's instructions.
- D. When spring return actuators are used on normally closed dampers, the seals shall be compressed when the dampers have been closed by the actuator.

- E. Damper / actuator combinations shall modulate smoothly from fully closed to fully open and return.
- F. Electric / Electronic Control valves shall be manufactured by Belimo, Model Type, PICCV design with a five year warranty or approved comparable product of equal functional reliability and warrantee duration.
 - 1. Shall be mounted following the actuator manufacturer's recommendations.

2.16 IP INTERFACE DEVICES

- A. Install IP to LON Routers or Building Controllers for each required connection to the owner's TCP/IP network. Locations are identified on the drawings.
- B. The IP to LON Routers or Building Controller shall be configured and commissioned to ensure that the only data traffic on the TCP/IP is data that is essential for operation of the system. Messages between field devices on the same field bus shall not be allowed to pass onto the TCP/IP network.

2.17 CONTROLLERS

- A. Install programmable process controllers, supervisory logic controllers and application specific devices on each field bus to meet the requirements of the sequence of control for all systems.
- B. All process control loops for an integral system shall reside in a single controller. Each controllable end device creates one process control loop. Examples of integral systems are:
 - 1. Air Handling Units
 - 2. Variable Volume Boxes
 - 3. Variable Speed Drives
 - 4. Lighting Control Systems (Panels)
 - 5. Energy Management Monitoring Devices
- C. To the maximum extent possible, all process control loops for built up systems shall reside in a single controller. An example is a chiller with its associated chilled water and condenser water pumping systems or a boiler system with steam to hot water heat exchangers. The objective of this requirement is that the contractor shall use large point count, primary controllers in lieu of multiple secondary controllers.
- D. Supervisory logic for integral and built up systems may reside in separate supervisory logic controllers with the output commands to the process control loops traversing the field bus to the controllers executing the process control.

2.18 CONTROL DAMPERS

- A. Install dampers in accordance with the manufacturer's instructions to operate and to obtain leakage rates specified herein. Adjust the damper linkage such that the damper closes before the Belimo or approved equal actuator is fully closed to assure tight shutoff of the damper.

- B. Blank-off and seal around dampers and between dampers and sleeves or frames with EPA and CARB approved, low VOC solvent based, sealants to eliminate air bypass leakage.
 - 1. Note: No water base sealants are acceptable.
- C. For outdoor air damper assemblies, stage the opening of each section to prevent stratification and poor mixing of outside and return air.

2.19 CONTROL VALVES

- A. Install in an accessible location, with room for actuator removal and service. Adjust the actuator to provide tight shutoff. Provide visible, color coded, valve stem indicator and adjust to indicate proper travel.
- B. Control Valves:
 - 1. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved.
 - 2. Water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25 percent the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.
 - 3. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all hot and chilled water applications, except those described hereinafter. The valve discs shall be composition type. Valve stems shall be stainless steel.
 - 4. Ball valves shall be acceptable for water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, air handling units, and fan coil units.

2.20 AIRFLOW / TEMPERATURE MEASURING DEVICES

- A. Manufacturers:
 - 1. Ebtron, Inc.
 - 2. Kurz Instruments.
 - 3. Sierra Instruments.
 - 4. FCI.

B. Provide one thermal dispersion airflow / temperature measurement device (ATMD) at each location indicated on the plans, schedules and/or control schematics.

1. Fan inlet measurement devices shall not be used unless indicated on drawings or schedules.
2. Each ATMD shall consist of one to four sensor probes and a single, remote transmitter. Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, aluminum 6063 alloy tube with 304 stainless steel mounting brackets.
3. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable.
4. The temperature output of the ATMD can be used in place of the specified temperature measuring device (TMD) when the location of the ATMD and TMD are effectively the same.
5. Sensor Density Requirements:
 - a. Sensor density (#/area) affects minimum installed distances required from disturbance types. Published sensor density data by the product manufacturer shall be submitted for approval.
 - b. Should there be no published document indicating these relationships for a particular product, the number of individual sensor nodes provided for each rectangular location shall be as follows:

Duct or Plenum Area (ft ²)	Total # Nodes / Location	Duct or Plenum Area (m ²)
<= 1	1 or 2	<= 0.093
>1 to <4	4	>0.093 to < 0.372
4 to < 8	6	0.372 to < 0.743
8 to < 12	8	0.743 to < 1.115
12 to <16	12	1.115 to < 1.486
>=16	16	>= 1.486

- c. The number of individual sensor nodes for each rectangular location shall be maximized for performance within the placement conditions provided. In no instance shall field selected locations provide less distance between disturbances than required for maximum performance. When minimum distances allowed by the highest density of sensor distribution are exceeded, a lower density configuration that provides the same performance is acceptable.
 - d. The number of individual sensor nodes provided for each round or oval duct location shall approximate the total required for rectangular locations or be detailed in published documentation by the manufacturer.
 - e. Submittal documents shall include schedules indicating the number of sensors per location, the duct area and the equivalent density (#/area) for approval.
6. Thermistors shall be potted in an engineering thermoplastic assembly using water-proof, marine epoxy and shall not be damaged by moisture or direct contact with water.
 7. Signal processing circuitry on or in the sensor probe is not acceptable.
 8. Each sensing node shall be individually wind tunnel calibrated at 16 points to NIST traceable airflow standards.
 9. Each sensing node shall be individually calibrated in constant temperature oil baths at 3 points to NIST traceable temperature standards.

10. All internal wiring between thermistors and probe connecting cables shall be Kynar jacketed.
 11. Manufacturer shall provide UL listed, FEP jacketed, plenum rated cable(s) between sensor probes and the remote transmitter.
- C. Measurement Performance:
1. Each sensing node shall have a temperature accuracy of ± 0.14 deg F (0.08 deg C) over the entire operating temperature range of -20 deg F to 160 deg F (-28.9 deg C to 71 deg C).
 2. Each sensing node shall have an airflow accuracy of $\pm 2\%$ of reading.
 3. The ATMD shall be capable of measuring airflow rates over the full range of 0 to 5,000 FPM (25.4 m/s) between -20 deg F to 160 deg F (-28.9 deg C to 71 deg C).
- D. Integral Transmitter and Communications:
1. The transmitter shall be powered by 24 VAC, be over-voltage and over-current protected, and have a watchdog circuit to provide continuous operation after power failures and/or brown-outs.
 2. The power requirement for the ATMD shall not exceed 22 V A.
 3. The transmitter shall determine the airflow rate and temperature of each sensing node prior to averaging.
 4. The transmitter shall have two isolated and fused analog output signals and one RS-485 network connection.
 5. Each analog output shall be field configurable as linear 0-5/1-5 VDC, 0-10/2-10 VDC or 4-20mA signals.
 6. The RS-485 network connection shall be field configurable as BACnet MS/TP or Modbus RTU.
 7. The RS-485 connections shall transmit the average airflow rate, average temperature, individual airflow rates of each sensor node, and individual temperatures of each sensor node and system status.
 8. All integrated circuits shall be industrial rated for operation down to -40 deg F (-40 deg C).
 9. All electrical plugs, receptacles and circuit board interconnects shall be gold plated.
- E. Listings and Certifications:
1. The ATMD shall be UL 973 listed.
 2. The ATMD shall be BTL listed.
- F. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans, prior to fabrication and installation.
1. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.

2.21 PROGRAMMING FOR PROGRAMMABLE DEVICES

- A. These requirements apply to Building Controllers, programmable process controllers, supervisory logic controllers, automatic time scheduling devices, trend logging devices, alarm handling devices and automatic time schedule switch-over devices.
- B. The BAS provider shall create and download application programs that meet the requirements of the sequence of control, time scheduling requirements, trend logging requirements and alarm handling requirements.
 - 1. The BAS provider shall use a consistent point naming concept throughout the project that allows for easy transition from building to building and system to system.
 - 2. The BAS provider shall employ extensive code annotation for each functional block, signal and device. The owner shall be able to easily recognize the function of each functional block, signal in or out of any device or the device itself.
 - 3. All time schedules shall be fully configured with weekly schedules and all of the holidays identified by the AOC.
 - 4. All trend logs identified in the sequence of control shall be fully configured and operational.
 - 5. All alarm handling shall be fully configured with consistent alarm messages and priorities or category numbers to identify the system from which the alarm originates.
 - 6. All application parameters identified as (adj) in the sequence of control shall be exposed as viewable parameters using LonTalk network variables with an appropriate SNVT and appropriate initial values shall be set.
 - 7. All external point values and internal point values identified as (rpt) in the sequence of control shall be exposed as viewable values using LonTalk network variables with an appropriate SNVT.
 - 8. Manual control of all external points (and those internal points requiring manual control) shall be programmed using either the priority override concept or the software switchover concept (See the definition of terms section for a discussion of these two concepts). The network variables that communicate manual control commands from the OWS to the controllers shall be LonTalk variables with an appropriate SNVT. Proprietary implementation of manual control is not acceptable.
 - 9. For all variables broadcast onto the field bus, event driven communication shall be used to avoid data storms. As a minimum the program shall provide for the send on delta parameter and minimum send time parameter for each output variable.
 - 10. The BAS provider shall embed into the programs sufficient comment statements to clearly describe each section of the program. This applies to both line programming and graphical programming systems.
 - 11. If graphical programming systems with multiple layers for the functional block diagrams are used, no more than two layers shall be used.

2.22 CONFIGURATION OF APPLICATION SPECIFIC DEVICES

- A. Application specific devices shall be configured to meet the sequence of control.

2.23 DEVICE-TO-DEVICE DATA FLOW

- A. All device-to-device data flow shall be in place and configured to meet the sequence of control for the new systems and to integrate the existing systems.
- B. All device-to-device data flow shall be implemented through the use of LonTalk variables with an appropriate SNVT (Standard Network Variable Type). Proprietary data flow from device to device is not acceptable.
- C. Appropriate binding services shall be used to ensure that the average bandwidth utilization is less than 30 percent. The owner reserves the right to conduct network bandwidth testing to ensure this requirement is met.
- D. If reducing the number of devices per field bus is required to meet the network bandwidth requirements, all costs of making changes shall be borne by the contractor.

2.24 DISTRIBUTED CONTROL REQUIREMENTS

- A. The programmed applications for a single integrated system shall not be distributed over more than one field bus. Examples:
 - 1. A chiller is controlled by a controller on field bus number 1. The controllers that control the pumps and tower shall also be on field bus number 1 as these systems are integrated in their control requirements.
 - 2. Multiple air handling units are controlled by controllers on field bus number 1. The chiller system is controlled by controllers on field bus number 2. The chiller control logic requires the chilled water valve positions from each of the air handling unit controllers. It is acceptable that these related but non-integral systems are controlled by controllers on different field busses.

2.25 SYSTEM UNITS AND RESOLUTION

- A. The BAS provider shall use SNVTs with the appropriate units for each input network variable, input application parameter and output network variable.
- B. The BAS provider shall use SCPTs with the appropriate structure for each input application parameter that is based on the SCPT (Standard Configuration Property Types) concept.
- C. The UMCS must communicate with the operators visually and in reports using the inch-pound system.
- D. The conversion of data from a field level device must be automatically converted from SI units to inch-pound units prior to display.
- E. For BAS operator initiated values, the BAS operator shall be able to enter values in units from the inch-pound system of units and the system must then automatically convert the value to units from the SI system of units for dispatch to the field level devices.
- F. The system must be able to display values visually or in reports with a resolution equal to the resolution of the data as defined in the SNVT Master List or the SCPT Master list. Where

conversion from the SI system to the Inch-Pound system of units results in a two numeric digit resolution, the resolution of display must be equal to the rounded up value. Example: SNVT temp data has a resolution of 0.01 degrees C. This is a single digit resolution. Upon conversion to degrees F, the resolution would be 0.018 degrees F. This is a two digit resolution. The round up process would produce a required resolution for display of 0.02 degrees F.

2.26 SERVERS AND BAS WORKSTATIONS

- A. All required software for fully functional systems shall be installed and configured. The owner shall provide the IP connections and identify the specific rooms where the computers shall be installed.

2.27 SYSTEM SERVER

- A. All field level devices shall be addressed and imported into the system server database.
- B. For the existing control system that is being integrated into the new system, the addresses of the existing field devices shall not be changed.

2.28 EXISTING BAS OPERATOR WORKSTATIONS

A. Dynamic Data Displays:

1. Points lists shall be organized on a per field device basis.
2. If the software provides for the sub-division of point data within a field device, the data shall be organized by physical sub-system as a minimum (fan section, mixed air section, etc.).
3. The workstation shall be configured to automatically update values without any action by the operator.
4. Value updates in points lists shall be configured to update at least once every 5 seconds.
5. Binary data shall be configured to display state descriptors (OFF, ON; OPEN, CLOSED; etc.) and not the states of 0 and 1.
6. Analog data shall display with a resolution equal to the resolution defined as part of the SNVT used to transmit the data.
7. Analog data displays shall include engineering units.
8. All text fields associated with a specific element of data shall be filled out to provide the maximum amount of information to the operator.
 - a. Terminal Equipment Summary Page: On this page the dynamic data and set points that are associated with multiple terminal units are presented in a tabular format. The objective is to present a summary of terminal unit performance for an area of the facility. One page is required for each group of terminal units. In the tabular data, do not use less than 12 pt font size. Multiple linked pages may be used if there are a large number of terminals served by one delivery system.
 - 1) Display in the table:
 - a) Process variables.

- b) Set points for each process.
 - c) Command to each end device.
 - d) Status of each end device.
 - e) Load factors such as terminal load for a VAV terminal unit.
 - 2) Link to the page for each Terminal Unit.
 - 3) Link up to the Floor Plan page.
 - b. Terminal Unit Page: A graphical representation of a terminal unit such as a VAV terminal or fan coil terminal. One page for each terminal unit.
 - 1) Link up to the Floor Plan page.
 - 2) The graphic representation of the equipment shall be 3-dimensional and shall represent the actual installed terminal unit (if the VAV does not have a fan, a fan should not be shown, etc.).
 - 3) Display:
 - a) Process variables.
 - b) Command to end devices.
 - c) Status of end devices.
 - d) Set points for each process.
 - e) Modes (auto, heat, cool, etc.).
 - f) Capacity indicators (terminal load, %heat, %cool, etc.).
 - g) Reset schedules.
 - h) Occupancy commands and status.
 - i) Alarm points.
9. For all points on a graphic page that are subject to being under manual or test mode, the display shall indicate when test mode or manual mode has been applied to the point.
 10. Color Graphic Page Requirements:
 - a. The sequence of control defines the buildings and all of the equipment items for which graphic pages shall be constructed as described above.
 - b. The BAS provider shall develop similar additional graphic pages to be defined during the construction period as follows:
- B. User Groups:
1. The BAS provider shall configure four users groups, one for each level of security. The group names shall be representative of the "names" below:
 - a. BAS Administrators
 - b. BAS Engineers
 - c. BAS Operators
 - d. BAS Viewers

C. Users:

1. The BAS provider shall configure two users in each user group. The names and passwords shall be representative of the "names" below:
 - a. BAS Administrators Group:
 - 1) Admin1 / Admin1
 - 2) Admin2 / Admin2
 - b. BAS Engineers Group:
 - 1) Engr1 / Engr1
 - 2) Engr2 / Engr2
 - c. BAS Operators Group:
 - 1) Oper1 / Oper1
 - 2) Oper2 / Oper2
 - d. BAS Viewers Group:
 - 1) View1 / View1
 - 2) View2 / View2
2. With the exception of the BAS Viewers Group, these users shall not be added to the system until all testing has been completed and the system has been accepted. The BAS provider shall accept all responsibility for actions that result from the unauthorized issuance of user names and passwords above the level of viewers prior to system acceptance unless specifically instructed to do so in writing by the AOC.

D. BAS Alarm Processing:

1. All alarms required by the sequence of control shall be fully configured for delivery to the operator workstations and the alarm files.
2. A common alarm file shall be established to receive alarms from all of the field devices.
3. A separate alarm file shall be established on a per building basis to receive just the alarms from that building.
4. The alarm messages shall be descriptive and include as a minimum:
 - a. System identification
 - b. Date
 - c. Time to the second
 - d. Nature of the alarm such as high value, low value, or fail to start.
5. The system shall be configured to send an alarm message on return to normal.
6. All users shall receive all alarms.

2.29 WEB SERVER

- A. The web server shall be configured to present data from all of the field devices.

- B. The web server shall be configured to allow 3 concurrent users.
- C. The web server shall be configured to require a user name and password for log-in from a web client.
- D. The web server shall be configured to allow the web clients to do the following:
 - 1. View all graphic pages that can be viewed from a operator workstation.
 - 2. View historical trend logs
 - 3. Receive and acknowledge alarms
 - 4. Manually control points
 - 5. Initiate generation and view static reports
 - 6. Adjust time schedule parameters

2.30 CONTROL SEQUENCES

- A. BAS Control sequences are to be determined by the BAS provider in the design and deployment of BAS.

2.31 CONTROL SYSTEM CHECKOUT, TESTING AND TRAINING

- A. The BAS provider shall furnish all labor and test apparatus required to execute the start up testing and owners commissioning plan. Key tasks to be executed and documented in the start-up testing and commissioning verification report include:
 - 1. Verification of all primary and secondary voltages.
 - 2. Verification that power wiring for all devices conforms to manufacturer's instructions.
 - 3. Verification that all labeling is in place.
 - 4. Verification and Inspection of wiring for loose strands and tight connections.
 - 5. Verification and Inspection of all BAS control panel electrical grounding
 - 6. Verification of field bus topology, grounding of shields (if used) and installation of termination devices.
 - 7. Verification that each I/O device is landed per the submittals and functions per the sequence of control.
 - a. Analog sensors shall be properly scaled and a value reported to the OWS.
 - b. Binary sensors shall have the specified normal position and the state is reported to the OWS.
 - c. Analog outputs have the specified normal position and move full stroke when so commanded.
 - d. Binary outputs have the specified normal state and respond to energize / de-energize commands.
 - 8. Analog sensors have been calibrated with high quality instrumentation suitable for the sensor being calibrated.
 - a. The instruments shall display a current (12 month) NIST traceable calibration sticker. Associated instrument calibration certificates shall be made available within 24 hours of a request.

- b. The measured value, reported value, and the calculated offset that was entered into the database shall be recorded.
 - c. The calibration criteria shall be:
 - 1) Space Temperature: +/- 0.4 degrees F
 - 2) Air Temperature: +/- 0.5 degrees F
 - 3) Fluid Temperature: +/- 0.6 degrees F
 - 4) Air Flow Rate: +/- 5 %
 - 5) Liquid Flow Rate: +/- 5 %
 - 6) Differential Pressure: +/- 3 %
 - 7) Gauge Pressure: +/- 5%
 - 8) Relative Humidity: +/- 3 % relative humidity
 - 9) CO₂: +/- 2 %
9. Loop Tuning:
- a. The contractor shall tune all P, PI and PID control loops.
 - b. The loop tuning criteria shall be a stable control loop where the average error over 15 minutes and 30 samples shall be less than:
 - 1) Space Temperature: +/- 0.75 degrees F
 - 2) Air Temperature: +/- 1.50 degrees F
 - 3) Air Humidity: +/- 5 % relative humidity
 - 4) Chilled Water Temp: +/- 1.00 degrees F
 - 5) Hot Water Temp: +/- 1.00 degrees F
 - 6) Duct Pressure: +/- 0.2 inches wg.
- B. Training:
- 1. Coordinate with the requirements of Sections 01 9113 and 01 9114.
 - 2. To be defined by the "Lon" System BAS provider, the AOC representatives, and AOC BAS designated service providers.
- C. LEED System Interface:
- 1. Coordinate communication / interface with the building's interactive LEED Educational Display as required for Credit IDC1.1. Refer to Section 10 1400 "Signage" for details on the display panel. The BAS provider shall coordinate with the Signage provider to ensure delivery of all BAS system data points and graphics required for integration into the Educational Display.

PART 3 - EXECUTION (Not Used)

END OF SECTION 23 0900

SECTION 23 0993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:
 - 1. Division 23 Section "Instrumentation and Control for HVAC."

1.2 SUMMARY

- A. This Section includes control sequences for HVAC systems and terminal units.

1.3 SUBMITTALS

- A. Shop Drawings showing operating sequences of various equipment, devices, components, and materials included in the Text and defining the components' contribution to the system.

PART 2 - PRODUCTS - (Not Applicable)

PART 3 - EXECUTION

3.1 GENERAL CONTROL SEQUENCE

- A. Duct Smoke Detectors:
 - 1. Buildings with an Above Ceiling Return Air Plenum or Without a Distributed - Full Area Fire Detection System: All fire and smoke detectors are furnished by the Fire Alarm Contractor. Duct detectors shall be mounted by Mechanical Contractor and connected by Fire Alarm Contractor. Duct detector power and supervisory and remote annunciation shall be by Fire Alarm Contractor. Fire and smoke detection functions shall be initiated by dry contact outputs from the electrical fire detection and control system. These output contact circuits will be brought to the appropriate mechanical equipment room or equipment location by the Fire Alarm Contractor for interface with the mechanical systems and final terminated by this Contractor. See electrical drawings for fire alarm system description and notes.
- B. Existing 120 VAC source was provided for existing VAV terminal units and controllers. This contractor shall be responsible for control power wiring from the existing junction box location(s) to all his controllers and devices requiring control power.

C. The existing on-site operator's central work station shall be located per owner's requirements. It shall provide for man/machine interface functions as specified heretofore and shall be linked to all remote DDC master controllers with data communications for direct access to all local controllers.

1. The data link in remote mechanical equipment room (MER) conduit locations shall be securely installed in conduit.
2. Should this communication link be interrupted at any location, the local DDC control systems in each MER shall continue to provide for all local control strategies, including time scheduling and outdoor temperature functions. Only global type functions demand limiting, historical data collection, remote status and alarm reporting, trend logging, etc.) shall be interrupted by a communication link failure.

D. Safety Sequences:

1. Fans:
 - a. Division 28 fire alarm system shall hard-wire shut down of supply and return fans required by IMC. The H-O-A switch (where present) at the motor starter or VFD shall not override this shut-down.
 - b. When fire and/or smoke is detected in a supply air system or a space served by that system, the exhaust and relief fans normally operated and associated with that supply air system shall also be stopped by the DDC control system.

E. Occupied Modes for Occupancy Monitored Spaces: The DDC control system shall tie into the building lighting control system and also occupancy sensors through contacts, relays or BacNet IP interface. An air-handling system or temperature control zone shall be in Occupied Mode, Standby Occupied Mode, or Unoccupied Mode as determined by the following:

1. Occupied Mode: The occupancy sensor detects an occupant.
2. Occupied Standby Mode: The system or zone is scheduled "Occupied," but no occupants are detected. The system and zone shall operate as in "Occupied Mode" except that the DDC system shall control to "Occupied Standby Mode" temperature setpoints.
3. Unoccupied Mode: The system or zone is scheduled "Unoccupied," and no occupants are detected.

F. Occupied Modes for Spaces Without Occupancy Sensors: An air-handling system or temperature control zone shall be in Occupied Mode, or Unoccupied Mode as determined by the following.

1. Occupied Mode: The system or zone is scheduled "Occupied."
2. Unoccupied Mode: The system or zone is scheduled "Unoccupied."

3.2 VAV AHU WITH SUPPLY FAN VFD, EXHAUST/ RETURN FAN VFD, CHILLED WATER COOLING AND HYDRONIC HEATING (AHU-2)

A. Air Handler Start/Stop:

1. The air handler will be started/stopped via an optimal start routine, a weekly schedule or by operator command from the operator workstation.

B. Weekly Schedule:

1. Air handling unit shall have a time schedule. The building schedule will start/stop every air handler unit.

C. Optimal Start:

1. A separate optimal start routine for heating and cooling determine the latest possible start time of mechanical equipment, such that, zone set-point is met prior to ventilation pre-occupancy purge. The routine utilizes the previous day's start time and the zone farthest from setpoint to calculate the current day's start time. The routine filters out any day in which a substantial increase or decrease in start time would be required.
2. There are three modes of operation that can occur; precooling, preheating and normal cooling.

D. Precooling Mode:

1. Precooling is only used during an optimal start.
2. The precooling routine is enabled if the intake outdoor air temperature is 5 deg F (adj.) less than the zone temperature (occupied temperature), the intake outdoor air temperature is greater than 35 deg F (adj.), the outside air humidity is less than 60 percent (adj.) and none of the zones require heating.
3. If all conditions are met, the air handler supply fan will start, the outside air dampers will be positioned to 100 percent (open), the air handling unit relief fan will start, all mechanical cooling will be disabled and the zones will control to their occupied setpoints.
4. Precooling with outdoor air temp out of above range and close outdoor air damper and run chilled water to bring zone temperature to occupied temperature.

E. Preheating Mode:

1. Preheating is only used during an optimal start.
2. The preheat routine is enabled if all zones are less than their occupied cooling setpoint and at least one zone is below its occupied heating setpoint.
3. If all conditions are met the air handler will start, the outside air dampers will be positioned to 0 percent (closed), the air handling unit relief fan will remain off, all mechanical cooling will be disabled and the zones will control to their occupied setpoints. The discharge air setpoint will be adjusted to 75 deg F (adj.) and the zones will control to their occupied set points.

F. Ventilation Pre-Occupancy Purge:

1. After optimal start, pre-cooling or pre-heating routines, outdoor ventilation must be provided for the predetermined duration immediately prior to occupancy.

G. Normal Cooling Mode:

1. Normal cooling mode will be enabled at occupancy. Normal cooling mode will also be enabled during an optimal start if the precooling / preheating modes are not available and mechanical cooling from the central plant is available.
2. Normal cooling mode modulates the cooling coil to maintain discharge air temperature setpoint.

H. Supply Fan Control:

1. The supply fan Variable Frequency Drive (VFD) will modulate to control a duct static pressure setpoint.
2. If the duct static pressure sensor fails the VFD will be modulated to 0 percent (adj).
3. During air handler unit shutdown the VFD is modulated to 0 percent.

I. Exhaust Fan / Return Fan:

1. VFD exhaust fan shall modulate to maintain building pressurization and return plenum pressurization.

J. Discharge Air Setpoint:

1. Discharge air setpoint is reset based on the supply fan speed as follows:
 - a. VFD Speed 0 percent to 20 percent (adj) Discharge Air Temperature setpoint will be reset linearly from 65 deg F (adj) to 55 deg F (adj).
 - b. VFD Speed 20 percent (adj) to 80 percent (adj) Discharge Air Temperature setpoint will be a constant 55 deg F (adj).
 - c. VFD Speed 80 percent (adj) to 100 percent Discharge Air Temperature setpoint will be reset linearly from 55 deg F (adj) to 45 deg F (adj).

K. Cooling Control:

1. The hydronic cooling coil shall modulate to maintain the discharge air temperature setpoint.
2. During air handling unit shutdown the cooling coil control will be modulated to 0 percent.

L. Heating Control:

1. The hydronic heating coil is modulated to maintain the discharge air temperature setpoint.
2. During air handling unit shutdown the heating control will be modulated to 0 percent.

M. Carbon Dioxide Control:

1. Carbon dioxide sensors at various locations in the building will be polled and will reset the minimum position of the outside air damper. As the CO₂ level at any one of the sensors increases above setpoint (adj), the outside air damper minimum position will be reset (adj.) to allow for more outside air to enter the building, up to the maximum scheduled ventilation rate.
2. Outside air dampers and unit exhaust / return fan VFD must also maintain proper building pressurization.

N. Economizer Control:

1. The economizer routine will be enabled if the outside air temperature is 5 deg F (adj) cooler than the return air temperature.

2. The economizer dampers will modulate to maintain the Discharge Air Reset setpoint. If the economizer routine is not available the outside air dampers will remain at their minimum position and the return air dampers will remain at their maximum position.

O. Operator Station Display: Indicate the following on operator workstation display terminal:

1. System graphic(s) as required to display, in detail, each system indicated within the sequence of operation.
2. System on-off indication.
3. System occupied / unoccupied mode.
4. System fan on-off indication.
5. Exhaust / return fan on-off indication.
6. Outside-air-temperature indication.
7. Mixed-air-temperature indication.
8. Mixed-air-temperature set point.
9. Mixed-air damper position.
10. Filter air-pressure-drop indication.
11. Filter low-air-pressure set point.
12. Filter high-air-pressure set point.
13. Heating air-temperature indication.
14. Heating air-temperature set point.
15. Supply-fan-discharge air-temperature indication.
16. Supply-fan-discharge air-temperature set point.
17. Cooling and heating coil control valves and valve position.
18. Supply-fan-discharge static-pressure indication.
19. Supply-fan-discharge static-pressure set point.
20. Supply-fan airflow rate, utilizing fan law calculations.
21. Supply-fan speed.
22. Exhaust-air static-pressure indication.
23. Exhaust-air static-pressure set point.
24. Exhaust-fan airflow rate, utilizing fan law calculations.
25. Exhaust-fan speed.
26. Building static-pressure indication.
27. Building static-pressure set point.
28. Indoor / outdoor CO₂ levels.
29. See drawings and specifications for additional points to be monitored.

3.3 VAV BOX WITH MODULATING HEAT (VAV-)

A. Damper Control:

1. The VAV box damper will be controlled to maintain the minimum / maximum CFM flow setpoint. As the space temperature sensor drops below set point, the VAV damper will open to allow more flow through the box. The VAV controller will reset the CFM setpoint based upon the space temperature. As the space temperature falls below setpoint, the VAV controller will reset the CFM setpoint to a lower value. As space temperature rises above setpoint, the VAV controller will reset the CFM setpoint to a higher value.

B. Hot Water Valve:

1. The hot water valve and VAV damper will be modulated to maintain the space temperature. As the space temperature falls below setpoint, the VAV damper will modulate to minimum air flow. As the damper reaches minimum position and the space is still below setpoint, the hot water valve will be modulated open and VAV box supply CFM will slowly increase until the space setpoint temperature is reached. Hot water valve and VAV box CFM will be closed to minimum position as needed.

C. Discharge Air Temp Sensor:

1. A discharge air temp sensor is provided on each box for monitoring purposes.

3.4 ENERGY MEASUREMENT INSTRUMENTATION

- A. The HVAC building control system shall have the capability to perform automatic measurement of energy consumption and to monitor performance.

3.5 ENERGY MANAGEMENT DATA COLLECTION REQUIREMENTS

- A. Electrical values such as V, A, kW, KVAR, KVA, PF, kWh, KVARH, frequency, and percent THD shall be monitored.
- B. Mechanical values such as CHW flow and pressure, HW flow and pressure, equipment status, and equipment capacity shall be monitored, measured, and stored.
- C. The collection of data shall be maintained for trending for at least two years locally on the central HVAC building control system.
- D. Energy management measurements shall have the capability to totalize and mark trends in both instantaneous and time-based numbers for chillers, boilers, air-handling units, exhaust fans, and pumps.
- E. Energy monitoring data shall be automatically converted to a user-defined standard database, transmitted to a designated interface PC, and presented in a color spreadsheet format on demand.

3.6 BUILDING LIGHT CONTROL

- A. Interface and display Building lighting control system - monitor only.

3.7 FIRE ALARM SYSTEM

- A. Interface and display Building fire alarm system - monitor only.

3.8 SECURITY SYSTEM

- A. Interface and display Building security system - monitor only.

3.9 BUILDING EMERGENCY GENERATOR SYSTEMS

- A. Interface and display Building emergency generator system - monitor only.

END OF SECTION 23 0993

SECTION 232113 - HYDRONIC PIPING

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 pipe and fitting materials and joining methods for the following:

1. Hot-water heating piping.

- B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services) "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

- C. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

- B. Qualification Data: For Installer.

- C. Welding certificates.
- D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications:

- 1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

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

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

- 1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
- 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

- 1. Hot-Water Heating Piping: 200 psi at 200 deg F.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).

C. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.
- E. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

2.4 JOINING MATERIALS

- A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAG-1, silver alloy for joining copper with bronze or steel.
- C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. Central Plastics Company.
 - d. Hart Industries International, Inc.
 - e. Jomar International Ltd.
 - f. Matco-Norca.
 - g. Watts Regulator Co.
 - h. Zurn Industries, LLC.
 - i. Or approved equal.
 - 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 150 psig (1035 kPa).
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Capitol Manufacturing Company.
- b. Central Plastics Company.
- c. Matco-Norca.
- d. Watts Regulator Co.
- e. Zurn Industries, LLC.
- f. Or approved equal.

2. Description:

- a. Standard: ASSE 1079.
- b. Factory-fabricated, bolted, companion-flange assembly.
- c. Pressure Rating: 150 psig (1035 kPa).
- d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

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

- a. Advance Products & Systems, Inc.
- b. Calpico, Inc.
- c. Central Plastics Company.
- d. Pipeline Seal and Insulator, Inc.
- e. Or approved equal.

2. Description:

- a. Nonconducting materials for field assembly of companion flanges.
- b. Pressure Rating: 150 psig (1035 kPa).
- c. Gasket: Neoprene or phenolic.
- d. Bolt Sleeves: Phenolic or polyethylene.
- e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

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

- a. Elster Perfection.
- b. Grinnell Mechanical Products.
- c. Matco-Norca.
- d. Precision Plumbing Products, Inc.
- e. Victaulic Company.
- f. Or approved equal.

2. Description:

- a. Standard: IAPMO PS 66.
- b. Electroplated steel nipple, complying with ASTM F 1545.
- c. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).

- d. End Connections: Male threaded or grooved.
- e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-water heating piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
 - 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
 - 2. Schedule 40, Grade B, Type 96 steel pipe; Class 250, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

3.2 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."
- P. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- Q. Install shutoff valve immediately upstream of each dielectric fitting.
- R. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results."
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples or unions.

3.4 HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.
- B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
 - 2. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m).
 - 2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m).
 - 3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m).
 - 4. NPS 2 (DN 50): Maximum span, 10 feet (3 m).
 - 5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m).
 - 6. NPS 3 (DN 80) and Larger: Maximum span, 12 feet (3.7 m).

- E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
 2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
 3. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
 4. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 6. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
 7. NPS 3 (DN 80) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).

3.5 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections.

3.7 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide in-service testing of new portions of piping.
- B. Perform the following tests on hydronic piping:
 - 1. While filling system, use vents installed at high points of system to release air.
 - 2. After in service test pressure has been applied for at least 4 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat test until there are no leaks.
 - 3. Prepare written report of testing.
- C. Perform the following before operating the system:
 - 1. Open manual valves fully.
 - 2. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 - 3. Set temperature controls so all coils are calling for full flow.
 - 4. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 - 5. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 233113 - METAL DUCTS

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. Single-wall rectangular ducts and fittings.
2. Single-wall round and flat-oval ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," ASCE/SEI 7 and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
1. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
 2. See Section 230548 for additional information.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
4. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
5. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
6. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.

5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: In congested areas, plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 2. Suspended ceiling components.
 3. Structural members to which duct will be attached.
 4. Size and location of initial access modules for acoustical tile.
 5. Penetrations of smoke barriers and fire-rated construction.
 6. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.
- B. Welding certificates.
- C. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports, AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports, and AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
 3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Incorporated.
 - d. Sheet Metal Connectors, Inc.
 - e. Spiral Manufacturing Co., Inc.
 - f. Or approved equal.
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G60 (Z180) or G90 (Z275).
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Factory- or Shop-Applied Antimicrobial Coating:
1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
 2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 5. Shop-Applied Coating Color: Black or White.
 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

- D. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- E. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.4 DUCT LINER

- A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation; Insulation Group.
 - b. Johns Manville.
 - c. Knauf Insulation.
 - d. Owens Corning.
 - e. Or approved equal.
 - 2. Maximum Thermal Conductivity:
 - a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - 3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Insulation Pins and Washers:
 - 1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
1. 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.
 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 3. Butt transverse joints without gaps, and coat joint with adhesive.
 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 6. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
 7. 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 higher than 2500 fpm (12.7 m/s) or where indicated.
 8. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 - a. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
 9. 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.

2.5 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches (76 mm).
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
11. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
12. Service: Indoor or outdoor.

13. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.7 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper B-Line, Inc.; a division of Cooper Industries.
 2. Ductmate Industries, Inc.
 3. Hilti Corp.
 4. Kinetics Noise Control.
 5. Loos & Co.; Cableware Division.
 6. Mason Industries.
 7. TOLCO; a brand of NIBCO INC.
 8. Unistrut Corporation; Tyco International, Ltd.
 9. Or approved equal.
- B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California, an agency acceptable to authorities having jurisdiction.
 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
- D. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
- E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round and flat-oval ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
 - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
 - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
 - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
 - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Structural-steel fasteners appropriate for construction materials to which hangers are being attached.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

- A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems," ASCE/SEI 7.
 - 1. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - 2. Brace a change of direction longer than 12 feet (3.7 m).
- B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints on ducts that are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California, an agency acceptable to authorities having jurisdiction.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for and Setting Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - b. Supply Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - c. Return Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - d. Exhaust Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Test for leaks before applying external insulation.
 - 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Each section tested must have a minimum of a 20-foot length straight-run, a minimum of two elbows and a connection to the terminal. Do not pressurize systems above maximum design operating pressure.

6. Give seven days' advance notice for testing. Maximum acceptable leakage is to be 3 percent for system up to 3-inch w.g. Maximum acceptable leakage is to be 1 percent for systems from 3.1-inch w.g. to 10-inch w.g.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

- a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel.

1. See the following Duct Schedule for additional information.

B. Supply Ducts:

1. Ducts Connected to Terminal Units:

- a. Pressure Class: Positive 2-inch wg (500 Pa).
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 6.
- d. SMACNA Leakage Class for Round and Flat Oval: 3.
- e. Duct Liner: Fibrous glass, Type I, 1 inch (25 mm) thick (5'-0" beyond discharge of fan coil or terminal unit).

2. Ducts Connected to Variable-Air-Volume Air-Handling Units:

- a. Pressure Class: Positive 4-inch wg (1000 Pa).

- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 3.
- d. SMACNA Leakage Class for Round and Flat Oval: 3.
- e. Duct Liner: Fibrous glass, Type I, 1 inch (25 mm) thick (for extent indicated on plans).

C. Return Ducts:

1. Ducts Connected to Constant-Volume and Variable-Volume Air-Handling Units:

- a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 6.
- d. SMACNA Leakage Class for Round and Flat Oval: 3.
- e. Duct Liner: Fibrous glass, Type I, 1 inch (25 mm) thick.

2. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Positive or negative 3-inch wg.
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 6.
- d. SMACNA Leakage Class for Round and Flat Oval: 3.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

- a. Pressure Class: Negative 2-inch wg (500 Pa).
- b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
- c. SMACNA Leakage Class for Rectangular: 6.
- d. SMACNA Leakage Class for Round and Flat Oval: 3.
- e. Duct Liner: None.

2. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Positive or negative 3-inch wg.

E. Transfer Air Ducts Not Listed Above:

- a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 6.
- d. SMACNA Leakage Class for Round and Flat Oval: 3.
- e. Duct Liner: 1 inch (25 mm) thick.

F. Liner:

- 1. Supply Fan Plenums: Fibrous glass, Type II, 2 inches thick.
- 2. Return- and Exhaust-Fan Plenums: Fibrous glass, Type II, 2 inches thick.
- 3. Transfer Ducts: Fibrous glass, Type I, 1 inch thick.

G. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
2. PVC-Coated Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Galvanized or match duct material.
3. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Galvanized or match duct material.
4. Aluminum Ducts: Galvanized sheet steel coated with zinc chromate.

H. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm (5 m/s) or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm (7.6 m/s) or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

- c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Welded.

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

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. Manual volume dampers.
2. Fire dampers.
3. Smoke dampers.
4. Combination fire and smoke dampers.
5. Corridor dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Flexible ducts.
11. Duct accessory hardware.

B. Related Requirements:

1. Division 28 Section Fire-Alarm System for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

A. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

- a. Special fittings.

- b. Manual volume damper installations.
- c. Control-damper installations.
- d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
- e. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.
- B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60 (Z180) or G90 (Z275).
 - 2. Exposed-Surface Finish: Mill phosphatized.

- B. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

- 1. Standard leakage rating, with linkage outside airstream.
- 2. Suitable for horizontal or vertical applications.
- 3. Frames:
 - a. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
- 4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. [Galvanized-steel, 0.064 inch (1.62 mm) thick.
- 5. Blade Axles: Galvanized steel.
- 6. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 7. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

- 1. Standard leakage rating, with linkage outside airstream.
- 2. Suitable for horizontal or vertical applications.
- 3. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
- 4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
- 5. Blade Axles: Galvanized steel.

6. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Tie Bars and Brackets: Aluminum.

2.4 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Air Balance Inc.; a division of Mestek, Inc.
 2. Arrow United Industries; a division of Mestek, Inc.
 3. Cesco Products; a division of Mestek, Inc.
 4. Greenheck Fan Corporation.
 5. Nailor Industries Inc.
 6. NCA Manufacturing, Inc.
 7. Pottorff.
 8. Prefco; Perfect Air Control, Inc.
 9. Ruskin Company.
 10. Vent Products Company, Inc.
 11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
 12. Or approved equal.
- B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 3000-fpm velocity.
- D. Fire Rating: 1-1/2 and 3 hours per Code plan.
- E. Frame: Curtain type with blades outside airstream or curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory-installed, galvanized sheet steel.
 1. Minimum Thickness: 0.05 (1.3 mm) thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.024-inch- (0.61-mm) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

- J. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

2.5 SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Air Balance Inc.; a division of Mestek, Inc.
 2. Cesco Products; a division of Mestek, Inc.
 3. Greenheck Fan Corporation.
 4. Nailor Industries Inc.
 5. Pottorff.
 6. Ruskin Company.
 7. Or approved equal.
- B. General Requirements: Label according to UL 555S by an NRTL.
- C. Smoke Detector: Reference Division 28, section "Digital, Addressable Fire-Alarm System" for detectors and interconnection.
- D. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.
- E. Blades: Roll-formed, horizontal, interlocking or overlapping, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel.
- F. Leakage: Class I.
- G. Rated pressure and velocity to exceed design airflow conditions.
- H. Mounting Sleeve: Factory-installed, 0.05-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.
- I. Damper Motors: Two-position action.
- J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements.
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

5. Electrical Connection: 115 V, single phase, 60 Hz, spring return closed, normally closed, power open.

K. Accessories:

1. Auxiliary switches for signaling, fan control or position indication (damper open and closed switches).
2. Momentary test switch, indicator lights (open/closed), test and reset switches, damper remote mounted.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

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

1. Air Balance Inc.: a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.
7. Or approved equal.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 3000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours per Code plan.

E. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.

F. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

G. Smoke Detector: Reference Division 28, section "Digital, Addressable Fire-Alarm System" for detectors and interconnection.

H. Blades: Roll-formed, horizontal, interlocking, overlapping, 0.063-inch- (1.6-mm-) thick, galvanized sheet steel.

I. Leakage: Class I.

J. Rated pressure and velocity to exceed design airflow conditions.

K. Mounting Sleeve: Factory-installed, 0.05-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.

L. Master control panel for use in dynamic smoke-management systems.

M. Damper Motors: Two-position action.

N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
6. Electrical Connection: 115 V, single phase, 60 Hz, spring return closed, normally closed, power open.

O. Accessories:

1. Auxiliary switches for signaling, fan control or position indication (damper open and closed switches).
2. Momentary test switch, indicator lights (open/close), test and reset switches, damper remote mounted.

2.7 CORRIDOR DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Nailor Industries Inc.
4. Pottorff.
5. Ruskin Company.
6. Or approved equal.

B. General Requirements: Label combination fire and smoke dampers according to UL 555 for 1-hour or 1-1/2-hour rating by an NRTL.

C. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

D. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.

E. Blades: Roll-formed, horizontal, interlocking or overlapping, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel.

- F. Mounting Sleeve: Factory-installed, 0.05-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.
- G. Damper Motors: Two-position action.
- H. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements.
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
 - 7. Electrical Connection: 115 V, single phase, 60 Hz.

2.8 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Nexus PDQ; Division of Shilco Holdings Inc.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
 - 4. Or approved equal.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

2.9 TURNING VANES

- A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vaness and Vane Runners," and 4-4, "Vane Support in Elbows."
- C. Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

2.10 REMOTE DAMPER OPERATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pottorff.
 - 2. Ventfabrics, Inc.
 - 3. Young Regulator Company.
 - 4. Or approved equal.
- B. Description: Cable system designed for remote manual damper adjustment.
- C. Tubing: Aluminum.
- D. Cable: Stainless steel.
- E. Wall-Box Mounting: Recessed.
- F. Wall-Box Cover-Plate Material: Steel.

2.11 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating; a division of Mestek, Inc.
 - 2. Cesco Products; a division of Mestek, Inc.
 - 3. Ductmate Industries, Inc.
 - 4. Elgen Manufacturing.
 - 5. Flexmaster U.S.A., Inc.
 - 6. Greenheck Fan Corporation.
 - 7. McGill AirFlow LLC.
 - 8. Nailor Industries Inc.
 - 9. Pottorff.
 - 10. Ventfabrics, Inc.
 - 11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

12. Or approved equal.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: Continuous and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Continuous and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Continuous and two compression latches with outside and inside handles.

2.12 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
 2. Duro Dyne Inc.
 3. Elgen Manufacturing.
 4. Ventfabrics, Inc.
 5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
 6. Or approved equal.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

2.13 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. Quiet Flex.
3. Casco.
4. Or approved equal.

B. Acoustical Insulated, Flexible Duct: UL 181, Class 1, acoustically transparent nylon inner fabric which allows broadband sound energy to penetrate the duct wall supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
2. Non-Clamp Connectors: Liquid adhesive plus tape.

2.14 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

- B. Install 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. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- D. Set dampers to fully open position before testing, adjusting, and balancing.
- E. Install test holes at fan inlets and outlets and elsewhere as indicated.
- F. Install fire and smoke dampers according to UL listing.
- G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 2. Control devices requiring inspection.
 - 3. Elsewhere as indicated on drawings or specifications.
- H. Install access doors with swing against duct static pressure.
- I. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
 - 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 - 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 - 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 - 5. Body Access: 25 by 14 inches (635 by 355 mm).
 - 6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- J. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- K. Install flexible connectors to connect ducts to equipment.
- L. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- M. Connect terminal units to supply ducts directly. Do not use flexible ducts to change directions.
- N. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch (5'-0") lengths of flexible duct clamped or strapped in place. Support to avoid sagging of flexible ductwork and each length of duct shall be installed with no more than 2-45 degree elbows or 1-90 degree elbow.

- O. Connect flexible ducts to metal ducts with adhesive and draw bands.
- P. Install duct test holes where required for testing and balancing purposes.
- Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Shutoff, single-duct air terminal units.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

- 1. Air terminal units.
- 2. Liners and adhesives.
- 3. Sealants and gaskets.
- 4. Seismic-restraint devices.

- B. LEED Submittals:

- 1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

- C. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.

- 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- 2. Wiring Diagrams: For power, signal, and control wiring.
- 3. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

- D. Delegated-Design Submittal:

- 1. Materials, fabrication, assembly, and spacing of hangers and supports.
- 2. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.6 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. All Variable Air Volume (VAV) terminal boxes shall be provided with ARI 880 Certification, ARI Seal and a 5 year warranty on terminal boxes.
- B. Structural Performance: Hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," ASCE/SEI 7 and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." Also see Section 230548.
1. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

2.2 SYSTEM DESCRIPTION

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

2.3 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Anemostat Products; a Mestek Company.
 2. Carnes.
 3. Environmental Technologies, Inc.

4. Krieger.
 5. METALAIRE, Inc.
 6. Nailor Industries Inc.
 7. Phoenix Controls Corporation.
 8. Price Industries.
 9. Titus.
 10. Trane; a business of American Standard Companies.
 11. Trox USA Inc.; a subsidiary of the TROX GROUP.
 12. Tuttle & Bailey.
 13. Warren Technology.
 14. Or approved equal.
- B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: 0.034-inch (0.85-mm) steel double wall.
1. Casing Lining: Adhesive attached, 1-inch- (25-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - a. Cover liner with nonporous foil and perforated metal.
 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections, size matching inlet size.
 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.
 2. Damper Position: Normally open.
- E. Attenuator Section: 0.034-inch (0.85-mm) steel sheet.
1. Lining: Adhesive attached, 1-inch- (25-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - a. Cover liner with nonporous foil and perforated metal.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- F. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a

maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

- G. Electric Controls: Damper actuator and thermostat.
 - 1. Damper Actuator: 24 V.
 - 2. Thermostat: Wall-mounted electronic type by DDC system.

2.4 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Steel Cables: Galvanized steel complying with ASTM A 603.
- D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.5 SEISMIC-RESTRAINT DEVICES

- A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California, an agency acceptable to authorities having jurisdiction.
 - 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
- C. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips.
- D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

- E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.6 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

3.2 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Structural-steel fasteners appropriate for construction materials to which hangers are being attached.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 SEISMIC-RESTRAINT-DEVICE INSTALLATION

- A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" and ASCE/SEI 7.
- B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints on air terminal units that are suspended with vibration isolators.

- E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California, an agency acceptable to authorities having jurisdiction.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, or to upper truss chords of bar joists.

3.4 CONNECTIONS

- A. Install piping adjacent to air terminal unit to allow service and maintenance.
- B. Hot-Water Piping: In addition to requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- C. Connect ducts to air terminal units according to Section 233113 "Metal Ducts."
- D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.5 IDENTIFICATION

- A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Air terminal unit will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 3. Verify that controls and control enclosure are accessible.
 4. Verify that control connections are complete.
 5. Verify that nameplate and identification tag are visible.
 6. Verify that controls respond to inputs as specified.

3.8 DEMONSTRATION

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

END OF SECTION 233600

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

- 1. Diffusers, grilles and registers as scheduled on the plans. Scheduled models by reference include required features and performance in addition to those specified herein. Where in conflict with this specification section the scheduled products will govern.

B. Related Sections:

- 1. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.
- 2. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

- 1. Data Sheet: Indicate materials of construction, finish, and mounting details.
- 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- 3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses; throw and drop; and noise criteria ratings. Indicate selections on data.

B. Data for Verification of Seismic mounting and support.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

- 1. Ceiling suspension assembly members.
- 2. Method of attaching hangers to building structure.
- 3. Size and location of initial access modules for acoustical tile.

4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver diffusers, registers and grilles wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.
- B. Store diffusers, registers and grilles in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Anemostat Products; a Mestek company.
 2. Carnes.
 3. Hart & Cooley Inc.
 4. Krueger.
 5. METALAIRE, Inc.
 6. Nailor Industries Inc.
 7. Price Industries.
 8. Titus.
 9. Tuttle & Bailey.

2.2 CEILING DIFFUSERS AND GRILLES

- A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide ceiling air diffusers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
 1. Devices shall be specifically designed for variable-air-volume flows.
- C. Ceiling Compatibility: Provide diffusers and grilles with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

- D. Types: Provide ceiling diffusers and grilles of type, capacity, and with accessories and finishes as listed on diffusers, registers and grilles schedule.
1. Diffuser and Grille Faces:
 - a. Round: Round housing, core of concentric rings, round duct connection.
 - b. Square: Square housing, core of square concentric louvers, square or round duct connection.
 - c. Plaque: Square housing, core of square concentric louver with plaque face, square or round duct connection.
 - d. Rectangular: Rectangular housing, core of rectangular concentric louvers, square or round duct connection.
 - e. Perforated: Round, square, or rectangular housing covered with removable perforated panel in frame. Conceal air pattern devices above panel.
 - f. Linear: Extruded aluminum continuous slot, single or multiple.
 2. Diffuser and Grille Mountings:
 - a. Flush: Diffuser housing above ceiling surface with flush perimeter flange and gasket to seal against ceiling.
 - 1) Include filter mounting frame where scheduled.
 - b. Lay-In: Diffuser housing sized to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.
 - 1) Include filter mounting frame where scheduled.
 3. Diffuser and Grille Dampers:
 - a. Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of diffuser.
 - b. Butterfly: Two semicircular flaps connected to linkage adjustable from face of diffuser with key, and with straightening grid.
 - c. Fire Damper: Combination adjustable opposed blade damper and fusible link fire damper with UL approved link and assembly designed to meet requirements of NFPA 90A.
 4. Accessory: Filter where scheduled.

2.3 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. General: Install diffusers, registers and grilles in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function.
- B. Install diffusers, registers, and grilles level and plumb.
- C. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of diffusers, registers and grilles with other work.
- D. 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 practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- E. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- F. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

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

END OF SECTION 233713

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

- 1. Building wires and cables rated 600 V and less.
- 2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

- 1. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
- 2. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.
- 3. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

- A. VFC: Variable frequency controller.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Alcan Products Corporation; Alcan Cable Division.
 2. Alpha Wire.
 3. Belden Inc.
 4. Encore Wire Corporation.
 5. General Cable Technologies Corporation.
 6. Southwire Incorporated.
- B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.
- C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THW-2, Type THHN-2-THWN-2, Type XHHW-2, Type UF, Type USE, and Type SO.
- D. VFC Cable:
 1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
 2. Type TC-ER with oversized crosslinked polyethylene insulation, dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires, and sunlight- and oil-resistant outer PVC jacket.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. AFC Cable Systems, Inc.
 2. Gardner Bender.
 3. Hubbell Power Systems, Inc.
 4. Ideal Industries, Inc.
 5. Ilseco; a branch of Bardes Corporation.
 6. NSi Industries LLC.
 7. O-Z/Gedney; a brand of the EGS Electrical Group.
 8. 3M; Electrical Markets Division.
 9. Tyco Electronics.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

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

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger, except VFC cable, which shall be extra flexible stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- B. Exposed Branch Circuits, Including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- C. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

- G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 CONNECTIONS

- A. 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-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
 - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Test and Inspection Reports: Prepare a written report to record the following:
 1. Procedures used.
 2. Results that comply with requirements.
 3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- E. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency and testing agency's field supervisor.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. Dossert; AFL Telecommunications LLC.
3. ERICO International Corporation.
4. Fushi Copperweld Inc.
5. Galvan Industries, Inc.; Electrical Products Division, LLC.
6. Harger Lightning and Grounding.
7. ILSCO.
8. O-Z/Gedney; A Brand of the EGS Electrical Group.
9. Robbins Lightning, Inc.
10. Siemens Power Transmission & Distribution, Inc.

2.2 SYSTEM DESCRIPTION

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 7. Armored and metal-clad cable runs.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

- F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
- C. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- D. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- E. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
- E. Grounding system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power Distribution Units or Panelboards Serving Electronic Equipment: 5 ohm(s).
- H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
2. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
1. Structural members in paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Qualification Data: For professional engineer.
- C. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
- D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit.
 3. Anamet Electrical, Inc.
 4. Electri-Flex Company.
 5. O-Z/Gedney.
 6. Picoma Industries.
 7. Republic Conduit.
 8. Robroy Industries.
 9. Southwire Company.
 10. Thomas & Betts Corporation.
 11. Western Tube and Conduit Corporation.
 12. Wheatland Tube Company.
- B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. GRC: Comply with ANSI C80.1 and UL 6.

- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. EMT: Comply with ANSI C80.3 and UL 797.
- G. FMC: Comply with UL 1; zinc-coated steel.
- H. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- I. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: compression.
 - 2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- J. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Anamet Electrical, Inc.
 - 3. Arcco Corporation.
 - 4. CANTEX Inc.
 - 5. CertainTeed Corporation.
 - 6. Condux International, Inc.
 - 7. Electri-Flex Company.
 - 8. Kraloy.
 - 9. Lamson & Sessions; Carlon Electrical Products.
 - 10. Niedax-Kleinhuis USA, Inc.
 - 11. RACO; Hubbell.
 - 12. Thomas & Betts Corporation.
- B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. ENT: Comply with NEMA TC 13 and UL 1653.
- D. LFNC: Comply with UL 1660.
- E. Rigid HDPE: Comply with UL 651A.

- F. Continuous HDPE: Comply with UL 651B.
- G. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.
- H. RTRC: Comply with UL 1684A and NEMA TC 14.
- I. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- J. Fittings for LFNC: Comply with UL 514B.
- K. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- L. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Adalet.
 - 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 - 3. EGS/Appleton Electric.
 - 4. Erickson Electrical Equipment Company.
 - 5. FSR Inc.
 - 6. Hoffman.
 - 7. Hubbell Incorporated.
 - 8. Kraloy.
 - 9. Milbank Manufacturing Co.
 - 10. Mono-Systems, Inc.
 - 11. O-Z/Gedney.
 - 12. RACO; Hubbell.
 - 13. Robroy Industries.
 - 14. Spring City Electrical Manufacturing Company.
 - 15. Stahlin Non-Metallic Enclosures.
 - 16. Thomas & Betts Corporation.
 - 17. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

- F. Metal Floor Boxes:
 - 1. Material: Cast metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Poke Thru Round Type .
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).
- J. Gangable boxes are allowed.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Indoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Exposed, Subject to Physical Damage: GRC identified for such use.
 - 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 - 5. Damp or Wet Locations: GRC.
- B. Minimum Raceway Size: 3/4-inch (21-mm) trade size.
- C. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - 3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
 - 4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

- D. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface raceways only where indicated on Drawings.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- I. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- K. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- L. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated

throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

- N. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- P. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- Q. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- R. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- S. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
- T. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
 - 1. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 2. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- U. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 1. Use LFMC in damp or wet locations subject to severe physical damage.
 - 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- V. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of box unless otherwise indicated.
- W. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

- X. Locate boxes so that cover or plate will not span different building finishes.
- Y. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- Z. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- AA. Set metal floor boxes level and flush with finished floor surface.
- BB. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

3.4 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

- B. Related Sections include the following:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

- A. The IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
- B. Delegated-Design Submittal: For seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
 - a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other electrical Sections for equipment mounted outdoors.
 2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
 3. Field-fabricated supports.
 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.
 - c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- B. Qualification Data: For professional engineer and testing agency.
- C. Welding certificates.
- D. Field quality-control test reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

- C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SEISMIC-RESTRAINT DEVICES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, or a comparable product by one of the following:
 - 1. Amber/Booth Company, Inc.
 - 2. California Dynamics Corporation.
 - 3. Cooper B-Line, Inc.; a division of Cooper Industries.
 - 4. Hilti Inc.
 - 5. Loos & Co.; Seismic Earthquake Division.
 - 6. Mason Industries.
 - 7. TOLCO Incorporated; a brand of NIBCO INC.
 - 8. Unistrut; Tyco International, Ltd.
- D. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
 - 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- E. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

- F. Restraint Cables: ASTM A 603 galvanized-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

2.2 FACTORY FINISHES

- A. Finish: Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
 - 3. Baked enamel or powder coat for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Equipment and Hanger Restraints:
 - 1. Install restrained isolators on electrical equipment.

2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Perform tests and inspections.
- C. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after isolated equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

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

1.3 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER AND CONTROL RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING."
- D. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.
- E. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- G. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.
- B. Colors for Cables Carrying Circuits at 600 V and Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.
- B. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
- C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.
- D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.5 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
- C. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.6 EQUIPMENT IDENTIFICATION LABELS

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

2.7 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
 1. Minimum Width: 3/16 inch (5 mm).
 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 4. Color: Black except where used for color-coding.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

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

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors,

at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

- F. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

END OF SECTION 260553

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Indoor occupancy sensors.

- B. Related Requirements:

- 1. Section 262726 "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- B. Shop Drawings: Show installation details for occupancy and light-level sensors.

- 1. Interconnection diagrams showing field-installed wiring.
- 2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Bryant Electric; a Hubbell company.
 2. Cooper Industries, Inc.
 3. Hubbell Building Automation, Inc.
 4. Leviton Mfg. Company Inc.
 5. Lightolier Controls.
 6. Lithonia Lighting; Acuity Lighting Group, Inc.
 7. Lutron Electronics Co., Inc.
 8. NSi Industries LLC; TORK Products.
 9. RAB Lighting.
 10. Sensor Switch, Inc.
 11. Square D; a brand of Schneider Electric.
 12. Watt Stopper.
- B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
 4. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 5. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 7. Bypass Switch: Override the "on" function in case of sensor failure.
 8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.
- C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

2.2 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Bryant Electric; a Hubbell company.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Leviton Mfg. Company Inc.
5. Lightolier Controls.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Lutron Electronics Co., Inc.
8. NSi Industries LLC; TORK Products.
9. RAB Lighting.
10. Sensor Switch, Inc.
11. Square D; a brand of Schneider Electric.
12. Watt Stopper.

- B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application, and shall comply with California Title 24.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.

- C. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m).
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
4. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
5. Concealed "off" time-delay selector at 30 seconds, and 5, 10, and 20 minutes.
6. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.

2.3 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 WIRING INSTALLATION

- A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch.
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections.

- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Lighting control devices will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
 - 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
 - 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.6 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.13 "Addressable-Fixture Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Receptacles with integral surge-suppression units.
3. Isolated-ground receptacles.
4. Snap switches and wall-box dimmers.
5. Wall-switch and exterior occupancy sensors.
6. Communications outlets.
7. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.
- F. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no fewer than two.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand (Pass & Seymour).
- B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

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

2.3 STRAIGHT-BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cooper; 5351 (single), CR5362 (duplex).

- b. Hubbell; HBL5351 (single), HBL5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5361 (single), 5362 (duplex).
- B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cooper; IG5362RN.
 - b. Hubbell; IG5362.
 - c. Leviton; 5362-IG.
 - d. Pass & Seymour; IG5362.
 2. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, non-feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cooper; VGF20.
 - b. Hubbell; GFR5352L.
 - c. Pass & Seymour; 2095.
 - d. Leviton; 7590.

2.5 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- 1) Single Pole:

- 2) Cooper; AH1221.
- 3) Hubbell; HBL1221.
- 4) Leviton; 1221-2.
- 5) Pass & Seymour; CSB20AC1.

- 6) Two Pole:

- 7) Cooper; AH1222.
- 8) Hubbell; HBL1222.
- 9) Leviton; 1222-2.
- 10) Pass & Seymour; CSB20AC2.

C. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Cooper; 1995.
- b. Hubbell; HBL1557.
- c. Leviton; 1257.
- d. Pass & Seymour; 1251.

2.6 WALL PLATES

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

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.05-inch- (1.2-mm-) thick, anodized aluminum.

2.7 POKE-THROUGH ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Pass & Seymour/Legrand.
3. Square D/Schneider Electric.
4. Thomas & Betts Corporation.
5. Wiremold/Legrand.

B. Description:

1. Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
2. Comply with UL 514 scrub water exclusion requirements.

3. Service-Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jack.
4. Size: Selected to fit nominal 3-inch (75-mm) cored holes in floor and matched to floor thickness.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused 3-inch (75-mm) cored openings and reestablish fire rating of floor.

2.8 FINISHES

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.
- D. Device Installation:
 1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.

2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

- A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. Test Instruments: Use instruments that comply with UL 1436.

2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 265100 - INTERIOR LIGHTING

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. Interior lighting fixtures, lamps, and ballasts.
- 2. Exit signs.
- 3. Lighting fixture supports.

- B. Related Sections:

- 1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
- 2. Section 262726 "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

1.3 DEFINITIONS

- A. BF: Ballast factor.
- B. CCT: Correlated color temperature.
- C. CRI: Color-rendering index.
- D. HID: High-intensity discharge.
- E. LER: Luminaire efficacy rating.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of lighting fixture including dimensions.

2. Ballast, including BF.
 3. Energy-efficiency data.
 4. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
 5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - a. Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
 - b. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Shop Drawings: For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Installation instructions.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- B. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- C. Field quality-control reports.
- D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Plastic Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.

1.9 COORDINATION

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- C. Metal Parts: Free of burrs and sharp corners and edges.

- D. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- F. Diffusers and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least **0.125 inch (3.175 mm)** minimum unless otherwise indicated.
 - b. UV stabilized.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
- G. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp and ballast characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
 - c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
 - d. Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
 - e. CCT and CRI for all luminaires.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

- A. General Requirements for Electronic Ballasts:
 - 1. Comply with UL 935 and with ANSI C82.11.
 - 2. Designed for type and quantity of lamps served.
 - 3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
 - 4. Sound Rating: Class A.
 - 5. Total Harmonic Distortion Rating: Less than [10] [20] percent.
 - 6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 - 7. Power Factor: 0.95 or higher.
 - 8. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.

- B. luminaires controlled by occupancy sensors shall have programmed-start ballasts.
- C. Electronic Programmed-Start Ballasts for T8 Lamps: Comply with ANSI C82.11 and the following:
 - 1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
 - 2. Automatic lamp starting after lamp replacement.
 - 3. Ballast Manufacturer Certification: Indicated by label.
- D. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
- E. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
 - 1. Dimming Range: 100 to 5 percent of rated lamp lumens.
 - 2. Ballast Input Watts: Can be reduced to 20 percent of normal.
 - 3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
 - 4. Control: Coordinate wiring from ballast to control device to ensure that the ballast, controller, and connecting wiring are compatible.
- F. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.
 - 1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
 - a. High-Level Operation: 100 percent of rated lamp lumens.
 - b. Low-Level Operation: 30 percent of rated lamp lumens.
 - 2. Ballast shall provide equal current to each lamp in each operating mode.
 - 3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

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

10. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

2.5 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.

2.6 FLUORESCENT LAMPS

- A. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches (1220 mm), 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life 20,000 hours unless otherwise indicated.
- B. Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at three hours operation per start, and suitable for use with dimming ballasts unless otherwise indicated.
 1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
 2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
 3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
 4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
 5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
 6. 57 W: T4, triple tube, rated 4300 initial lumens (minimum).
 7. 70 W: T4, triple tube, rated 5200 initial lumens (minimum).

2.7 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- B. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- C. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
- D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures:

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
2. Install lamps in each luminaire.

B. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

C. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 STARTUP SERVICE

- A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
 - 1. Adjust aimable luminaires in the presence of Architect.

END OF SECTION 265100

SECTION 270544 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

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

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

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

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

- C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- F. Sleeves for Rectangular Openings:
 - 1. Material: Galvanized-steel sheet.
 - 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

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

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Presealed Systems.

2.4 GROUT

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

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 - 2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."

- b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

END OF SECTION 270544

SECTION 27 42 19 – ELECTRONIC SIGNAGE

1 - GENERAL DESCRIPTION

1.1 SUMMARY OF WORK INCLUDED

- A. Scope includes all of the work indicated on, or reasonably inferred from the Drawings and Specifications identified as a part of the contract documents including but not limited to:
1. An electronic display system serving the entry to each courtroom to announce the court calendar for that space.
 2. An electronic information and wayfinding kiosk system including interactive touchscreen displays in the public lobby area.
 3. An electronic automated cueing system located in the Clerk's public window area on the first floor to include a touchscreen service cueing request kiosk and overhead service announcement displays to provide automated cueing of patrons awaiting service.
- B. Related Work:
1. 27 0000 – Communications Systems
 2. 27 0528 – Pathways for Communications Systems
 3. 27 1000 – Structured Cabling Systems
- C. Provide, install, certify, and document systems that are complete, operational, and consistent with the expectations of the Owner as established herein. It is the Contractor's responsibility to provide all of the requisite components, features, and appurtenances that are needed to ensure that each of these systems will comply with the functional and performance requirements contained herein.
- D. Pay all fees and charges for inspections, permits, and other services required to legally accomplish this part of the work of Division 27.

1.2 SYSTEM DESCRIPTION

- A. Provide and install a complete courtroom entry display system including the associated video generation PCs, associated application and server software, displays (12" diagonal), architectural bezels, display mounts, interfacing electronics and interconnect cabling required to achieve a complete and functional integrated system. The system shall integrate and operate seamlessly with the existing courthouse software application utilized for courtroom calendaring. The Courts shall provide a single desktop PC on which the calendar display application operates. It is intended that the facility structured cabling system and associated Owner-provided IP network will provide the needed system electronic communication function. Any interfacing electronics and/or software needed to complete the system shall be furnished and installed by the contractor.
- B. Provide and install a video information and wayfinding system which provides touchscreen terminals for public use in the public lobby area. This system shall include including the associated video generation PCs, associated application and server software, displays,

architectural bezels, display mounts, interfacing electronics and interconnect cabling required to achieve a complete and functional integrated system. The system shall integrate with and complement the existing courthouse software application utilized for courtroom calendaring. Additionally, the system shall provide via a touchscreen interface, access to information about the location of the various courts departments within the facility as well as key courts personnel. The Courts shall provide a single desktop PC on which the kiosk information application operates. It is intended that the facility structured cabling system and associated Owner-provided IP network will provide the needed system electronic communication function. Any interfacing electronics and/or software needed to complete the system shall be furnished and installed by the contractor.

- C. Provide and install a complete electronic cueing system including floor-standing public check-in kiosk with touchscreen display, server software and 21" (diagonal) displays at the public window (ceiling) locations shown. The Courts shall provide a single desktop PC on which the cueing display application operates. It is intended that the facility structured cabling system and associated Owner-provided IP network will provide the needed system electronic communication function. The kiosk shall be equipped with a touchscreen terminal for information display and service request entry by patrons desiring service from the Clerk's public service windows. All functional and interfacing hardware and software needed to complete the system shall be furnished and installed by the contractor.

2 - PRODUCTS

2.1 Courtroom Calendar Display System

- A. The courts will provide information regarding the existing computer systems, network and software applications that the system must be compatible with.
- B. System installation includes furnishing, installing, tailoring, debugging and maintaining (through the warranty period) the system software.
- C. The current court computer systems utilize the Microsoft Windows operating and network software.

2.2 Automated Public Cueing System

- A. The courts will provide information regarding the existing computer systems, network and software applications that the system must be compatible with.
- B. System installation includes furnishing, installing, tailoring, debugging and maintaining (through the warranty period) the system software.
- C. The current court computer systems utilize the Microsoft Windows operating and network software.
- D. Manufacturer: ACF Technologies "Q-Flow" system or approved equal.

2.3 Touchscreen Displays

- A. Kiosk touchscreen displays shall be 17" (diagonal measurement) in size and be supplied complete with the associated display mount and any needed bezel.
- B. Mounting of the displays within the kiosks shall be fully coordinated with the kiosk supplier and Architect.
- C. All display interface electronics (KVM to twisted pair cabling or local mini-PC) and software required to achieve complete display functionality shall furnished and installed.

3 – EXECUTION

3.1 GENERAL

- A. Coordinate with the Courts to develop the operating details and IT coordination required to implement each system.
- B. Coordinate the architectural appearance of each display with the Architect.
- C. Provide all needed infrastructure to achieve system completion including communications cabling, mounting hardware and other installation accessories.

END OF SECTION 27 4219

SECTION 280544 - SLEEVES AND SLEEVE SEALS FOR ELECTRONIC SAFETY AND SECURITY
PATHWAYS AND CABLING

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

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.
2. Penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

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

- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- F. Sleeves for Rectangular Openings:
 - 1. Material: Galvanized-steel sheet.
 - 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

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

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Presealed Systems.

2.4 GROUT

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

2.5 SILICONE SEALANTS

- A. **Silicone Sealants:** Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 1. **Grade:** Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. **Silicone Foams:** Multicomponent, silicone-based, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. **Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:**
 1. **Interior Penetrations of Non-Fire-Rated Walls and Floors:**

- a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

END OF SECTION 280544

SECTION 282300 - VIDEO SURVEILLANCE

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 DEFINITIONS

- A. AGC: Automatic gain control.
- B. BNC: Bayonet Neill-Concelman - type of connector.
- C. B/W: Black and white.
- D. CCD: Charge-coupled device.
- E. FTP: File transfer protocol.
- F. IP: Internet protocol.
- G. LAN: Local area network.
- H. MPEG: Moving picture experts group.
- I. NTSC: National Television System Committee.
- J. PC: Personal computer.
- K. PTZ: Pan-tilt-zoom.
- L. RAID: Redundant array of independent disks.
- M. TCP: Transmission control protocol - connects hosts on the Internet.
- N. UPS: Uninterruptible power supply.
- O. WAN: Wide area network.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Video surveillance system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 ACTION SUBMITTALS

- A. Shop Drawings: For video surveillance. Include plans showing relocation of cameras.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NECA 1.
- C. Comply with NFPA 70.
- D. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. Install existing owner provided cameras and reconnect into the existing video surveillance system. Provide wiring that is compatible and/or matches existing system.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN, WAN, and IP network before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WIRING

- A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."
- B. Wiring Method: Install cables in raceways unless otherwise indicated.

1. Except raceways are not required in accessible indoor ceiling spaces and attics.
 2. Except raceways are not required in hollow gypsum board partitions.
 3. Conceal raceways and wiring except in unfinished spaces.
- C. Wiring within Enclosures: 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.
- D. Splices, Taps, and Terminations: 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-486B.
- E. For LAN connection and fiber-optic and copper communication wiring, comply with Section 271300 "Communications Backbone Cabling" and Section 271500 "Communications Horizontal Cabling."
- F. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

- A. Install cameras and infrared illuminators level and plumb.
- B. Install cameras with 84-inch- (2134-mm-) minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
- C. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.
- D. Install power supplies and other auxiliary components at control stations unless otherwise indicated.
- E. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.
- F. Avoid ground loops by making ground connections only at the control station.
1. For 12- and 24-V dc cameras, connect the coaxial cable shields only at the monitor end.
- G. Identify system components, wiring, cabling, and terminals according to Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
 - 2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
 - a. Prepare equipment list described in "Informational Submittals" Article.
 - b. Verify operation of auto-iris lenses.
 - c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
 - d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet (17 to 23 m) away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
 - e. Set and name all preset positions; consult Owner's personnel.
 - f. Set sensitivity of motion detection.
 - g. Connect and verify responses to alarms.
 - h. Verify operation of control-station equipment.
 - 3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
 - 4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
- E. Video surveillance system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.5 ADJUSTING

- A. 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 Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
 - 1. Check cable connections.

2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
3. Adjust all preset positions; consult Owner's personnel.
4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
5. Provide a written report of adjustments and recommendations.

3.6 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

END OF SECTION 282300