

**SECTION 000100  
PROJECT MANUAL COVER**

<b>NEWBURGH ENLARGED CENTRAL SCHOOL DISTRICT</b>
<b>PHASE 5: 2019 CAPITAL IMPROVEMENT PROJECT</b>
<b>400 OLD FORGE HILL ROAD</b>
<b>NEW WINDSOR, NY 12553</b>

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**CPL PROJECT NO.:13940.20**

**A. DOCUMENT DATE: SEPTEMBER 27, 2021**

**NEW YORK STATE EDUCATION DEPARTMENT CONTROL NUMBERS:**

<b>VAILS GATE ELEMENTARY SCHOOL</b>	<b>SED# 44-16-00-01-0-018-009</b>
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Volume 2: Division 19 through 33

**DESIGN PROFESSIONAL'S  
CERTIFICATIONTHE UNDERSIGNED  
CERTIFIES THAT, TO THE BEST OF HIS OR  
HER KNOWLEDGE, INFORMATION AND  
BELIEF, THAT THE "DESIGN CONFORMS TO  
ALL APPLICABLE PROVISIONS OF THE NEW  
YORK STATE UNIFORM FIRE PREVENTION  
CODE AND BUILDING CODE, NEW YORK  
STATE ENERGY CONSERVATION CODE AND  
THE BUILDING STANDARDS OF THE NEW  
YORK STATE EDUCATION DEPARTMENT.  
AND THAT THE "WORK WILL INVOLVE  
KNOWN OR SUSPECTED ACBM AND WILL BE  
DONE IN ACCORDANCE WITH INDUSTRIAL  
CODE RULE #56"**

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<b>ARCHITECT/ENGINEER</b>	<b>OWNER</b>	<b>CONSTRUCTION MANAGER</b>
<b>CPL</b>	<b>NEWBURGH ENLARGED CITY SCHOOL DISTRICT</b>	<b>THE PALOMBO GROUP INC.</b>
<b>50 FRONT STREET, SUITE 202</b>	<b>124 GRAND STREET</b>	<b>195 FRONT STREET, FIRST FLOOR</b>
<b>NEWBURGH, NY 12550</b>	<b>NEWBURGH, NY 12550</b>	<b>NEWBURGH, NY 12550</b>
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**SECTION 192000  
THEATRICAL LIGHTING SYSTEMS****PART 1 GENERAL****1.1 PROJECT INFORMATION:**

- A. Owner: Newburgh Enlarged City School District  
400 Old Forge Hill Road  
New Windsor, NY 12553
- B. Architect: CPL  
Architecture Engineering Planning  
50 Front Street, Suite 102  
Newburgh, NY 12250
- C. Consultant: AVL Designs, Incorporated  
1788 Penfield Road, Suite 1  
Penfield, New York 14526  
Phone (585) 586-1100
- D. Contractor: The successful bidder for the work described herein. Also referred to as the contractor, the lighting contractor, the lighting installer or the bidder.
- E. Others: Various companies doing construction work under the general contract.

**1.2 PROFESSIONAL STANDARDS:**

- A. The contractor is expected to install all work to the appropriate industry professional standards, manufacturer recommendations, and current applicable codes. If any work required exceeds the skills of the contractor, they will employ appropriate subcontractors for the scope required.
- B. The acceptability of materials and workmanship will be determined by the Architect, Consultant, and CM.
- C. Any work that might be damaged, be inadvertently painted, or become dirty during construction will be protected by the contractor. All responsibility for protection shall be by the contractor. The contractor will provide final cleaning and or repair of all equipment in their scope to like new condition.
- D. The contractor will attend and/or arrange meetings as required to make sure their scope is coordinated with all other trades. The contractor is responsible to make known to all other trades critically dimensioned items and locations to avoid conflicts. Where conflicts occur follow required procedures in the project manual to seek resolution.
- E. Where any substandard work is provided by related trades that impedes the work of the contractor, they will notify the CM, Consultant, Architect, or Engineer in writing as called for one the project manual to rectify the issue.
- F. Where work is provided by others the contractor is responsible to verify installation conditions that relate to their work. If installation of related work is substandard the contractor shall generate a written RFI through proper channels based upon the project manual. The contractor shall not install their work to any substandard devices, etc. provided by others until such work has been resolved or until the contractor has received written authorization from the construction manager to proceed. If the contractor ignores substandard installation work by others and proceeds to install his devices to these items, then he accepts and bears sole responsibility to repair, reinstall and correct any found deficiencies to the satisfaction of the owner upon final inspections.
- G. The contractor will comply with the AHJ (Authority Having Jurisdiction) as it relates to programming any and all emergency interfaces.
- H. The contractor is expected to possess knowledge of the equipment of their industry and to provide all small items required to install the specified equipment. Provide small items such as

rack rails, DIN rails, rack panels, power cords, connectors, wall-wart power supplies, crimps, Nicopress and other items that may not be called out on drawings or in specs but are required to support primary equipment.

- I. When in doubt about any aspect of the work the contractor should not proceed until they obtain clarification from the appropriate entity following procedures detailed in the project manual.

### 1.3 DEFINITIONS:

Code Requirements	Minimum requirements as specified by all applicable and published codes.
Concealed	Work installed in pipe and duct shafts, chases or recesses, inside walls, above ceilings, in slabs or below grade.
Equal or Equivalent	Equally acceptable as determined by Owner's Representative.
Extend	To increase the length(s) of any indicated conduit/wiring so as to reach a particular specified or implied point – including the provision of any misc. additional equipment as required for proper extension and to maintain full system functionality.
Final Acceptance	Owner acceptance of the project from Contractor upon certification by Owner's Representative.
Furnish	Supply and deliver to installation location to the appropriate trade responsible for installation.
Furnished by Others	Receive delivery at job site or where called for and install.
Inspection	Visual observations by Owner's site Representative
Install	Mount and connect equipment and associated items and make ready for use.
Labeled	Refers to classification by a standards agency.
Or Approved Equal	Approved equal or equivalent as determined by Owner's Representative.
Owner's Representative	The Prime Professional, Construction Management or Clerk of the Works.



Patching	Repair of holes, marks, and damage left from removals. Consult project manual for requirements.
Provide	Furnish, install and connect ready for use.
Relocate	Disassemble, disconnect, and transport equipment to new locations, then clean, test, and install ready for use.
Replace	Remove and provide new item.
Remove	Safely Disconnect including any and all wiring, hardware, conduit (except concealed), anchors, suspension hardware etc. Legally dispose of items not called out to be offered to or returned to owner.
Review	A general contractual conformance check of specified products.
Satisfactory	As specified in contract documents.

Refer to General Conditions of the Contract for additional definitions.

#### 1.4 INTENT OF DRAWINGS:

- A. Throughout the contract documents there are various manufacturers and products referenced. It is understood that these products establish a basis of design that all other "or equal" substitutions must meet or exceed. All submitted devices must be the referenced product or approved equal.
- B. The drawings in this package are diagrammatic in nature, unless detailed dimensioned drawings are included. The drawings show the approximate locations of equipment and devices. The final and exact locations of all non-dimensioned devices are subject to the approval of the Owner or the Owner's Representative. Devices with detailed installation dimensions; however, are critically located and must be installed to those indicated dimensions unless alternate instructions have been given to the contractor in writing by the consultant.
- C. The contractor(s) shall inspect the entire building(s) with the Owner's representative prior to beginning any work and shall identify the exact locations and installation methods for all devices, conduit and wiring prior to beginning work.
- D. Typical details are shown for the installation of various devices. The details do not apply to all situations. Installation methods for all work shall be subject to the Owner's and construction manager's approval. Provide all work and equipment required for a professional, workman-like installation.

#### 1.5 SECTION INCLUDES BUT IS NOT LIMITED TO:

- A. Removals – May include storage and reinstallation of some items.
- B. Provision of Theatrical lighting system and related work scope as indicated on drawings including controls for lighting fixtures.
- C. Furnishing some equipment for install by others.

- D. Wiring, setup, focus and commissioning.
- E. Training and closeout documents.

#### **1.6 RELATED SECTIONS & DOCUMENTS:**

- A. The contractor(s) shall examine the full set of construction drawings and specifications and ascertain all aspects of the scope of work described within this specification. The contractor will be responsible for cooperation with and adherence to the overall scope and intent of the project relative to the work being done by the contractor.
- B. Drawings and general provisions of the Contract including General and Supplementary Conditions and Division 0, 1 and 26 specification sections apply to work of this section (related specification sections may vary depending upon the particular CSI format being adhered to). All related drawings, contract conditions and general requirements found in the project manual that apply to the general contract will apply to the work described in this specification. Examine all referenced documents for general project requirements relating to the work in this specification. Contact the architects, engineers and/or construction manager for any clarification required to properly bid this project. It is the contractor's responsibility to obtain necessary clarification before bidding. No change orders will be allowed for existing project conditions and contractor requirements not properly investigated by the contractor.

#### **1.7 RELATED WORK NOT INCLUDED:**

- A. The contractor is responsible for all work on the TL series drawings and written specifications.

#### **1.8 GENERAL REQUIREMENTS:**

- A. Removals - Offer all existing portable and removed equipment to the owner prior to legally disposing of these items. Obtain written permission from the owner for all existing removed items that they do not desire to retain prior to disposal.
- B. Provide all equipment outlined and described within this specification and assemble it into a complete, properly functioning system for use by the owner as described within this specification.
- C. It is the contractor's responsibility to clarify any misunderstandings or drawing-to-drawing/drawing-to-spec discrepancies prior to bid. In cases of a difference between stated quantities in drawings, specs or electrical drawings, the higher quantity will prevail.
- D. Check each component before installation as well as each portion of the project during installation to ensure that the intent of this specification is achieved.

#### **1.9 BIDDER QUALIFICATIONS – SUBMITTALS:**

- A. The bidder shall provide references of at least three (3) installations of comparable scope performed by the bidder, including location, system description, and name, address, and telephone number of the architects, consultants, and owners and the names of contract persons for each.
- B. The bidder must maintain service facilities and have service available on site within 24 hours. The bidder must be a factory authorized dealer for all products submitted and may be required to submit such proof of factory authorization in writing, or in the form of copies of authorized agreements with the various vendors.
- C. The bidder and all persons performing theatrical lighting system related work on this project must be certified (those performing low voltage terminations, system commissioning, programming, fixture focus/hang, DMX/RDM/Network addressing and other related areas). This will require the installer to either be a current ETCP (Entertainment Technician Certification Program) certified entertainment electrician or an equivalent factory trained and certified installer (from the equipment supplier) or a crew working under the direct supervision of a certified foreman (of either certification described above). This applies to all theatrical lighting equipment installation and any other assemblies indicated as being provided or installed by the contractor. Proof of current certification MUST be provided in the submittals package (this is

typically in the form of a pdf copy of the current and active certification certificates from PLASA). Out of date or expired certifications shall not be recognized as meeting the requirements of ETCP certification.

#### **1.10 INQUIRIES AND COMMUNICATIONS:**

- A. All questions should be posed in writing as called for in the project manual.
- B. Direct communications to the consultant via phone are recommended for initial discussion about intent or site issues. (unless prohibited in the project manual). No action may be taken based on verbal communications, they must be followed up in writing as called for in the project manual.
- C. Where discrepancies occur, and pre-bid instructions have not been obtained by written request, the contractor will abide by the owner's decision at no additional cost to the owner.

#### **1.11 COORDINATION:**

- A. Cooperate with other trades to achieve well-coordinated progress at all times. Notify the owner and consultant as often as necessary with regards to job progress or changes in the installation schedule. No change orders for additional payment will be allowed based upon conflicts with other trades on the project site. All such conflicts will be reported to the architect, construction manager, owner, and consultant in writing. All reasonable attempts will be made to correct any difficulties.
- B. Staff the job site adequately at all times to maintain a progress in keeping with the total project progress. No allowances will be made for overtime required to maintain job progress.
- C. Provide all materials to be installed by others in a timely fashion based upon the related trades' schedules.
- D. The job site will be left in a clean safe condition at the end of any workday. All cleanup and debris removal to a site designated by the owner will be the responsibility of the bidder on a daily basis.
- E. All storage of tools and materials will be done by the contractor. No on-site storage security will be provided by the owner.
- F. The contractor will attend regular meetings with the architect, owner, general contractor, and the consultant when requested by any of the above, in order to achieve project coordination and progress.
- G. The contractor shall be required to share all approved lighting system shop drawings with the EC prior to rough-in. He shall work closely with the electrician in determining final control wiring types, quantities and requirements, related device locations, backbox sizes, conduit routings, etc. before the EC has purchased his supplies and in order to meet the construction schedule.

#### **1.12 DELIVERIES:**

- A. It is each contractor's responsibility to receive all device shipments, equipment, deliveries, etc. for their own equipment on/at the job site personally. Each contractor shall be responsible to arrange for storage of all received materials on site until the appropriate time when they shall either turn them over to installing contractor or install them.
- B. If the contractor chooses to allow a third party to receive shipments on his behalf the contractor bears sole responsibility for any missing and/or damaged parts.
- C. Any equipment that is furnished by the contractor for installation by others shall be turned over to the installing contractor at a time that fits into their production schedule and the project's overall construction schedule.

#### **1.13 STANDARDS REFERENCES:**

- A. The contractor is responsible for the provision of material and methods installation of equipment conforming to the currently applicable standards of:
  - 1. ADA - Americans with Disabilities Act

2. AISC - American Institute of Steel Construction
  3. AISI - American Iron and Steel Institute
  4. ANSI - American National Standards Institute
  5. ASME - American Society of Mechanical Engineers
  6. ASTM - American Society for Testing Materials
  7. AWS - American Welding Society
  8. EIA - Electronic Industries Association
  9. ESTA - Entertainment Services and Technology Association
  10. FCC - Federal Communications Commission
  11. IEC - International Electronics Commission
  12. IEEE - Institute of Electrical and Electronics Engineers
  13. IFI - Industrial Fasteners Institute
  14. ISO - International Organization for Standardization
  15. NACM - National Association of Chain Manufacturers
  16. NEC - The National Electric Code
  17. NEMA - National Electrical Manufacturers Association
  18. NFPA - National Fire Protection Association
  19. OSHA - Occupational Safety and Health Association
  20. SAE - Society of Automotive Engineers
  21. SMPTE - Society of Motion Picture and Television Engineers
  22. TIA - Telecommunications Industry Association
  23. UL - Underwriters Laboratories (Electrical components, devices and accessories shall bear a UL label where applicable. UL listed and labeled as defined by NFPA70, article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.)
  24. USITT - United States Institute for Theater Technology "Recommended Guidelines for stage rigging and stage machinery-specifications and practices".
- B. Provide certification and labels where applicable. Comply with federal, state and local regulations and applicable union regulations where required. Provide all equipment with proper labels for sale and use within New York State.
  - C. Provide only equipment that is standard, new equipment, the latest model of regular stock product and is supplied with all parts regularly used with the equipment offered for the purpose intended. The contractor guarantees that no modification of the equipment has been made contrary to the manufacturer's regular practice.
  - D. Review all materials and equipment prior to installation and notify owner as to any changes or discrepancies between published specifications and the actual material and equipment to be installed, including discontinued product updates, etc.

#### 1.14 EQUIVALENTS:

- A. The successful bidder shall submit any product equivalents prior to award of the contract. When requested, the successful bidder shall also submit information, describing in specific detail, how the equivalent bid material differs from the appearance, quality and performance required by the base specification. Submittal of the manufacturer's advertising cut sheets alone is not acceptable for proof of equivalency.
- B. Proof of equivalency may require the bidder to provide physical samples, a full-sized mockup or specific manufacturer information detailing technical equivalency. Proof of equivalency shall be the burden of the submitting contractor/bidder and not that of the consultant. Proof of equivalency relates to all pertinent functions of the specified equipment, regardless of if that information is reflected on any manufacturer's issued cut sheets.
- C. If proposing equivalents that affect the system design as shown on the drawings, the bidder must submit flow charts, and any other drawings necessary to show differences in the system operation from the primary referenced system.

- D. The bidder will pay for any and all changes to related work scope required by the equivalent products.
  - 1. This includes electrical, architectural, structural and other changes that might be needed to implement an equivalent product.
    - a. Some products with virtual identical functions have varying power requirements, physical dimensions, etc.
- E. The risk of whether bid equivalents will be accepted is borne by the contractor. See section 2.1 "Performance Requirements" for more information.
- F. No equivalents will be considered after the Contract award unless specifically provided in the Contract Documents.
- G. Final judgment as to equality will be solely that of the consultant, architect, construction manager and owner.
- H. The costs for any changes by other trades required to implement the equivalents proposed will be borne by the contractor.

#### 1.15 SUBMITTALS:

- A. Equipment: After bid award but before ordering any equipment or starting any work submit to the owner for approval a list of all equipment to be furnished showing types, models, quantities and manufacturer. Attach catalog sheets for all items submitted.
- B. The quantity and form (paper and/or electronic copies) of all submittal material required shall be provided by the contractor to the appropriate parties as is indicated in the contract front end documents (in addition to any requirements listed below). If there are no indications in the contract front-end documents, then the contractor shall submit (1) electronic copy of each area, category, etc. of items as listed below. All submissions are understood to be intended for approval by the construction manager, the architect, owner, general contractor and the consultant prior to any fabrication or installation of any devices.
- C. Submit a schedule for submission of drawings for fabrication and site work.
- D. Submit a complete submission package with all required paperwork.
- E. Submit each of the following as each pertains to this project. Provide a copy for each related person performing indicated work who holds these certifications:
  - 1. Current training certifications.
  - 2. Current ETCP certification.
  - 3. Current manufacturer certifications.
- F. Submit material schedules and shop drawings for approval by the architect, consultant and owner prior to any fabrication or installation as follows:
  - 1. The full set of submitted drawings and data sheets must be presented in a professional manner.
  - 2. All drawings for submission must be CADD drawn (created with a computer aided drafting program). Hand drawings are not allowed. Illegible drawings shall not be acceptable.
  - 3. All cut sheets for submission must be high-resolution electronic (pdf) copies of the manufacturer's actual data sheets. Mark up each sheet with highlights or boxes around submitted products, options, etc. No data sheets shall be acceptable that are illegible, poorly photocopied or hand marked up with scribbles, etc.
  - 4. Drawings of proposed mounting methods for all equipment.
  - 5. Samples of proposed marking systems for wire and equipment labeling.
  - 6. Rack layouts, panel layouts and proposed labeling.
  - 7. Schedule for submission of drawings for fabrication and site work.
- G. Quality Assurance

1. The Basis of design for the dimming, relay and control systems equipment as well as most of the theatrical fixtures shall be manufactured by Electronic Theater Controls, Inc., 3030 Laura Lane, Middleton, Wisconsin. The equipment is described in complete technical data available from the manufacturer.
2. Fabrication shall begin only after approved drawings and a written notice to proceed have been delivered to the manufacturer at the manufacturer's place of business.
3. A qualified engineering representative employed by the manufacturer shall visit the job site after installation is complete and prior to the energization of the system to inspect, test and adjust the system.
4. This representative shall terminate & connect all control wiring, verify all load and line wiring, and energize the system. The factory representative will also program architectural control presets.

#### **1.16 GENERAL SYSTEM DESCRIPTION:**

- A. Theatrical Lighting System:
  1. Architectural Lighting Controls
  2. Performance Lighting consoles
  3. Integrally dimmed LED lighting
  4. Hang and focus of luminaires
  5. Integration of house/work/accent lighting into overall system architecture
  6. Commissioning, Training and closeout documentation

## **PART 2 PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS:**

- A. The requirements of the referenced equipment are not generic in nature. Specific performance, control and routing capabilities are necessary for any alternate or substituted equipment. The details set forth herein and within the functional descriptions of each system are the critical criteria for the selection of each piece of equipment.
- B. In bidding equipment from manufacturers other than those referenced be aware that all functional information included in this specification as well as the manufacturer's specifications, physical size, serviceability, acoustic output, warranty terms, product availability and other non-technical issues may be determining factors in product equivalency. Final judgment as to equality will be solely that of the owner, architect and consultant.
- C. If the contractor substitutes a piece of equipment that does not meet with all of the critical device functionality of the specified equipment (functionality and feature set as detailed below, inherent in the specified equipment, available as provided option and/or required based upon the intents of the contract documents), then he will have to replace all substandard equipment or substituted equipment that does not meet, match or exceed the specified equipment with either the specified equipment or an alternate piece(s) of equipment that meets/exceeds the specified equipment's feature set and shall provide all reprogramming, installation, conduit, wire, etc. as is required.
- D. All lighting must meet these minimum requirements:
  1. Minimum Foot Candle Requirements: See Section S804 of the New York State Education Department's Manual of Planning Standards – 2014 Draft. Reference Table S804-1.
  2. All luminaires must meet or exceed the minimum initial NEMA LE5 Target Efficacy Rating (TER). See Section S804 of the New York State Education Department's Manual of Planning Standards – 2014 Draft. Reference Tables S804-2 & S804-3.
  3. All LED fixtures shall feature power factor correction (PFC) in their circuitry and/or meet a minimum power factor (PF) of .9. Active PFC is preferred, although passive PFC is acceptable, if the fixtures meet the minimum PF.
- E. Equivalents Criteria:

1. Lighting control system device substitutions require proof that the substituted product meets all performance requirements including but not limited to:
  - a. Product warranty period
  - b. Physical device size
  - c. Device installation options (rack mount, DIN rail mount, etc.)
  - d. Physical quantity of inputs, outputs, sourcing & sinking
  - e. Output modes (0-10V, 0-15V, 0-2.5V, 0-5V, etc.)
  - f. Current rating per channel
  - g. RDM discoverability and remote manipulation capabilities
  - h. Selectable starting addresses
  - i. Signal isolation and fault protection limits
  - j. Voltage step selections (.05V, .1V, etc.)
  - k. Quantity of DMX universe control
  - l. Protocol conversion and compatibility with alternate control schemes (sACN, DMX, RDM, 0-10V, DALI, etc.)
  - m. Display, programming buttons & configuration limitations
  - n. Panic controls interface
2. Lighting control console substitutions require proof that the substituted product meets all performance requirements including but not limited to:
  - a. Product warranty period and advanced replacements policies
  - b. Physical console size
  - c. Console fader wing attachment locations and options as well as how these devices interconnect with the console and the monitor mounts, clearances in low-profile rolltop units, ability to configure as the specified system, etc.
  - d. Quantity of individual faders
  - e. Moving light knobs/wheels
  - f. Remote focus unit device interface without the need for remote or multiple wireless access points, etc.
  - g. Ability to output to an external monitor
  - h. Quantity and type of physical external monitor outputs
  - i. Ability to interface with touch screen monitors
  - j. Control channel count capacity
  - k. DMX universe count control capacity
  - l. Built in touch screen control
  - m. Drag and drop features on console touchscreen
3. Architectural control system substitutions require proof that the substituted product meets all performance requirements including but not limited to:
  - a. Product warranty period
  - b. Physical device size
  - c. Required device backbox sizes
  - d. Architectural control system topology
  - e. Preset recall by button stations and LCD displays.
  - f. LCD display size, color & programming options
  - g. LED indicator light on individual control station devices
  - h. Form factor
  - i. No required, additional or "buried" accessories or devices in order to obtain system performance requirements.
  - j. No spare wire requirements
  - k. Ability for each pushbutton station button to trigger the unique preset desired and not simply manufacturer determined or hardware/software restrictive preset order recalls.
  - l. Ability for architectural control system to read console snapshots and recall them via presets.

- m. No "room" restrictions in system topology or functionality.
- n. Proximity detector on LCD stations
- o. For all 0-10V, DMX, network or RDM devices the equipment provided must meet or exceed all programmatic, voltage options, etc. of the specified equipment.
- 4. LED fixture substitutions require proof that the substituted product meets all performance requirements including but not limited to:
  - a. Product warranty period and advanced replacements policies
  - b. Physical LED strip size, flexibility & durability
  - c. PF (power factor)
  - d. Light output pattern
  - e. Efficacy (lumens per watt)
  - f. CRI
  - g. PWM frequency adjustability (to high rates)
  - h. Light output intensity in FC distribution
  - i. Form factor
  - j. Wattage of LED's
  - k. Expected and average LED & related drive electronics lifespan
  - l. Total length of runs powered by a single, dimmable LED driver/power supply shall meet or exceed specified products.
  - m. LED driver/power supply(ies) and their ability to dim the LED's smoothly and down to 1% is critical.
  - n. Ability of LED fixtures/strips to fit in intended locations and with all physical limitations of surrounding structure.
  - o. Binning tolerances & LED quality control must match or exceed specified product.
  - p. LED drivers, interfaces, mounting options, etc. shall meet or exceed specified product.
  - q. No rope lighting or similar products (not even LED rope lighting) shall be considered as an equal to the specified LED strip lighting products nor shall any rope lighting equivalents be approved.
  - r. Lumen outputs at deep colors
  - s. Visual representation of white light output of fixture - color temperature variants
  - t. Power draw requirements.
  - u. Beam spread characteristics
  - v. Fixture power supplies must have inherent brown-out protection built in, such as a switching power supply, that shall be self-resettable, not fuse driven and shall not require human interaction in order to operate.
  - w. Color mixing capabilities without excessive rainbowing effects at beam edges
  - x. Fixture lens options
  - y. Total numbering and visual quality of distinct renderable colors
  - z. Critical accessories and mounting options.
  - aa. Cooling requirements – convection cooled vs. fan cooled and including fan noise, tonality of fans, etc.
- 5. Wire substitutions require proof that the substituted product meets all performance requirements including but not limited to:
  - a. Jacket Type
  - b. Number of Conductors
  - c. Jacket Shape – i.e. round, twisted, etc.
  - d. Number of strands and gauge
  - e. Flexibility
  - f. Overall physical size of wire
  - g. Capacitance and resistance conductor-to-conductor as well as single conductor.



- F. No contractor-manufactured products shall be acceptable in place of referenced items except for those items enumerated in this specification as "custom."
- G. The current manufacturer's data sheet, user's manual and actual technical specifications/capabilities/feature set for each referenced piece of equipment in force at the date of printing of this specification shall be the basis for the specifications of the referenced equipment.
- H. Any necessary product accessories such as additional duplex power outlets, power supplies, rack mount kits, connectors, adapters or other small items are the responsibility of the contractor to provide, whether or not they are called out in detail within these specifications. This may include additional electrical work, depending upon the differences between substituted and specified equipment and shall be the sole responsibility of the contractor to provide at no additional cost to the owner.
- I. Specification details are provided only for the features required for current and intended future uses of the products.
- J. Quantities:
  - 1. Where no quantity is indicated in the written specifications, the contractor shall supply quantities as indicated on drawings.
  - 2. Items not indicated on drawings but necessary for project completion shall be provided as required for project execution at no additional cost.

## **2.2 THEATRICAL LIGHTING CONSOLE: REFERENCED PRODUCT ETC COLORSOURCE 20/40**

- A. General
  - 1. The lighting control console shall be a microprocessor-based system specifically designed to provide complete control of stage, studio, and entertainment lighting systems. The console shall be the ColorSource 20 or ColorSource 40 as manufactured by Electronic Theatre Controls, Inc., or equal.
  - 2. The system shall provide control of 512 DMX512A addresses on a maximum of forty (40) or eighty (80) control channels. Any or all of the DMX512A outputs may be controlled by a channel.
  - 3. A maximum of 999 cues may be contained in non-volatile electronic memory.
  - 4. Twenty (20) or forty (40) faders shall provide access to individual intensity channels, intensity for devices as well as playbacks.
  - 5. Four (4) configurable faders shall provide functionality for output of bump buttons, cue list control or crossfade control.
  - 6. The console shall have one (1) built-in 7" color multi-touch touchscreen. The touchscreen shall provide the primary interface for system configuration, programming show data and multi-parameter control.
  - 7. Six (6) softkey buttons shall be provided, five of which may be configured by the user.
  - 8. Console shall be equipped with an on-board help system, with on-board tutorial videos.
  - 9. Console shall not require the use of an external monitor for normal use.
  - 10. Console software upgrades shall be made by the user via USB drive. Changing internal components shall not be required.
  - 11. The console shall provide a USB port allowing show data to be saved for archival or transfer to other consoles or a personal computer.
  - 12. Systems that do not provide the above capabilities shall not be acceptable.
- B. Controls and Playback
  - 1. Patching
    - a. The console shall provide patching facilities for dimmers and multi-parameter devices via a built in library of fixture definitions. The fixture library shall be updated via software based updates. It shall be possible to create custom fixture definitions using an offline application.

- b. The console shall support patching, address setting, and mode changes using Remote Device Management (RDM) on the local DMX/RDM port.
  - 2. Channel or Playback Faders
    - a. Twenty (20) or forty (40) proportional, fully overlapping faders shall be provided with 45mm potentiometers and bump buttons.
    - b. The faders shall provide direct manual control of intensity for all channels. Channel levels can be changed at any time by using the individual channel faders or through the use of the touch screen interface.
      - 1) Faders shall also control up to ten (10) pages of twenty (20) (or forty (40)) recordable memories or sequences. Memories shall record user-selected channel levels. Sequences shall record user-selected memories or channel levels.
        - i) With color mixing systems, output of color from fixtures shall appear to be a combination of the active memories in a color space.
  - 3. Programming Tools
  - 4. The console shall provide a 7" color multi-touch touchscreen with six (6) softkeys, as well as touch-based controls. The LCD shall provide system configuration, programming show data and multi-parameter control.
  - 5. Touch-based tools shall include:
    - a. Forty (40) programmable color chips and color picker.
    - b. Touch-based parameter controls.
    - c. Virtual Level/Rate wheel.
    - d. Virtual keypad for level entry.
    - e. Customizable channel display using Stage Map. It shall be possible to rearrange the graphical representations for control channels to closely mimic the positions of fixtures in the venue.
    - f. Effects (intensity, color, shape, and parameter)
      - 1) It shall be possible to assign multiple effects to the same channel and parameters. The playback of those effects shall play levels back relative to the combination of the two effects.
    - g. Fixture selection shall be made via:
      - 1) Auto fixture selection on fader moves.
      - 2) Pressing the selection button under channel faders.
      - 3) Touching the channel icon in the stage map display on the touch screen.
      - 4) Fixture Tags for Quick Selects
        - i) Selection of multiple fixture shall be possible through a special controls dock that groups channels together based on the channel tile positions within a pre-defined area in the topographical view for channels.
        - ii) Selection shall be possible through the use of informational tags. Selecting a predefined tag selects all fixtures sharing that same tag. At least two tags may be assigned to any one channel.
        - iii) There shall be at least 27 Quick Select groupings.
    - h. Two independent channels shall be provided with on/off functionality. Independents shall be patched in a location separate from patch.
  - 6. Playback Controls
    - a. A cue list of up to 999 cues shall be provided. Cues may be made up of channel levels and parameter settings or contain a reference to a recorded memory. Cues shall be editable and shall be able to be individually deleted and inserted.
    - b. Playback Toy for filtered and timed execution of playbacks.
    - c. Multiple bump modes (Flash, Solo, SoloChange, Move/GO).
    - d. Full history rubberbanding for playbacks.
- C. Interface Options
  - 1. The console shall provide connectors for the following:

- a. 12V AC or DC input for external power supply
- b. DMX512-A/RDM output (one (1) 5-pin XLR connector)
- c. USB connection (one (1) type A connector)
- D. Physical
  - 1. All operator controls and console electronics shall be housed in a single desktop console.
  - 2. Size and weight:
    - a. Twenty (20) fader console shall be equal to or less than 18.31" (465mm) wide 11" (279mm) deep 2.36" (60mm) high (including controls), and 6.9 lbs. (3.13 kg.)
    - b. Forty (40) fader console shall be equal to or less than 26.31" (668mm) wide 11" (279mm) deep 2.36" (60mm) high (including controls) and 9.55 lbs. (4.33kg).
  - 3. Twenty (20) fader console shall be able to be mounted into a 19" equipment rack with the use of additional mounting hardware.
  - 4. Console power shall be 12V AC or DC via an external power unit. The power unit shall operate with 90-265VAC line voltage, 50 or 60Hz. Console is provided with a universal power supply.

### **2.3 LIGHTING CONSOLE WIDESCREEN LCD DISPLAY: REFERENCED PRODUCT NEC MULTISYNC EA 222WME SERIES**

- A. Display:
  - 1. Viewable Image Size 22"
  - 2. Pixel Pitch 0.282mm
  - 3. Pixels Per Inch 90 @ native resolution
  - 4. Brightness (typical) 250 cd/m<sup>2</sup>
  - 5. Contrast Ratio (typical) 1000:1
  - 6. Viewing Angle (typical) 160° Vert., 170° Hor. (75U/85D/88L/88R) (CR>10)
  - 7. Response Time (typical) Rapid Response (5ms)
  - 8. Display Colors More than 16.7million
- B. Synchronization Range:
  - 1. Horizontal 31.5-82.3KHz (Analog/ Digital)
  - 2. Vertical 56-75Hz (Analog/Digital)
- C. Input Signal:
  - 1. Video Analog 0.7 Vp-p / 75 Ohms
  - 2. Sync Separate Sync: TTL Level (positive/negative)
- D. Inputs - DVI-D, VGA 15-pin D-Sub and DisplayPort
- E. Resolutions Supported - Analog/Digital:
  - 1. 720 x 400 @ 70 Hz
  - 2. 640 x 480 @ 60-75 Hz
  - 3. 800 x 600 @ 56-75 Hz
  - 4. 832 x 624 @ 75 Hz
  - 5. 1024 x 768 @ 60-75 Hz
  - 6. 1152 x 864 @ 70-75 Hz
  - 7. 1152 x 870 @ 75 Hz
  - 8. 1280 x 960 @ 60-75 Hz
  - 9. 1280 x 1024 @ 60-75 Hz
  - 10. 1360 x 768 @ 60 Hz
  - 11. 1440 x 900 @ 60-75 Hz
  - 12. 1440 x 1050 @ 60-70 Hz
  - 13. 1680 x 1050 @ 60 Hz
- F. Native Resolution - 1680 x 1050 @ 60 Hz
- G. Additional Features:

1. Auto brightness (ambient sensor)
  2. Thin frame (bezel)
  3. Widescreen format
  4. Integrated speakers
  5. Integrated 4-port USB 2.0 hub
  6. Monitor adjustments - Height-adjustable stand (110mm), pivot, tilt, swivel, no-touch auto adjust
  7. Cable management
  8. AccuColor color control
  9. Digital smoothing
  10. Digital controls
  11. DDC/CI, NaViSet software - Plug and Play (VESA DDC 1/2B)
  12. VESA DPMS power management
  13. OSD user controls
  14. ISO 13406-2 Class II, ECMA-370, Windows 7-certified
  15. Dynamic Video Mode, HDCP, ECO Mode
  16. Resettable carbon meter
  17. Resettable cost meter
  18. HDMI-capable via DVI adapter
  19. EPEAT Gold & Silver compliance, Energy Star 5.0, lead-free, RoHS-compliant, TCO 5.1 compliant
  20. Carrying handle
  21. Headphone jack
  22. 3-year warranty
- H. Voltage Rating - AC 100-120V / AC 220-240V
- I. Power Consumption (typical):
1. On (w/ USB + audio) - 23W
  2. Power Savings Mode <1W
  3. ECO Mode ON:
    - a. With USB & Audio - 17W
    - b. Without USB & Audio - 13W
- J. Dimensions (W x H x D):
1. Net (with stand) 20 x 15-19.4 x 8.7 in. / 507.8 x 382 - 492 x 220mm
  2. Net (without stand) 20 x 13.1 x 2.8 in. / 507.8 x 332.1 x 71.8mm
- K. Weight:
1. Net (with stand) - 15.4 lbs. / 7 kg
  2. Net (without stand) - 9.9 lbs. / 4.5 kg
- L. VESA Hole Configuration Specifications - 100 x 100mm
- M. Environmental Conditions:
1. Operating Temperature - 5-35°C / 41-95°F
  2. Operating Humidity - 20-80%
  3. Operating Altitude - 2000m / 6562 ft.
  4. Storage Temperature -10 - 60°C / 14-140°F
  5. Storage Humidity - 10-85%
  6. Storage Altitude - 12,192m / 40,000 ft.
- N. Limited Warranty - 3 years parts and labor, including backlight.
- 2.4 ARCHITECTURAL CONTROL SYSTEM RACK ENCLOSURE: REFERENCED PRODUCT ETC UNISON ERN SERIES CONTROL ENCLOSURES**
- A. Control Enclosures

1. The control Enclosure shall be the Unison ERn Series Control Enclosure as manufactured by Electronic Theatre Controls, Inc., or equal.
- B. Mechanical
  1. The ERn Control Enclosure shall be a surface mounted panel constructed of 18 gauge formed steel panels with a hinged, lockable full-height door containing an integral electrostatic air filter.
    - a. The Enclosure door shall have an opening to allow limited access to the control module face panel.
    - b. Enclosures shall be convection cooled without the use of fans.
  2. Control Enclosures shall be sized to accept one or two Control Processors and one or two Station Power Modules, including various options and accessories.
    - a. The two-space Control Enclosure (ERn2) shall support a single Station Power Supply module
    - b. The four-space Control Enclosure (ERn4) shall support two Control Processors, and two Station Power Supply modules, or, one Control Processor, one Station Power Supply Module and one Station Bus Repeaters module, or one control processor and one dual Station Bus Dual Repeater module.
  3. All Enclosure components shall be properly treated and finished.
    - a. Exterior surfaces shall be finished in fine textured, scratch resistant, powder-based epoxy paint.
  4. Enclosure(s) shall also be available in a 19" rack mounted (RM) version.
    - a. Rack-mounted version shall have an independent Enclosure suspension kit, with a full height, locking door/cover attached to the kit.
    - b. Rack-mounted version shall have an opening to access the control module face panel, and openings to view indicators on option modules.
  5. Enclosure dimensions and weights (without modules) shall not exceed:
    - a. ERn2 - 15" W x 9" H, 10" D, 15 lb.
    - b. ERn2-RM - 19" W 11"H 10" D, 20 lb.
    - c. ERn4 - 15" W x 14" H x 10" D, 20 lb.
    - d. ERn4-RM - 19" W x 16" H x 10" D, 25 lb.
  6. Top, bottom, and side knockouts shall facilitate conduit entry.
  7. Enclosures shall be designed to allow easy insertion and removal of all control and option modules without the use of tools.
    - a. Supports shall be provided for precise alignment of modules into power and signal connector blocks.
    - b. With modules removed, Enclosures shall provide clear front access to all power and control wire terminations.
  8. Option Modules
    - a. Ethernet Switch (ENET - Surface Mount ERn only)
      - 1) The Control Enclosure shall support an optional 5-port Ethernet Switch, with at least 4 ports supplying Power over Ethernet (PoE).
      - 2) The Ethernet Switch module shall be 10/100BaseTX, auto MDI/MDIX, 802.3af PSE compliant.
      - 3) The Ethernet Switch module shall contain power, status, and activity indicators. All indicators shall be visible when the Enclosure door is open for wall mounted ERn.
    - b. Redundant Power Supply (RRPS)
      - 1) The Control Enclosure shall support an optional redundant power supply which shall automatically provide power to the control electronics upon failure or removal of the primary power supply.
      - 2) The redundant power supply shall assert itself seamlessly without a loss of power to the control electronics.

- 3) The redundant power supply shall seamlessly remove itself when the primary power supply is reengaged.
      - 4) The redundant power supply shall provide visible indication that it is active.
    - c. Station Bus Repeaters (ERn4 only)
      - 1) The Control Enclosure shall support an optional module to expand the station bus length an additional 400 meters, and the station count an additional 30 stations (62 maximum per processor/Enclosure)
      - 2) Wall-mount and 19" Rack-Mount versions of the Station Bus Repeaters shall also be available to support mid-span insertion away from the Control Enclosure.
    - d. Station Bus Dual Repeaters (ERn4 only)
      - 1) The Control Enclosure shall support an optional module to expand the station bus length to two additional 400-meter segments (a total of 1200 meters from a single Enclosure, and the station count to 62 stations (62 maximum per processor/Enclosure).
      - 2) Wall-mount and 19" Rack-Mount versions of the Station Bus Dual Repeaters shall also be available to support mid-span insertion away from the Control Enclosure.
  - 9. Provide the following accessories
    - a. RideThru Option (RTO)
      - 1) The Control Enclosure shall support an optional, short-term back-up power source for the control electronics installed inside the Enclosure.
      - 2) RideThru Option (RTO) provides power for control electronics during brief power outages or dropouts.
      - 3) The short-term back-up power source shall automatically engage upon the loss of normal power, seamlessly transitioning the supply power for the control electronics power to itself.
      - 4) The short-term back-up power supply shall detect the return of normal power, and seamlessly return the control electronics to normal power.
      - 5) The short-term back-up power source shall support the control electronics for at least 10 seconds.
    - b. BatteryPack Option (BPO – Surface Mount ERn Only)
      - 1) The Control Enclosure shall support an optional, long-term back-up power source for the control electronics installed outside the Enclosure.
      - 2) The long-term back-up power source shall automatically engage upon the loss of normal power, seamlessly transitioning the supply power for the control electronics power to itself.
      - 3) The long-term back-up power source shall supply power to the control electronics for at least 90 minutes.
      - 4) The long-term back-up power supply shall detect the return of normal power, and seamlessly return the control electronics to normal power.
      - 5) A test switch/indicator shall be available without opening the rack door or removal of any modules/components.
  - C. Electrical
    - 1. Control Enclosures shall be available in 100-, 120-, 230- and 240-volt, single-phase configurations.
    - 2. Control Enclosures shall be completely pre-wired by the manufacturer. The contractor shall provide input and control wiring.
    - 3. Control Enclosures shall be designed to support the following wire terminations:
      - a. AC (single phase)
      - b. Echelon link power (Belden 8471 or equivalent)
      - c. 24Vdc (2- 16AWG Wire)
      - d. DMX512A Port A (In or Out) (Belden 9729 or equivalent)

- e. DMX512A Port B (In or Out) (Belden 9729 or equivalent)
- f. RS232 Serial In/Out (Belden 9729 or equivalent)
- g. Unshielded Twisted Pair (UTP) Category 5 Ethernet
- h. Contact Closure In (14AWG to 26AWG Wire)
- i. Contact Closure Out (14AWG to 26AWG Wire)
  - 1) Contact Closure Out shall provide 1A @ 30VDC
- 4. Station Power Modules
  - a. Station power supply modules shall provide LinkPower for at 32 stations and 1.5A@24VDC of Auxiliary (AUX) power.
  - b. Station power repeater modules shall provide LinkPower for 30 stations and 1.5A@24VDC of Auxiliary (AUX) power.
  - c. Station power module shall support over-current/short protection for LinkPower and Aux. LinkPower shall support fault detection on each leg of the balanced data bus.
- 5. All control wire connections shall be terminated via factory provided connectors.
- D. Thermal
  - 1. Ambient room temperature: 0-40°C / 32-104°F
  - 2. Ambient humidity: 30-90% non-condensing.

## **2.5 ARCHITECTURAL CONTROL PROCESSOR: REFERENCED PRODUCT ETC UNISON PARADIGM CONTROL PROCESSOR MODULES**

- A. The Architectural Control Processor shall be the Unison Paradigm P-ACP Series Control Processor as manufactured by Electronic Theatre Controls, Inc.
- B. Mechanical
  - 1. The Architectural Control Processor (ACP) assembly shall be designed for use in DRd Series Dimming Enclosures and ERn Series Control Enclosures.
  - 2. The processor shall utilize microprocessor based, solid state technology to provide multi-scene lighting and building control.
  - 3. ACP module electronics shall be contained in a plug-in assembly.
    - a. The module shall be housed in a formed steel body and contain no discrete wire connections.
      - 1) No tools shall be required for module removal or insertion.
  - 4. The ACP shall be convection cooled.
  - 5. User Interface
    - a. The ACP shall utilize a backlit liquid crystal display capable of graphics and eight lines of text.
    - b. The ACP shall provide an alpha-numeric keypad for data entry and navigation.
    - c. The ACP shall provide a touch-sensitive control wheel for navigation.
    - d. The ACP shall provide shortcut buttons to assist in navigation, selection, and data entry.
    - e. The ACP keypad, buttons, and wheel shall be backlit for use in low-light conditions.
      - 1) The backlight shall have a user selectable time out, including no time out.
  - 6. The ACP shall provide a front-panel RJ45 jack for Ethernet connection to the processor for configuration, live control, and web-browser-based system access.
    - a. The Ethernet port shall be secured behind the locking door.
  - 7. The ACP shall provide a Secure Digital (SD) Removable Media slot on the front panel for transfer of configuration data.
    - a. The SD slot shall be secured behind the locking door.
  - 8. The ACP shall provide a Universal Serial Bus (USB) port on the front panel for transfer of configuration data.
    - a. The USB port shall be secured behind the locking door.
  - 9. Architectural Lighting System configuration and program information shall be stored in flash memory, which does not require battery backup.

- a. The ACP shall provide a Compact Flash (CF) Card as backup flash memory and storage.
  - b. The CF Card is stored in the back of the ACP and can be accessed only by removing the ACP.
  - c. The ACP data can be exchanged by inserting the CF card into another ACP.
- C. Electrical
- 1. The ACP shall require no discrete wiring connections; all wiring shall be terminated into Dimming or Control Enclosure.
  - 2. The ACP shall require low-voltage power supplied by the Dimming or Control enclosure.
  - 3. The ACP shall be hot-swap capable.
  - 4. The ACP shall support Echelon LinkPower communications with remote devices, including button stations, button/fader stations, Touchscreen stations, sensors, and third party LonMARK compliant products.
    - a. The LinkPower network shall utilize polarity-independent, low-voltage Class II twisted pair wiring, type Belden 8471 (unshielded) or Belden 8719 (shielded) or equivalent. One # 14 AWG drain wire will be required for system not using grounded metal conduit. Touchscreen stations, interface stations and portable stations connectors will also require (2) #16 AWG wires.
    - b. The LinkPower network shall be topology free. Network wiring may be bus, loop, home run, star or any combination of these.
    - c. Link power wiring shall permit a total wire run of 1640 ft. (500m) without a repeater. Repeater option modules shall be available to increase wiring maximums in increments of 1640 ft. (500m).
    - d. Link power wiring between stations shall not exceed 1313 ft. (400m).
  - 5. The ACP shall support 10/100BaseTX, auto MDI/MDIX, 802.3af compliant Ethernet networking using TCP/IP, ESTA BSR E1.17 Advanced Control Networks (ACN) and ESTA BSR E1.31 (sACN) Protocols for internal communication and integration with third-party equipment.
  - 6. The ACP shall support EIA-RS232 serial protocol for bi-directional command and communication with third-party equipment.
  - 7. The ACP shall support two discrete ESTA DMX512A ports, configurable as input or output ports.
    - a. °When used in a Dimming Enclosure, the second port is always an output port.
  - 8. The ACP shall provide four onboard dry contact closure inputs for integration with third-party products.
  - 9. The ACP shall provide four onboard contact closure outputs, rated at 1A@30VDC, for integration with third-party equipment.
- D. Functional
- 1. Capacity
    - a. Shall support 1024 channels of control
    - b. Shall support 2 physical DMX ports, each of which may be configured as an input or output
  - 2. System
    - a. Runtime application shall utilize support Net3 system interoperability
    - b. System shall support the use of Network Time Protocol for real time clock synchronization
    - c. System shall support remote firmware upload an over Ethernet connection from a connected PC running the Light Designer software or another connected processor.
    - d. System shall support local firmware upload from removable media (SD Card, USB Flash Drive)
  - 3. Diagnostics
    - a. Shall output an Event log



- b. Standard log shall store a fixed-length history of recent activity
- c. Separate critical log shall only store important messages (such as boot-up settings)
- 4. Configuration Data
  - a. Configuration Data can be uploaded over an Ethernet connection from a PC running Light Designer application
  - b. Configuration Data can be retrieved from another Paradigm Processor
  - c. A Paradigm Processor shall make its configuration data available for retrieval by another Processor as a backup/recovery mechanism
  - d. Configuration Data shall be stored on solid-state media that can be removed to facilitate transfer between Processor units
  - e. Configuration Data may be loaded to and from removable media access provided on front panel
  - f. Configuration Data for the entire System shall be available for download from any single Processor
  - g. Shall store configuration data for Dimming enclosure processors and shall make available for download
- 5. Scalability
  - a. Adding additional Processors to a System shall proportionately increase its overall capabilities up to a maximum System size
  - b. The maximum number of Processors configured as a System shall be at least 12.
  - c. Multiple Processors shall utilize the Ethernet network to remain time synchronized and share control information
  - d. Multiple Processors shall utilize the Ethernet network to maintain configuration data synchronization as modifications are made
  - e. Failure of a single Processor shall not prohibit continuing operation of the remaining Processors
  - f. It shall be possible for multiple Systems to coexist on the same physical network with logical isolation between Systems
- 6. Local User Interface
  - a. Shall provide access to Processor setup (IP address)
  - b. Shall provide access to Processor status and diagnostics
  - c. Where the Processor is installed within a Dimming enclosure, shall provide access to Dimming enclosure setup, status and diagnostics
  - d. Shall provide control functionality for Control Channels, Zones, Fixtures, Groups, Presets, Macros, Walls and Sequences within the current configuration.
  - e. Shall provide functionality to schedule astronomical and real time events (add/edit/delete)
  - f. Shall allow for display of local DMX information
  - g. Shall allow for transfer of log files to local removable media
  - h. Shall allow to perform firmware upgrades for connected Dimming enclosures
  - i. Shall allow for transfer of configuration to and from Dimming enclosures using removable media
  - j. Shall allow for transfer of configuration to and from LCD Stations using removable media
  - k. Shall allow for binding of Stations
- 7. Access Controls
  - a. There shall be 2 user accounts - Administrator, and User with separate password protection
  - b. Account and password settings shall be local to each Processor
  - c. Access Controls shall be applied to certain areas of the Paradigm Local User Interface and Web Interface
- 8. Web User Interface
  - a. Shall be an internal web server accessible via Ethernet port

- b. Shall support common web browsers on Windows and Mac platforms
  - c. Shall provide functionality to Activate and Deactivate Presets
  - d. Shall provide functionality to schedule timed events (add/delete)
  - e. Shall display status information
  - f. Shall display log files
  - g. Shall allow for configuration of Processor settings (date, time)
  - h. Shall allow for upload and download of configuration data
  - i. There shall be links to other web-enabled devices in the System, including other Paradigm Processors
9. Stations
- a. Stations shall be connected to a Paradigm Processor via a LinkPower network or Ethernet
  - b. Station discovery and binding shall be accomplished from the Local User Interface or Light Designer
10. Net3 and ACN Devices
- a. Net3 Devices shall be connected to and controlled from Paradigm Processors via Ethernet
  - b. Paradigm Processors shall provide DMX-Net3 gateway functionality
  - c. It shall be possible to send and receive Macro triggers defined within the System configuration via Net3
  - d. There shall be support for Streaming ACN on up to 24 universes per Processor
11. Operation
- a. When contained in a dimming enclosure, a snapshot of the dimming enclosure output data shall be stored in persistent memory so that hardware can access it for immediate output on boot
  - b. DMX output refresh rate shall be configurable
  - c. There shall be support for 16-bit DMX Attributes
  - d. DMX inputs may be patched to DMX and Streaming ACN outputs as external sources
  - e. Streaming ACN inputs shall be patched to DMX outputs (gateway) as external sources
  - f. Where there are multiple external sources then priority and HTP shall be used to perform arbitration
  - g. External and internal sources shall be arbitrated based on user-selection of standard or custom rules
  - h. On Preset Record, the values of Attributes within the Preset shall be updated to reflect the current output
  - i. The total output may be the combination of many different Presets running concurrently
  - j. There shall be no hard limit on number of concurrent cross fades
  - k. Multiple Presets controlling the same Attribute shall first interact based on priority and second based on Latest Takes Precedence (LTP) or Highest Takes Precedence (HTP)
  - l. LTP and HTP operation shall be supported simultaneously and interact (at the same priority) using HTP
  - m. Settings due to LTP Presets may be automatically discarded from operation when overridden
  - n. It shall be possible to specify that a Preset or Attribute Control will persist when overridden
  - o. A Preset may be designated as an HTP Override and shall cause HTP values to be discarded
  - p. It shall be possible to modify the rate of a Preset (Cross fades, Effects) from a Control within the System
  - q. Each Preset shall have a status that can be Activated, Deactivated or Altered

- r. Preset status may be set based on matching levels in the current output as an option
- s. On startup the System shall be capable of automatically executing timed events within the previous 24 hours to synchronize its initial output state with the current time of day
- 12. Serial Input/Output
  - a. RS232 shall support 8-bit word length, parity selection and 1 or 2 stop bits
  - b. RS232 shall support baud rates from 4800 to 115,200 bps
  - c. Serial input and output messages are fully customizable
  - d. Serial output messages can be generated by any Control or Event

## **2.6 ARCHITECTURAL CONTROL PROCESSOR: REFERENCED PRODUCT ETC UNISON STATION POWER MODULE**

- A. Station processor Modules
  - 1. The Station Power Module shall be the Unison Paradigm P-SPM Series Station Power Module as manufactured by Electronic Theatre Controls, Inc., or equal.
- B. Mechanical
  - 1. The Station Power Module (SPM) assembly shall be designed for use in DRd Series or ERn Rack Enclosures.
  - 2. The SPM shall convert input power into low-voltage (Class II) power with data line and a secondary auxiliary low-voltage line to energize button, button/fader, touchscreen, and interface devices for multi-scene lighting and building control.
  - 3. SPM module shall be contained in a plug-in assembly.
    - a. The module shall be housed in a formed steel body and contain no discrete wire connections.
      - 1) No tools shall be required for module removal or insertion.
  - 4. The SPM shall be convection cooled.
  - 5. User Interface
    - a. The SPM shall utilize light emitting diodes (LED's) to indication function, status and fault.
  - 6. The SPM shall be secured behind the locking door.
  - 7. Wall-mounted, direct wire and 19" rack-mount, connectorized repeater and dual-repeater variants shall be available from the same manufacturer where required on the project.
- C. Electrical
  - 1. The SPM shall require no discrete wiring connections; all wiring shall be terminated into the dimming enclosure, unless required by a variant.
  - 2. The SPM shall require line-voltage power supplied by the contractor, terminated inside the dimming or control enclosure.
  - 3. The SPM shall be hot-swap capable.
  - 4. The SPM, in conjunction with a matching Architectural Control Processor (ACP), shall support Echelon LinkPower communications with remote devices, including button, button/fader, touchscreen and interface stations, and shall interoperate with LonMARK-approved third-party devices.
    - a. The LinkPower network shall utilize polarity-independent, low-voltage Class II twisted pair wiring, type Belden 8471 (unshielded) or Belden 8719 (shielded) or equivalent. One # 14 AWG drain wire will be required for system not using grounded metal conduit.
    - b. The LinkPower network shall be topology free. Network wiring may be bus, loop, home run, star or any combination of these.
      - 1) Link power wiring shall permit a total wire run of 1640 ft. (500m)
      - 2) Repeaters allow an additional wire run of 1640 ft. (500m)
    - c. Dual-repeaters allow two additional wire runs of 1640 ft. (500m)
  - 5. Link power wiring between stations shall not exceed 1313 ft. (400m).

6. The SPM shall support auxiliary power for certain remote devices, including touchscreen and interface stations, as required by the device.
  - a. The auxiliary power network shall utilize polarity-dependent, low-voltage Class II wiring, consisting of two # 16 AWG wires.
  - b. Auxiliary wiring shall permit a total wire run of 1640 ft. (500m)
    - 1) Repeaters allow an additional wire run of 1640 ft. (500m)
    - 2) Dual repeaters allow two additional wire runs of 1640 ft. (500m)
  - c. The SPM shall supply 1.25 amps at 24v DC continuously.
- D. Functional
  1. Capacity
    - a. Each SPM shall:
      - 1) Supply power for up to 32 button and button/fader stations.
        - i) Repeaters and dual repeaters allow 30 additional stations, 62 total
    - b. Supply auxiliary power for a similar number of interface stations.
    - c. Shall supply auxiliary power for up to four Touchscreen stations, when a like number of other stations is deducted from the total.
      - 1) Repeaters and dual repeaters allow two additional Touchscreens (six total) when a like number of other stations are

deducted from the total.

2. Operation
  - a. The SPM shall not require configuration or programming.
  - b. The SPM shall automatically detect faults in the wiring, indicate the fault, including the fault polarity, and shut down the output power.
    - 1) The SPM shall automatically reset when the fault is clear and can be manually reset by removing and re-inserting the module.

## **2.7 WI-FI ROUTER/INTELLIGENT WIRELESS MESH SYSTEM: REFERENCED PRODUCT LINKSYS VELOP INTELLIGENT MESH WI-FI SYSTEM ACXXXX**

- A. Overview:
  1. System incorporates an Intelligent Mesh Technology Wi-Fi system that delivers seamless connectivity with the ability to mix and match nodes in order to modify performance.
  2. Each node provides a powerful Wi-Fi signal throughout the entire coverage area by continuously self-organizing and optimizing to find the fastest path to the Internet for seamless Wi-Fi.
  3. Provides an ultra-simple and powerful system that uses only one Wi-Fi network name and password for secure Wi-Fi. Leading-edge security allows content blocking. System is compatible with all Internet service provider supplied equipment and speeds. Setup is via an app-based interface.
  4. The system self-heals and self-optimizes to consistently deliver fast, hassle-free Wi-Fi.
  5. Software updates are automatic.
- B. What's in the Box:
  1. Linksys Velop Dual Band Node
  2. Power supply
  3. Ethernet cable
- C. Technical Specifications:
  1. Wi-Fi Technology:

- a. Dual-Band AC1300 (867 + 400 Mbps) ± with MU-MIMO and 256 QAM
- 2. Key Features:
  - a. Dual-Band Wi-Fi Mesh System
  - b. Seamless Wi-Fi
  - c. Easy App Controls
  - d. Intelligent Mesh™ Technology - Self-Organizing, Self-Optimizing and Self-Healing
  - e. One Wi-Fi Network
  - f. Auto Firmware Upgrade
  - g. Parental Control
  - h. Guest Access
  - i. Auto sensing WAN/LAN Ports
  - j. Wired/Wireless Backhaul
  - k. AP/Bridge Mode Mesh Wi-Fi System
  - l. Spot Finder- Mesh system uses signal strength, throughput, and latency to determine the optimal placement during set-up and post set-up.
  - m. Auto Wi-Fi Channel
  - n. Bluetooth 4.1 embedded
  - o. Speedtest support
  - p. Amazon Alexa support
  - q. 3-Year Warranty and Support
- 3. Network Standards:
  - 802.11b
    - a. 802.11a
    - b. 802.11g
    - c. 802.11n
    - d. 802.11ac
- 4. Wi-Fi Speed:
  - a. AC1300 (867 + 400 Mbps)
- 5. Wi-Fi Bands:
  - a. 2.4Ghz + 5GHz
- 6. Wi-Fi Range:
  - a. up to 1500 sq ft
- 7. Number of Ethernet Ports:
  - a. 2x WAN/LAN auto-sensing Gigabit Ethernet ports
- 8. Other Ports:
  - a. power jack
  - b. power switch
  - c. reset button
- 9. Antennas:
  - a. 3x internal antennas and high-powered amplifiers
- 10. Processor:
  - a. 716 MHz Quad Core
- 11. Memory:
  - a. 256 MB NAND Flash and 256 MB DDR3
- 12. LEDs:
  - a. One LED indicator
- 13. Wireless Encryption:
  - a. WPA2 personal
- 14. Easy Setup:
  - a. Simple and secured App based set-up
  - b. Required for set-up:
    - 1) Internet connection with Modem.

- 2) Mobile device with Android 4.4 or iOS 9 and higher, Bluetooth preferred.
- 15. Minimum System Requirements:
  - a. Required for set-up - Simple and secured App based set-up: Mobile devices with Android 4.0.3 or iOS 8 and higher
- 16. Dimensions (L x W x H):
  - a. 3.1" x 3.1" x 5.55" per Node
- 17. Weight:
  - a. 2.076 Lbs.
- 18. Security Features:
  - a. WPA2 personal
- 19. Regulatory Compliance:
  - a. FCC class B
- 20. Additional Information:
  - a. Bluetooth 4.0/LE for secure and easy App based set-up
- 21. Power Supply:
  - a. Input: 100-240V ~ 50-60Hz; Output: 12V, 1.0A
- D. Warranty:
  - 1. Three-year limited

## 2.8 HIGH RESOLUTION LED-BACKLIT HANDHELD DISPLAY: REFERENCED PRODUCT APPLE IPAD PRO

- A. Provide an iPad Pro that is the most current shipping model available. Provide with all software updates, etc. installed, set up and ready for use.
- B. Provide Wi-fi model
- C. Physical:
  - 1. Size: 9.74" H x 7.02" W x 0.23" D (247.6 mm x 178.5 mm x 5.9 mm)
  - 2. Weight: 1.03 pounds (0.468 kg)
- D. Display:
  - 1. Liquid Retina display
  - 2. 11" (diagonal) LED-backlit glossy widescreen Multi-Touch display with IPS technology
  - 3. 2388 x 1668 pixel resolution at 264 pixels per inch (ppi)
  - 4. Fingerprint-resistant oleophobic coating
  - 5. Support for display of multiple languages and characters simultaneously
  - 6. ProMotion technology
  - 7. Wide color display (P3)
  - 8. True Tone display
  - 9. Fully laminated display
  - 10. Antireflective coating
  - 11. 1.8% reflectivity
  - 12. 600 nits brightness
- E. Wireless and Cellular:
  - 1. Wi-Fi model:
    - a. Wi-Fi (802.11a/b/g/n)
    - b. Bluetooth 2.1 + EDR technology
  - 2. Location:
    - a. Wi-Fi
    - b. Digital compass
  - 3. Environmental:
    - a. Arsenic-free display glass
    - b. BFR-free

- c. Mercury-free LCD display
  - d. PVC-free Recyclable aluminum and glass Enclosure
- 4. Capacity: 16GB, 32GB or 64GB flash drive
- 5. Processor: A12X Bionic chip with 64-bit architecture Neural Engine and Embedded M12 coprocessor
- 6. Camera:
  - a. 12-megapixel camera
  - b. *f*/1.8 aperture
  - c. Digital zoom up to 5x
  - d. Five-element lens
  - e. Quad-LED True Tone flash
  - f. Panorama (up to 63 megapixels)
  - g. Sapphire crystal lens cover
  - h. Backside illumination sensor
  - i. Hybrid IR filter
  - j. Autofocus with Focus Pixels
  - k. Tap to focus with Focus Pixels
  - l. Live Photos with stabilization
  - m. Wide color capture for photos and Live Photos
  - n. Improved local tone mapping
  - o. Exposure control
  - p. Noise reduction
  - q. Smart HDR for photos
  - r. Auto image stabilization
  - s. Burst mode
  - t. Timer mode
  - u. Photo geotagging
  - v. Image formats captured: HEIF and JPEG
- 7. Video Recording:
  - a. 4K video recording at 30 fps or 60 fps
  - b. 1080p HD video recording at 30 fps or 60 fps
  - c. 720p HD video recording at 30 fps
  - d. Quad-LED True Tone flash
  - e. Slo-mo video support for 1080p at 240 fps
  - f. Time-lapse video with stabilization
  - g. Cinematic video stabilization (1080p and 720p)
  - h. Continuous autofocus video
  - i. Noise reduction
  - j. Playback zoom
  - k. Video geotagging
  - l. Video formats captured: HEVC and H.264
- 8. TrueDepth Camera:
  - a. 7-megapixel photos
  - b. Portrait mode
  - c. Portrait Lighting
  - d. Animoji and Memoji
  - e. 1080p HD video recording at 30 fps or 60 fps
  - f. Retina Flash
  - g. *f*/2.2 aperture
  - h. Wide color capture for photos and Live Photos
  - i. Smart HDR
  - j. Backside illumination sensor

- k. Auto image stabilization
- l. Burst mode
- m. Exposure control
- n. Timer mode
- 9. Video Calling:
  - a. FaceTime video
  - b. iPad to any FaceTime-enabled device over Wi-Fi or cellular
- 10. Audio Calling:
  - a. FaceTime audio
  - b. iPad to any FaceTime-enabled device over Wi-Fi or cellular
- 11. Speakers:
  - a. Four speaker audio
- 12. Microphones:
  - a. Five microphones
- 13. Sensors:
  - a. Face ID
  - b. Three-axis gyro
  - c. Accelerometer
  - d. Barometer
  - e. Ambient light sensor
- 14. Face ID:
  - a. Enabled by TrueDepth camera for facial recognition
  - b. Unlock iPad
  - c. Secure personal data within apps
  - d. Make purchases from the iTunes Store, App Store, and Apple Books
- 15. Siri:
  - a. Use your voice to send messages, set reminders, and more
  - b. Get proactive suggestions
  - c. Use hands-free
  - d. Listen and identify songs
- 16. Charging & Expansion:
  - a. USB-C
- 17. Operating System:
  - a. iPad OS
- 18. Audio Playback:
  - a. Frequency response: 20Hz to 20,000Hz
  - b. Audio formats supported: AAC (8 to 320 Kbps), Protected AAC (from iTunes Store), HE-AAC, MP3 (8 to 320 Kbps), MP3 VBR, Dolby Digital (AC-3), Dolby Digital Plus (E-AC-3), Dolby Atmos, Audible (formats 2, 3, 4, Audible Enhanced Audio, AAX, and AAX+), Apple Lossless, AIFF, and WAV
  - c. User-configurable maximum volume limit.
- 19. TV and Video:
  - a. AirPlay Mirroring, photos, audio, and video out to Apple TV (2nd generation or later)
  - b. Supports Dolby Vision and HDR10 content
  - c. Video mirroring and video out support: Up to 4K through USB-C Digital AV Multiport Adapter and USB-C VGA Multiport Adapter (adapters sold separately)



- d. Video formats supported: H.264 video up to 4K, 30 frames per second, High Profile level 4.2 with AAC-LC audio up to 160 Kbps, 48kHz, stereo audio or Dolby Audio up to 1008 Kbps, 48kHz, stereo or multichannel audio, in .m4v, .mp4, and .mov file formats; MPEG-4 video up to 2.5 Mbps, 640 by 480 pixels, 30 frames per second, Simple Profile with AAC-LC audio up to 160 Kbps per channel, 48kHz, stereo audio or Dolby Audio up to 1008 Kbps, 48kHz, stereo or multichannel audio, in .m4v, .mp4, and .mov file formats; Motion JPEG (M-JPEG) up to 35 Mbps, 1280 by 720 pixels, 30 frames per second, audio in ulaw, PCM stereo audio in .avi file format.
- 20. Mail Attachment Support:
  - a. Viewable document types: .jpg, .tiff, .gif (images); .doc and .docx (Microsoft Word); .htm and .html (web pages); .key (Keynote); .numbers (Numbers); .pages (Pages); .pdf (Preview and Adobe Acrobat); .ppt and .pptx (Microsoft PowerPoint); .txt (text); .rtf (rich text format); .vcf (contact information); .xls and .xlsx (Microsoft Excel); .zip; .ics.
- 21. Languages:
  - a. Language support for English (U.S.), English (UK), French (France), German, Traditional Chinese, Simplified Chinese, Dutch, Italian, Spanish, Portuguese (Brazil), Portuguese (Portugal), Danish, Swedish, Finnish, Norwegian, Korean, Japanese, Russian, Polish, Turkish, Ukrainian, Hungarian, Arabic, Thai, Czech, Greek, Hebrew, Indonesian, Malay, Romanian, Slovak, Croatian, Catalan, and Vietnamese.
  - b. Keyboard support for English (U.S.), English (UK), French (France), French (Canadian), French (Switzerland), German, Traditional Chinese (Handwriting, Pinyin, Zhuyin, Cangjie, Wubihua), Simplified Chinese (Handwriting, Pinyin, Wubihua), Dutch, Italian, Spanish, Portuguese (Brazil), Portuguese (Portugal), Danish, Swedish, Finnish, Norwegian, Korean, Japanese (Romaji, Fifty Key), Japanese (Kana), Russian, Polish, Turkish, Ukrainian, Estonian, Hungarian, Icelandic, Lithuanian, Latvian, Flemish, Arabic, Thai, Czech, Greek, Hebrew, Indonesian, Malay, Romanian, Slovak, Croatian, Bulgarian, Serbian (Cyrillic/Latin), Catalan, Vietnamese, Tibetan, Macedonian, and Cherokee.
  - c. Dictionary support (enables predictive text and autocorrect) for English (U.S.), English (UK), French, German, Traditional Chinese, Simplified Chinese, Dutch, Italian, Spanish, Portuguese (Brazil), Portuguese (Portugal), Danish, Swedish, Finnish, Norwegian, Korean, Japanese (Romaji), Japanese (Kana), Russian, Polish, Turkish, Ukrainian, Hungarian, Lithuanian, Flemish, Arabic, Thai, Czech, Greek, Hebrew, Indonesian, Malaysian, Romanian, Slovak, Croatian, Catalan, Vietnamese, and Cherokee.
- 22. Accessibility:
  - a. Support for playback of closed-captioned content
  - b. Voice Over screen reader
  - c. Full-screen zoom magnification
  - d. Voice Control
  - e. Siri and Dictation
  - f. Assistive Touch
  - g. Zoom
  - h. Switch Control
  - i. Speak Screen
- 23. Battery and Power:
  - a. Built-in 29.37-watt-hour rechargeable lithium polymer battery
  - b. Up to 10 hours of surfing the web on Wi-Fi, watching video or listening to music
  - c. Up to 9 hours of surfing the web using 3G data network
  - d. Charging via power adapter or USB to computer system
- 24. Input and Output:
  - a. Dock connector port

- b. 3.5-mm stereo headphone jack
- c. Built-in speaker
- d. Microphone
- e. Micro-SIM card tray (Wi-Fi + 3G model only)
- 25. External buttons and controls: On/off, Sleep/wake, Mute, Volume and Up/down
- 26. System Requirements (when syncing to a Mac or PC):
  - a. Mac system Requirements:
  - b. Apple ID (required for some features)
  - c. Mac computer with USB 2.0 port
  - d. Mac OS Catalina 10.15, El Capitan 10.11.6, Mojave 10.14.6 or later
  - e. iTunes 12.8 or later
  - f. iTunes Store account
  - g. Internet access
  - h. Windows System Requirements:
  - i. Apple ID (required for some features)
  - j. PC with USB 2.0 port
  - k. Windows 7 or later
  - l. iTunes 12.10 or later
  - m. iTunes Store account
  - n. Internet access
- 27. Environmental Requirements:
  - a. Operating ambient temperature: 32° to 95° F (0° to 35° C)
  - b. Non-operating temperature: -4° to 113° F (-20° to 45° C)
  - c. Relative humidity: 5% to 95% non-condensing
  - d. Maximum operating altitude: 10,000 feet (3000 m)
- 28. Accessories: Provide with (1) iPad dock, (1) iPad keyboard dock, (1) iPad foldable stand case, (1) dock connector to USB cable and (1) iPad 10-Watt USB power adapter and all manufacturer's accompanying documentation. Provide with all necessary connectors, cables, etc. as needed in order to interface iPad with the computer, keyboard, dock, etc.
- 29. Software: Provide with the software suite(s) indicated (installed and ready to operate), including any licensing fees, app fees, etc. paid for (1) year (owner will be responsible for recurring charges after that time period has expired). Set all apps up in the owner's name and with the owner's information.

## 2.9 GENERAL NETWORK:

### A. General

1. The Electronic Theatre Controls Net3 network shall provide data distribution over a TCP/IP network. Data shall be layer 3 routable over the Ethernet network. Systems using proprietary formats or formats other than TCP/IP or non-layer 3 routable networks shall not be accepted.
2. Connections shall be made between consoles, facepanels, architectural processors, computers and Net3 Gateways over standard Ethernet distribution systems using 10/100BaseT wiring and/or 10/100BaseFL. All installations shall conform to established Ethernet wiring practice and installation shall be performed by contractors qualified to do this type of work. All wiring shall be tested at Category 5 or higher for full bandwidth operation to the appropriate IEEE standard.
3. The Lighting Control system must be supplied by a single manufacturer and must have seamless integration over Ethernet between the Entertainment and Architectural lighting control.

### B. Capacities

1. The network shall provide DMX routing, patching, and prioritization for choice of up to 32,910,848 DMX addresses. Each address may be input or output from any port on any DMX Gateway in the system. DMX input, routing and output shall be specifically supported on the system from multiple sources and locations up to the maximum number of Gateways supported by the Ethernet topology.
2. The network shall support multiple consoles, computers, file servers, printers, and architectural processors with discrete command lines and control. The Net3 network shall support multiple venues/systems on the same network.
3. Network configuration shall be via ETC Gateway Configuration Editor (GCE) software. The software shall permit complete user flexibility allowing the system operator to patch DMX data over Ethernet DMX (EDMX), assign Gateway labels for easy identification, assign DMX offsets and provide choice of DMX port prioritization. Each Gateway shall have a specific IP address provided automatically by the software. The user may edit this IP address. Systems that do not support simple Windows configuration, or systems that do not allow complete reconfiguration of the above mentioned features over Ethernet shall not be acceptable.
4. All configuration data for each network device shall be held at the device and system operation shall not require continuous on-line operation of the network configuration software.
5. Architectural and Entertainment systems connected to the same Net3 network shall be capable of arbitrating control over EDMX data. The system shall be capable of alternating control of individual dimmer data between architectural and entertainment systems without intervention by the user. The user shall dictate the conditions under which system shall automatically take control and the network shall allow user override of the user selected defaults. Systems which require direct user intervention to allocate control of dimmers between architectural and entertainment lighting systems shall not be allowed.
6. The Net3 network shall allow multiple DMX inputs assigned to the same EDMX range to be set at different priorities. This shall allow the user to assign high or low priority to each DMX input port in the network on a port by port basis. The network shall require a valid DMX signal present at the input to initiate prioritization. Systems that do not allow for prioritization shall not be allowed.

C. Operational Features

1. The video monitor outputs at any Net3 Remote Video Interface (RVI) shall be able to monitor the video output of any Net3 console connected to the network.
2. Each DMX Gateway shall control up to 512 DMX addresses per port, within the confines of up to 64,279 DMX (32,910,848 address) "universes". The specific DMX data input or output by the Gateway shall be freely configurable by the user. Duplicate outputs of DMX lines (DMX splitter) and discrete outputs shall be fully supported.
3. Any number of DMX universes may be configured with any length up to 512 addresses as long as the total does not exceed 32,910,848. Any range of DMX addresses may be selected for each. Multiple sources may be combined and a priority may be assigned to each source. Each DMX input may have its own universe and offset address for ease of use.
4. DMX ports shall be configurable for either input or output. Multiple DMX signal routing patches and multiple facilities shall be specifically supported and limited only by the file storage capacity of the computer with ETC Network Configuration Editor software installed.
5. File transmission, synchronization and access to software shall be supported.

**2.10 DUAL BAND ENTERPRISE CLASS WIRELESS ACCESS POINT: REFERENCED PRODUCT CISCO AIRONET 1600 SERIES ACCESS POINT**

A. FEATURES:

1. Sleek design with internal antennas

2. Extended operating temperature
3. Versatile RF coverage with optional external antennas
4. UL 2043 plenum-rated for above-ceiling installation options or suspended from drop ceilings
5. 802.11n performance with existing PoE switches
6. Locks for theft protection
7. Controller-based or standalone deployment options
8. Supports rogue access point detection and denial-of service attacks
9. Management frame protection detects malicious users and alerts network administrators
10. Cisco ClientLink 2.0 Beamforming
11. Support for all client types without any client requirements or dependencies
12. Cisco CleanAir Express Spectrum Intelligence
13. Identifies, classifies and provides automatic remedial actions for different types of interference
14. Locates and visualizes sources of interference
15. Cisco VideoStream Technology
16. Efficient multicast-to-unicast conversion
17. Video call admission control to prevent oversubscription
18. Queue prioritization to help ensure best user experience for corporate videos
19. Warranty: Limited Lifetime Warranty that provides full warranty coverage of the hardware for as long as the original end user continues to own or use the product. The warranty includes 10-day advance hardware replacement and ensures that software media is defect-free for 90 days.
20. Enterprise-class chipsets and optimized radios
21. 802.11n with 3x3 multiple-input multiple-output (MIMO) technology with two spatial streams, which sustains 300-Mbps rates
22. Radio resource management (RRM): Automated self-healing
23. CleanAir Express: detects RF interference and provides basic spectrum analysis capability
24. Cisco ClientLink 2.0 technology: Improves downlink performance to all mobile devices including 802.11n while improving battery life on mobile devices such as smartphones and tablets
25. Cisco BandSelect technology: Improves 5-GHz client connections in mixed-client environments
26. Cisco VideoStream technology: Uses multicast to improve rich-media applications
27. Can scale to up to 18,000 access points with full Layer 3 mobility across central or remote locations
28. Cisco Network Assistant: provides a centralized network view with a user-friendly GUI

**SPECIFICATIONS:**  
**Product Specifications**

Table 1 lists the product specifications for Cisco Aironet 1600 Series Access Points.

**Table 1.** Product Specifications for Cisco Aironet 1600 Series Access Points

Item	Specification
<b>Part Numbers</b>	<p><b>The Cisco Aironet 1600i Access Point: Indoor environments, with internal antennas</b></p> <ul style="list-style-type: none"> <li>• AIR-CAP1602I-x-K9 Dual-band controller-based 802.11a/g/n</li> <li>• AIR-CAP1602I-xK910 Eco-pack (dual-band controller-based 802.11a/g/n) 10 quantity access points</li> <li>• AIR-SAP1602I-x-K9 Dual-band stand-alone 802.11a/g/n</li> <li>• AIR-SAP1602I-xK9-5 Eco-pack (dual-band stand-alone 802.11a/g/n) 5 quantity access points</li> </ul> <p><b>The Cisco Aironet 1600e Access Point: Indoor, challenging environments, with external antennas</b></p> <ul style="list-style-type: none"> <li>• AIR-CAP1602E-x-K9 Dual-band controller-based 802.11a/g/n</li> <li>• AIR-CAP1602E-xK910 Eco-pack (dual-band 802.11a/g/n) 10 quantity access points</li> <li>• AIR-SAP1602E-x-K9 Dual-band stand-alone 802.11a/g/n</li> <li>• AIR-SAP1602E-xK9-5 Eco-pack (dual-band stand-alone 802.11a/g/n) 5 quantity access points</li> </ul>

Item	Specification																																																																															
	<p><b>Cisco SMARTnet® Service for the Cisco Aironet 1600 Series Access Point with internal and external antennas</b></p> <ul style="list-style-type: none"><li>• CON-SNT-C1602Ix - SMARTnet 8x5xNBD 1600i access point (dual-band 802.11 a/g/n, Controller-based), (e.g. CON-SNT-C1602IE for AP1600 internal antenna for E Domain, Controller based)</li><li>• CON-SNT-C1602Ex - SMARTnet 8x5xNBD 1600e access point (dual-band 802.11 a/g/n, Controller-based), (e.g. CON-SNT-C1602EA for AP1600 external antenna for A Domain, Controller based)</li><li>• CON-SNT-S1602Ix - SMARTnet 8x5xNBD 1600i access point (dual-band 802.11 a/g/n, Stand-alone), (e.g. CON-SNT-S1602IE for AP1600 internal antenna for E Domain, stand-alone)</li><li>• CON-SNT-S1602Ex - SMARTnet 8x5xNBD 1600e access point (dual-band 802.11 a/g/n, Stand-alone), (e.g. CON-SNT-S1602EA for AP1600 external antenna for A Domain, Stand-alone)</li></ul> <p><b>Cisco Wireless LAN Services</b></p> <ul style="list-style-type: none"><li>• AS-WLAN-CNSLT Cisco Wireless LAN Network Planning and Design Service</li><li>• AS-WLAN-CNSLT Cisco Wireless LAN 802.11n Migration Service</li><li>• AS-WLAN-CNSLT Cisco Wireless LAN Performance and Security Assessment Service</li></ul> <p><b>Regulatory domains: (x = regulatory domain)</b></p> <p>Customers are responsible for verifying approval for use in their individual countries. To verify approval and to identify the regulatory domain that corresponds to a particular country, please visit: <a href="http://www.cisco.com/go/aironet/compliance">http://www.cisco.com/go/aironet/compliance</a>.</p> <p>Not all regulatory domains have been approved. As they are approved, the part numbers will be available on the Global Price List.</p>																																																																															
Software	<ul style="list-style-type: none"><li>• Cisco Unified Wireless Network Software (available in Q4CY12)</li><li>• Cisco IOS® Software Release (available in Q4CY12)</li></ul>																																																																															
802.11n	<ul style="list-style-type: none"><li>• 3 x 3 multiple-input multiple-output (MIMO) with two spatial streams</li><li>• Maximal ratio combining (MRC)</li><li>• 20- and 40-MHz channels</li><li>• PHY data rates up to 300 Mbps</li><li>• Packet aggregation: A-MPDU (Tx/Rx), A-MSDU (Tx/Rx)</li><li>• 802.11 dynamic frequency selection (DFS) (Bin 5)</li><li>• Cyclic shift diversity (CSD) support</li></ul>																																																																															
Data Rates Supported	<p><b>802.11a: 6, 9, 12, 18, 24, 36, 48, and 54 Mbps</b></p> <p><b>802.11g: 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, and 54 Mbps</b></p> <p><b>802.11n data rates (2.4 GHz<sup>1</sup> and 5 GHz):</b></p> <table><tr><th rowspan="2">MCS Index<sup>2</sup></th><th colspan="2">GI<sup>3</sup> = 800ns</th><th colspan="2">GI = 400ns</th></tr><tr><th>20-MHz Rate (Mbps)</th><th>40-MHz Rate (Mbps)</th><th>20-MHz Rate (Mbps)</th><th>40-MHz Rate (Mbps)</th></tr><tr><td>0</td><td>6.5</td><td>13.5</td><td>7.2</td><td>15</td></tr><tr><td>1</td><td>13</td><td>27</td><td>14.4</td><td>30</td></tr><tr><td>2</td><td>19.5</td><td>40.5</td><td>21.7</td><td>45</td></tr><tr><td>3</td><td>26</td><td>54</td><td>28.9</td><td>60</td></tr><tr><td>4</td><td>39</td><td>81</td><td>43.3</td><td>90</td></tr><tr><td>5</td><td>52</td><td>108</td><td>57.8</td><td>120</td></tr><tr><td>6</td><td>58.5</td><td>121.5</td><td>65</td><td>135</td></tr><tr><td>7</td><td>65</td><td>135</td><td>72.2</td><td>150</td></tr><tr><td>8</td><td>13</td><td>27</td><td>14.4</td><td>30</td></tr><tr><td>9</td><td>26</td><td>54</td><td>28.9</td><td>60</td></tr><tr><td>10</td><td>39</td><td>81</td><td>43.3</td><td>90</td></tr><tr><td>11</td><td>52</td><td>108</td><td>57.8</td><td>120</td></tr><tr><td>12</td><td>78</td><td>162</td><td>86.7</td><td>180</td></tr><tr><td>13</td><td>104</td><td>216</td><td>115.6</td><td>240</td></tr></table>	MCS Index <sup>2</sup>	GI <sup>3</sup> = 800ns		GI = 400ns		20-MHz Rate (Mbps)	40-MHz Rate (Mbps)	20-MHz Rate (Mbps)	40-MHz Rate (Mbps)	0	6.5	13.5	7.2	15	1	13	27	14.4	30	2	19.5	40.5	21.7	45	3	26	54	28.9	60	4	39	81	43.3	90	5	52	108	57.8	120	6	58.5	121.5	65	135	7	65	135	72.2	150	8	13	27	14.4	30	9	26	54	28.9	60	10	39	81	43.3	90	11	52	108	57.8	120	12	78	162	86.7	180	13	104	216	115.6	240
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0	6.5	13.5	7.2	15																																																																												
1	13	27	14.4	30																																																																												
2	19.5	40.5	21.7	45																																																																												
3	26	54	28.9	60																																																																												
4	39	81	43.3	90																																																																												
5	52	108	57.8	120																																																																												
6	58.5	121.5	65	135																																																																												
7	65	135	72.2	150																																																																												
8	13	27	14.4	30																																																																												
9	26	54	28.9	60																																																																												
10	39	81	43.3	90																																																																												
11	52	108	57.8	120																																																																												
12	78	162	86.7	180																																																																												
13	104	216	115.6	240																																																																												

<sup>1</sup> 2.4 GHz: 2 GHz does not support 40 MHz.

<sup>2</sup> MCS Index: The Modulation and Coding Scheme (MCS) index determines the number of spatial streams, the modulation, the coding rate, and data rate values.

<sup>3</sup> GI: A Guard Interval (GI) between symbols helps receivers overcome the effects of multipath delays.

Item	Specification				
	14	117	243	130	270
	15	130	270	144.4	300
Frequency Band and 20-MHz Operating Channels	<b>A Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.462 GHz; 11 channels</li><li>• 5.180 to 5.320 GHz; 8 channels</li><li>• 5.500 to 5.700 GHz; 8 channels (excludes 5.600 to 5.640 GHz)</li><li>• 5.745 to 5.825 GHz; 5 channels</li></ul> <b>C Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.472 GHz; 13 channels</li><li>• 5.745 to 5.825 GHz; 5 channels</li></ul> <b>E Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.472 GHz; 13 channels</li><li>• 5.180 to 5.320 GHz; 8 channels</li><li>• 5.500 to 5.700 GHz; 8 channels (excludes 5.600 to 5.640 GHz)</li></ul> <b>I Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.472 GHz; 13 channels</li><li>• 5.180 to 5.320 GHz; 8 channels</li></ul> <b>K Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.472 GHz; 13 channels</li><li>• 5.180 to 5.320 GHz; 8 channels</li><li>• 5.500 to 5.620 GHz; 7 channels</li><li>• 5.745 to 5.805 GHz; 4 channels</li></ul>		<b>N Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.462 GHz; 11 channels</li><li>• 5.180 to 5.320 GHz; 8 channels</li><li>• 5.745 to 5.825 GHz; 5 channels</li></ul> <b>Q Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.472 GHz; 13 channels</li><li>• 5.180 to 5.320 GHz; 8 channels</li><li>• 5.500 to 5.700 GHz; 11 channels</li></ul> <b>R Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.472 GHz; 13 channels</li><li>• 5.180 to 5.320 GHz; 8 channels</li><li>• 5.660 to 5.700 GHz; 3 channels</li><li>• 5.745 to 5.805 GHz; 4 channels</li></ul> <b>S Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.472 GHz; 13 channels</li><li>• 5.180 to 5.320 GHz; 8 channels</li><li>• 5.500 to 5.700 GHz; 11 channels</li><li>• 5.745 to 5.825 GHz; 5 channels</li></ul> <b>T Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.462 GHz; 11 channels</li><li>• 5.280 to 5.320 GHz; 3 channels</li><li>• 5.500 to 5.700 GHz; 8 channels (excludes 5.600 to 5.640 GHz)</li><li>• 5.745 to 5.825 GHz; 5 channels</li></ul> <b>Z Regulatory Domain:</b> <ul style="list-style-type: none"><li>• 2.412 to 2.462 GHz; 11 channels</li><li>• 5.180 to 5.320 GHz; 8 channels</li><li>• 5.500 to 5.700 GHz; 8 channels (excludes 5.600 to 5.640 GHz)</li><li>• 5.745 to 5.825 GHz; 5 channels</li></ul>		
Note: This varies by regulatory domain. Refer to the product documentation for specific details for each regulatory domain.					
Maximum Number of Nonoverlapping Channels	<b>2.4 GHz</b> <ul style="list-style-type: none"><li>• 802.11b/g:<ul style="list-style-type: none"><li>◦ 20 MHz: 3</li></ul></li><li>• 802.11n:<ul style="list-style-type: none"><li>◦ 20 MHz: 3</li></ul></li></ul>		<b>5 GHz</b> <ul style="list-style-type: none"><li>• 802.11a:<ul style="list-style-type: none"><li>◦ 20 MHz: 24</li></ul></li><li>• 802.11n:<ul style="list-style-type: none"><li>◦ 20 MHz: 24</li><li>◦ 40 MHz: 11</li></ul></li></ul>		
Note: This varies by regulatory domain. Refer to the product documentation for specific details for each regulatory domain.					
Receive Sensitivity	<b>2.4 GHz</b> <b>802.11b</b> -101 dBm @ 1 Mb/s -99 dBm @ 2 Mb/s -92 dBm @ 5.5 Mb/s -89 dBm @ 11 Mb/s	<b>2.4 GHz</b> <b>802.11g</b> -93 dBm @ 6 Mb/s -93 dBm @ 9 Mb/s -92 dBm @ 12 Mb/s -90 dBm @ 18 Mb/s -87 dBm @ 24 Mb/s -85 dBm @ 36 Mb/s -80 dBm @ 48 Mb/s -79 dBm @ 54 Mb/s	<b>5 GHz</b> <b>802.11a</b> -92 dBm @ 6 Mb/s -91 dBm @ 9 Mb/s -91 dBm @ 12 Mb/s -89 dBm @ 18 Mb/s -86 dBm @ 24 Mb/s -83 dBm @ 36 Mb/s -79 dBm @ 48 Mb/s -78 dBm @ 54 Mb/s		

Item	Specification								
	<b>2.4 GHz</b> <b>802.11n (HT20)</b> -93 dBm @ MCS0 -91 dBm @ MCS1 -89 dBm @ MCS2 -86 dBm @ MCS3 -83 dBm @ MCS4 -78 dBm @ MCS5 -77 dBm @ MCS6 -76 dBm @ MCS7 -93 dBm @ MCS8 -90 dBm @ MCS9 -88 dBm @ MCS10 -85 dBm @ MCS11 -81 dBm @ MCS12 -77 dBm @ MCS13 -76 dBm @ MCS14 -74 dBm @ MCS15			<b>5 GHz</b> <b>802.11n (HT20)</b> -92 dBm @ MCS0 -89 dBm @ MCS1 -88 dBm @ MCS2 -85 dBm @ MCS3 -82 dBm @ MCS4 -77 dBm @ MCS5 -76 dBm @ MCS6 -75 dBm @ MCS7 -91 dBm @ MCS8 -88 dBm @ MCS9 -87 dBm @ MCS10 -84 dBm @ MCS11 -81 dBm @ MCS12 -76 dBm @ MCS13 -75 dBm @ MCS14 -73 dBm @ MCS15			<b>5 GHz</b> <b>802.11n (HT40)</b> -88 dBm @ MCS0 -87 dBm @ MCS1 -85 dBm @ MCS2 -82 dBm @ MCS3 -79 dBm @ MCS4 -74 dBm @ MCS5 -73 dBm @ MCS6 -72 dBm @ MCS7 -88 dBm @ MCS8 -86 dBm @ MCS9 -84 dBm @ MCS10 -81 dBm @ MCS11 -78 dBm @ MCS12 -73 dBm @ MCS13 -72 dBm @ MCS14 -70 dBm @ MCS15		
	<b>Maximum Total Transmit Power</b>			<b>2.4 GHz</b> <ul style="list-style-type: none"><li>802.11b<ul style="list-style-type: none"><li>22 dBm (3 antennas enabled)</li></ul></li><li>802.11g<ul style="list-style-type: none"><li>22 dBm (3 antennas enabled)</li></ul></li><li>802.11n (HT20)<ul style="list-style-type: none"><li>22 dBm (3 antennas enabled)</li></ul></li></ul>			<b>5 GHz</b> <ul style="list-style-type: none"><li>802.11a<ul style="list-style-type: none"><li>22 dBm (3 antennas enabled)</li></ul></li><li>802.11n non-HT duplicate mode<ul style="list-style-type: none"><li>22 dBm (3 antennas enabled)</li></ul></li><li>802.11n (HT20)<ul style="list-style-type: none"><li>22 dBm (3 antennas enabled)</li></ul></li><li>802.11n (HT40)<ul style="list-style-type: none"><li>22 dBm (3 antennas enabled)</li></ul></li></ul>		
	<b>Note:</b> The maximum power setting will vary by channel and according to individual country regulations. Refer to the product documentation for specific details.								
	<b>Available Total Transmit Power Settings</b>	<b>2.4 GHz</b>			<b>5 GHz</b>				
		Enabled antennas:			Enabled antennas:				
		1	2	3	1	2	3		
		17 dBm	20 dBm	22 dBm	17 dBm	20 dBm	22 dBm		
		14 dBm	17 dBm	19 dBm	14 dBm	17 dBm	19 dBm		
		11 dBm	14 dBm	16 dBm	11 dBm	14 dBm	16 dBm		
		8 dBm	11 dBm	13 dBm	8 dBm	11 dBm	13 dBm		
		5 dBm	8 dBm	10 dBm	5 dBm	8 dBm	10 dBm		
		2 dBm	5 dBm	7 dBm	2 dBm	5 dBm	7 dBm		
	<b>Note:</b> The maximum power setting will vary by channel and according to individual country regulations. Refer to the product documentation for specific details.								
	<b>Integrated Antenna</b>	<ul style="list-style-type: none"><li>2.4 GHz, gain 4.0 dBi, horizontal beamwidth 360°</li><li>5 GHz, gain 4.0 dBi, horizontal beamwidth 360°</li></ul>							
	<b>External Antenna (Sold Separately)</b>	<ul style="list-style-type: none"><li>Certified for use with antenna gains up to 6 dBi (2.4 GHz and 5 GHz)</li><li>Cisco offers the industry's broadest selection of 802.11n antennas delivering optimal coverage for a variety of deployment scenarios</li></ul>							
	<b>Interfaces</b>	<ul style="list-style-type: none"><li>10/100/1000BASE-T autosensing (RJ-45)</li><li>Management console port (RJ-45)</li></ul>							
<b>Indicators</b>	<ul style="list-style-type: none"><li>Status LED indicates boot loader status, association status, operating status, boot loader warnings, boot loader errors</li></ul>								
<b>Dimensions (W x L x H)</b>	<ul style="list-style-type: none"><li>Access point (without mounting bracket): 8.7 x 8.7 x 1.84 in. (22.1 x 22.1 x 4.7 cm)</li></ul>								
<b>Weight</b>	<ul style="list-style-type: none"><li>1.9 lbs. (0.86 kg)</li></ul>								



Item	Specification
<b>Environmental</b>	<p><b>Cisco Aironet 1600i</b></p> <ul style="list-style-type: none"> <li>• Nonoperating (storage) temperature: -22 to 158°F (-30 to 70°C)</li> <li>• Nonoperating (storage) Altitude Test -25°C, 15,000 ft.</li> <li>• Operating temperature: 32 to 104°F (0 to 40°C)</li> <li>• Operating humidity: 10 to 90% percent (noncondensing)</li> <li>• Operating Altitude Test -40°C, 9843 ft.</li> </ul> <p><b>Cisco Aironet 1600e</b></p> <ul style="list-style-type: none"> <li>• Nonoperating (storage) temperature: -22 to 158°F (-30 to 70°C)</li> <li>• Nonoperating (storage) Altitude Test -25°C, 15,000 ft.</li> <li>• Operating temperature: -4 to 122°F (-20 to 50°C)</li> <li>• Operating humidity: 10 to 90 percent (noncondensing)</li> <li>• Operating Altitude Test -40°C, 9843 ft.</li> </ul>
<b>System Memory</b>	<ul style="list-style-type: none"> <li>• 256 MB DRAM</li> <li>• 32 MB flash</li> </ul>
<b>Input Power Requirements</b>	<ul style="list-style-type: none"> <li>• AP1600: 44 to 57 VDC</li> <li>• Power Supply and Power Injector: 100 to 240 VAC; 50 to 60 Hz</li> </ul>
<b>Powering Options</b>	<ul style="list-style-type: none"> <li>• 802.3af Ethernet Switch</li> <li>• Cisco AP1600 Power Injectors (AIR-PWRINJ4=, AIR-PWRINJ5=)</li> <li>• Cisco AP1600 Local Power Supply (AIR-PWR-B=)</li> </ul>
<b>Power Draw</b>	<ul style="list-style-type: none"> <li>• AP1600: 12.95 W</li> </ul> <p><b>Note:</b> When deployed using PoE, the power drawn from the power sourcing equipment will be higher by some amount dependent on the length of the interconnecting cable. This additional power may be as high as 2.45W, bringing the total system power draw (access point + cabling) to 15.4W.</p>
<b>Warranty</b>	Limited Lifetime Hardware Warranty
<b>Compliance</b>	<p><b>Standards</b></p> <ul style="list-style-type: none"> <li>• <b>Safety:</b> <ul style="list-style-type: none"> <li>◦ UL 60950-1</li> <li>◦ CAN/CSA-C22.2 No. 60950-1</li> <li>◦ UL 2043</li> <li>◦ IEC 60950-1</li> <li>◦ EN 60950-1</li> </ul> </li> <li>• <b>Radio approvals:</b> <ul style="list-style-type: none"> <li>◦ FCC Part 15.247, 15.407</li> <li>◦ RSS-210 (Canada)</li> <li>◦ EN 300.328, EN 301.893 (Europe)</li> <li>◦ ARIB-STD 33 (Japan)</li> <li>◦ ARIB-STD 66 (Japan)</li> <li>◦ ARIB-STD T71 (Japan)</li> <li>◦ AS/NZS 4268.2003 (Australia and New Zealand)</li> <li>◦ EMI and susceptibility (Class B)</li> <li>◦ FCC Part 15.107 and 15.109</li> <li>◦ ICES-003 (Canada)</li> <li>◦ VCCI (Japan)</li> <li>◦ EN 301.489-1 and -17 (Europe)</li> <li>◦ EN 60601-1-2 EMC requirements for the Medical Directive 93/42/EEC</li> </ul> </li> <li>• <b>IEEE Standard:</b> <ul style="list-style-type: none"> <li>◦ IEEE 802.11a/b/g, IEEE 802.11n, IEEE 802.11h, IEEE 802.11d</li> </ul> </li> <li>• <b>Security:</b> <ul style="list-style-type: none"> <li>◦ 802.11i, Wi-Fi Protected Access 2 (WPA2), WPA</li> <li>◦ 802.1X</li> <li>◦ Advanced Encryption Standards (AES), Temporal Key Integrity Protocol (TKIP)</li> </ul> </li> <li>• <b>EAP Type(s):</b> <ul style="list-style-type: none"> <li>◦ Extensible Authentication Protocol-Transport Layer Security (EAP-TLS)</li> <li>◦ EAP-Tunneled TLS (TTLS) or Microsoft Challenge Handshake Authentication Protocol Version 2 (MSCHAPv2)</li> <li>◦ Protected EAP (PEAP) v0 or EAP-MSCHAPv2</li> </ul> </li> </ul>

Item	Specification
	<ul style="list-style-type: none"> <li>• Extensible Authentication Protocol-Flexible Authentication via Secure Tunneling (EAP-FAST)</li> <li>• PEAPv1 or EAP-Generic Token Card (GTC)</li> <li>• EAP-Subscriber Identity Module (SIM)</li> <li>• <b>Multimedia:</b> <ul style="list-style-type: none"> <li>• Wi-Fi Multimedia (WMM™)</li> </ul> </li> <li>• <b>Other:</b> <ul style="list-style-type: none"> <li>• FCC Bulletin OET-65C</li> <li>• RSS-102</li> </ul> </li> </ul>

## 2.11 ARCHITECTURAL BUTTON, FADER & INTERFACE STATIONS: REFERENCED PRODUCT ETC UNISON HERITAGE STATIONS

### A. Button Stations

1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc.
2. Mechanical
  - a. Unison Heritage Button stations shall operate using up to ten programmable buttons.
  - b. All button stations shall be available with white, cream, ivory, gray or black faceplates and buttons.
    - 1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard.
  - c. Stations shall have indicators lights at each button or fader.
    - 1) Indicators shall be comprised of red, green and blue LED's.
    - 2) Indicator color and state (steady On, Blink, Off) shall be configured in software, and shall operate relative to the button or fader it is associated with.
  - d. All faceplates shall be designed for flush or surface mounting.
  - e. Station faceplates shall be constructed of ABS plastic and shall use no visible means of attachment.
  - f. Station faceplates shall be indelibly marked for each button or fader function.
  - g. The manufacturer shall supply back boxes for flush mounted half gang stations and for all surface mounted stations.
  - h. All Button and Button/Fader stations shall be designed to accept the infrared signal from a remote hand held IR transmitter.
    - 1) The stations shall have a 60° reception angle and shall operate reliably within a 45' distance.
  - i. IR Transmitters shall be available in seven or twelve button configurations. Custom transmitters may have up to 10 programmable buttons.
    - 1) IR transmitters shall be mounted in a hand-held black plastic controller. Transmitter dimensions shall be 1.875" wide, 6.625" long and 0.60" deep.
3. Electrical
  - a. Unison control station wiring shall be an Echelon® Link power network.
    - 1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
    - 2) Touchscreen and Interface stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.
    - 3) Network wiring may be bus, loop, home run, star or any combination of these.
    - 4) Network insulation displacement connectors shall be provided with all stations.
4. Functional
  - a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Button, Button/Fader, and Interface or Astronomical time clock controls. System shall allow the programming of presets, sequences, macros and time clock events.
    - 1) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.

- i) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
      - ii) Presets shall be selectable via button, fader, IR transmitter, time clock event, macro activation or switch interface stations.
    - 2) System macros and sequences shall be programmable via LightDesigner system software.
      - i) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
      - ii) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
    - 3) System time clock events shall be programmable via LightDesigner system software, the processor user interface, or the internal web server.
      - i) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.
      - ii) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.
  - b. Station Button, Button/Fader, and Interface control components shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.
    - 1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, cue light, or room join/separate.
    - 2) Optional fader functions include manual master control, individual zone control, fade rate control or preset master control.
  - c. Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.
- B. Button/Fader Stations
- 1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc.
  - 2. Mechanical
    - a. Unison Heritage Button/Fader Stations shall operate using up to sixteen programmable faders and twelve programmable buttons.
    - b. All button/fader stations shall be available with white, cream, ivory, gray or black faceplates, fader knobs, and buttons.
      - 1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard.
    - c. Fader stations shall utilize standard 45-millimeter slide potentiometers.
    - d. Stations shall have indicators lights at each button or fader.
      - 1) Indicators shall be comprised of red, green and blue LED's
      - 2) Indicator color and state (steady On, Blink, Off) shall be configured in software, and shall operate relative to the button or fader it is associated with.
    - e. All faceplates shall be designed for flush or surface mounting.
    - f. Station faceplates shall be constructed of ABS plastic and shall use no visible means of attachment.
    - g. Station faceplates shall be indelibly marked for each button or fader function.
    - h. The manufacturer shall supply back boxes for flush mounted half gang stations and for all surface mounted stations.
    - i. All Button and Button/Fader stations shall be designed to accept the infrared signal from a remote hand held IR transmitter.

- 1) The stations shall have a 60° reception angle and shall operate reliably within a 45' distance.
- j. IR Transmitters shall be available in seven or twelve button configurations. Custom transmitters may have up to 10 programmable buttons.
  - 1) IR transmitters shall be mounted in a hand-held black plastic controller. Transmitter dimensions shall be 1.875" wide, 6.625" long and 0.60" deep.
3. Electrical
  - a. Unison control station wiring shall be an Echelon® Link power network.
    - 1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
    - 2) Touchscreen and Interface stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.
    - 3) Network wiring may be bus, loop, home run, star or any combination of these.
    - 4) Network insulation displacement connectors shall be provided with all stations.
4. Functional
  - a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Button, Button/Fader, and Interface, or Astronomical time clock controls. System shall allow the programming of presets, sequences, macros and time clock events.
    - 1) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.
      - i) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
      - ii) Presets shall be selectable via button, fader, IR transmitter, time clock event, macro activation or switch interface stations.
    - 2) System macros and sequences shall be programmable via LightDesigner system software.
      - i) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
      - ii) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
    - 3) System time clock events shall be programmable via LightDesigner system software, the processor user interface, or the internal web server.
      - i) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.
      - ii) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.
  - b. Station Button, Button/Fader, and Interface) control components shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.
    - 1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, cue light, or room join/separate.
    - 2) Optional fader functions include manual master control, individual zone control, fade rate control or preset master control.
  - c. Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.

#### C. Connector Stations

1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc.
2. Mechanical
  - a. Unison connector stations shall provide an interface to portable Unison stations.
  - b. All connector stations shall be available with white, cream, ivory, gray or black faceplates, fader knobs, and buttons.
    - 1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard.
  - c. All faceplates shall be designed for flush or surface mounting.
  - d. Station faceplates shall be constructed of ABS plastic and shall use no visible means of attachment.
  - e. Station faceplates shall be indelibly marked for each function.
  - f. The manufacturer shall supply back boxes for flush mounted half gang stations and for all surface mounted stations.
3. Electrical
  - a. Unison control station wiring shall be an Echelon® Link power network.
    - 1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
    - 2) Touchscreen and Interface stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.
    - 3) Network wiring may be bus, loop, home run, star or any combination of these.
    - 4) Network insulation displacement connectors shall be provided with all stations.
4. Functional
  - a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Button, Button/Fader, and Interface or Astronomical time clock controls. System shall allow the programming of presets, sequences, macros and time clock events.
    - 1) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.
      - i) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
      - ii) Presets shall be selectable via button, fader, IR transmitter, time clock event, macro activation or switch interface stations.
    - 2) System macros and sequences shall be programmable via LightDesigner system software.
      - i) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
      - ii) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
    - 3) System time clock events shall be programmable via LightDesigner system software, the processor user interface, or the internal web server.
      - i) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.
      - ii) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.
  - b. Station Button, Button/Fader, and Interface control components shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.

- 1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, cue light, or room join/separate.
  - 2) Optional fader functions include manual master control, individual zone control, fade rate control or preset master control.
  - c. Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.
- D. Contact Interface Station
1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc.
  2. General
    - a. Unison Contact Interface shall provide direct interface (in and out) to external devices via contact closure. Interface enclosure shall consist of 16 input connections and 16 output connections.
  3. Mechanical
    - a. The surface mount enclosure and cover shall be constructed of 16- gauge (.08) steel and are finished in black smooth matte powder coat paint. The enclosure shall be 14" W x 10.5" H x 3" D.
    - b. Conduit access points shall be provided on the top and bottom of the unit.
    - c. The assembly shall consist of up to 16 connections; 8 inputs functionally coupled with 8 normally open relay contact outputs. Inputs and outputs may be configured as either maintained or momentary.
  4. Electrical
    - a. Unison control station wiring shall be an Echelon® Link power network.
      - 1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
      - 2) Touchscreen and Interface stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.
      - 3) Network wiring may be bus, loop, home run, star or any combination of these.
      - 4) Network insulation displacement connectors shall be provided with all stations.
    - b. Ratings:
      - 1) The Input Rating shall be 5V@10mA (unit requires dry contact closure)
      - 2) Dry contact outputs shall consist of:
        - i) Normally-Open 2-pole contact closure outputs: 1A@30Vdc & .5A@120V.

## 2.12 LIGHTING CONTROL SYSTEM CONFIGURATION & CONTROL SOFTWARE: REFERENCED PRODUCT ETC LIGHTDESIGNER

- A. System Configuration
1. The Unison Paradigm LightDesigner software program shall be an application software package that facilitates off-line Unison Paradigm control system configuration. LightDesigner shall also enable a computer to be connected on-line with a Unison Paradigm lighting control system for real time preset selection, editing and recording.
    - a. Software setup shall include Configuration and Space (Room) Wizards, Zone, Preset, Sequence, Station and Wall Properties, Touchscreen Station Setups, Time clock Events and Macros.
    - b. The software program shall be supplied complete with Operators Manual and software disk.
  2. Functions
    - a. Configuration and Room Wizards
      - 1) The software shall provide easy step-by-step wizards to allow configuration of rooms, channels, walls and control stations.

- 2) The program shall allow setup of all system parameters including quantity of rooms, dimmers, zones, presets and control stations. System limitations shall be based on system's Unison processor.
- 3) System program shall support a graphic display of individual rooms, showing zones, presets, control stations and moveable wall placement. Systems with non-graphic displays shall not be acceptable.
- 4) Software shall support the programming and operation of multi-sectioned rooms with moveable partitions.
- 5) LightDesigner shall support the programming of station and component electronic security.
- 6) LightDesigner shall support the transfer of architectural system configurations to processors via Secure Digital (SD) Cards, USB Flash Drives, or Ethernet.
- b. Zone, Preset, Station and Wall Properties
  - 1) LightDesigner shall support the configuration of system zone properties. Configurable zone properties shall include zone name, input mode, dimmer to zone patch, and maximum and minimum zone levels.
  - 2) LightDesigner shall support the configuration of system-preset properties. Configurable preset properties shall include preset name and fade time. Presets shall have a discrete fade time, programmable from zero to 86,400 seconds with a resolution of one hundred milliseconds.
  - 3) LightDesigner shall support the custom programming of control station buttons and faders. Button function assignments shall include Preset (last action, pile on, or toggle), Off, Manual, Zone, Record, Raise, Lower, Wall (toggle or direct) Lockout (toggle or direct), No Action, and Macro. Button properties shall include Lockout Level and Legend. Fader assignments shall include Zone, Preset, Master, and Fade time. Fader properties shall include Lockout Level and Legend.
  - 4) LightDesigner shall support the configuration of system wall properties. Configurable wall properties shall include wall name.
- c. Time clock Events and Macros
  - 1) LightDesigner software shall support the programming of Astronomical Time Clock (ATC) events for up to ten standard day types and up to 24 custom day types. ATC events include selection of presets or macros. ATC events shall be triggered by sunrise, sunset, time of day and/or periodically.
  - 2) LightDesigner software shall support the programming of multifunction macro sequences. Macros shall be activated via buttons on any Unison station, or via time clock event.
- B. Touchscreen Station Configuration
  1. The Unison Paradigm Control Designer software program shall be an application software package that facilitates off-line Unison Paradigm Touchscreen station configuration.
    - a. Software setup shall include Configuration and Design Wizards, to create a graphical representation of a control environment.
    - b. The software program shall be downloadable from the manufacturer's website free of charge.
  2. Functions
    - a. Touchscreen Setup shall include standard or custom control pages. Standard page types shall include zone, preset, wall, or security.
    - b. Each page may contain graphic objects including buttons, straight or curved faders, and other graphic controls. Pages may also contain imported bitmap images, pop-up windows, animations, numeric keypads, tabs, and clocks.
    - c. Object Assignments shall include any Action assignable within the System.
    - d. It shall be possible to adjust LCD contrast and brightness. It shall also be possible to program the station to dim to any level during periods of inactivity.

C. Minimum Computer Requirements

1. The software shall require the Windows XP SP2 (Home or Pro) operating system running on a x86-Windows-compatible computer (2 GHz Pentium 4 or better) with a minimum of 1 GB of hard drive space and 1 GB RAM, OpenGL graphics acceleration, a monitor capable of displaying at least 1024 x 768 screen resolution, a CD-ROM optical drive, Ethernet port, USB port or SD card slot, keyboard and mouse.
2. Contractor shall provide computer with minimum requirements as listed above. See TL series drawings for more information on specific computer and related devices to provide for the lighting system control software.

**2.13 PURE SINE WAVE UNINTERRUPTIBLE POWER SUPPLY WITH SURGE SUPPRESSION AND POWER FILTRATION: REFERENCED PRODUCT MIDDLE ATLANTIC PREMIUM SERIES UPS-1000R/2200R RACKMOUNT UNINTERRUPTABLE POWER SUPPLY**

A. General

1. Provide the specific model of backup UPS as listed on the contract documents *and* as is needed based upon the plugged equipment power requirements (provide per intended load, regardless of what is shown on contract documents).

B. Specifications

1. Rackmount Uninterruptible Power Supply (UPS) shall be Middle Atlantic Products model # UPS- \_\_ R\_\_ (refer to chart). UPS shall be line interactive with AVR. Unit shall measure 19.00" W x 3.50" H x 19.00" D and occupy 2 rackspaces. UPS shall have a rear mounting range of 19" to 32" and not require more than one person to mount. Unit shall operate on 120 VAC/60Hz current. Unit shall have a nominal output of 120V. Unit shall have a capacity of \_\_ VA and \_\_ W (refer to chart). Unit shall have (8) NEMA 5- \_\_ receptacles on the rear of the unit (refer to chart). Unit shall have a priority outlet bank consisting of 4 outlets dedicated to ensure maximum run time of critical components. Unit shall have a non-critical outlet bank consisting of 4 outlets dedicated to load shedding, or individual outlet control, depending on model. Unit shall be IP enabled, depending on model, or when used with option IP Expansion card, model# UPS-IPCARD. Rackmount UPS shall include a 9' \_\_ (refer to chart) SignalSAFE™ power cord with NEMA \_\_ (refer to chart) plug. UPS shall have surge suppression that utilizes a clean line-to-neutral design that does not pass noise contamination to ground. Rackmount UPS shall have a hot swappable battery that allows for a \_\_ minute run time at half load and a \_\_ (refer to chart) minute run time at full load. Rear of unit shall have inputs that allow for the installation of up to 10 additional hot swappable batteries. Rackmount UPS shall be RoHS EU Directive 2002/95/ EC compliant. Rackmount UPS shall utilize Middle Atlantic Power Manager™ software. Rackmount UPS shall be warrantied to be free from defects in materials and workmanship under normal use and conditions for a period of 3 years; battery shall be warrantied for a period of 2 years. Rackmount UPS shall be UL listed in US and Canada.

C. Features:

1. Pure Sine Wave technology with Automatic Voltage Regulation to improve the quality of power provided to the A/V system
2. Surge suppression utilizes a clean line-to-neutral design that does not pass noise contamination to ground
3. Models with bank control available
4. Individual outlet control available
5. Internet enabled models available, which include: - Real time UPS monitoring via the Web - Remote management and configuration of UPS via Web Browser or NMS (Network Management System) - Auto-shutdown to protect servers/workstations from data loss due to power failure - Schedule shutdown/start-up/reboot of the UPS - Event logging to trace UPS operational history - Data logging for analyzing power conditions - Event notification via email and SNMP traps - Supports TCP/IP, SNMP/HTTP, NTP, DNS, SMTP protocol - MIB (Management Information Base) provided - Quick installation and user friendly interface - User upgradeable firmware via FTP - Security management provided



6. Control system integration via RS-232 and USB and analog I/O
  7. Load shedding allows extended run time for system-critical components by disconnecting power to less-critical components
  8. Line Interactive Technology
  9. Power Manager software allows extensive configuration and event notification capabilities
  10. Energy Saver design reduces power consumption by up to 75% when compared with traditional UPS designs
  11. 9' SignalSAFE™ power cord minimizes stray magnetic fields
  12. UL Listed in the US and Canada
- D. Accessories (Provide with all accessories listed on the contract drawings):
1. UPS-IPCARD - Web based control shall be enabled on non-internet enabled Middle Atlantic Products UPS by UPS-IPCARD, which shall be installed into the Expansion Port on the rear of the UPS. This shall be compatible with UPS firmware v1.65 or greater, and provide full functionality when used on models with firmware v1.75 or greater.
  2. UPS-RLCARD - Remote shutdown of the UPS shall be enabled on non-internet enabled Middle Atlantic Products UPS by UPS-RLCARD, which shall be installed into the Expansion Port on the rear panel of the UPS. This shall be compatible with UPS firmware v1.65 or greater. A user supplied remote push button and external +12VDC source shall be connected to the DB-9 connector on the UPS-RLCARD to activate the remote shutdown feature.
  3. Expansion Battery - Rackmount expansion battery pack shall be Middle Atlantic Products model# UPS-EBPR. Expansion battery pack shall be suitable for use with both UPS-1000R and UPS-2200R. UPS-EBPR shall measure 19.00" W x 3.50" H x 19.29" D and occupy 2 rackspaces. UPS-EBPR shall require 22.66" useable depth. With \_\_\_ hot swappable batteries connected to the unit, there is a \_\_\_ minute run time at half load and a \_\_\_ minute run time at full load (refer to chart). Rackmount expansion battery pack shall be warrantied for a period of 2 years.
  4. Replacement Battery - Replacement Battery Pack for the UPS shall be Middle Atlantic Products model # UPS-RBP. Replacement battery pack shall be suitable for use with both UPS-1000R\_\_ and UPS-2200R\_\_. Replacement battery shall be warrantied to be free from defects in materials and workmanship under normal use and conditions for a period of 2 years.
- E. Technical Specifications:

## UPS-1000 Series

Utility Voltage (AC)	≤ 80	81-105	106-133	133-147	>147
Fans Engaged	front & rear	rear only	none	rear only	front & rear
dBA above Ambient	22dBA	11dBA	0	11dBA	22dBA

## UPS-2200 Series

Utility Voltage (AC)	≤ 80	81-105	106-133	133-147	>147
Fans Engaged	Front & Rear	Rear only	None	Rear Only	Front & Rear
dBA above Ambient	27dBA	14dBA	0	14dBA	27dBA

Model#	Capacity	Outlet Control	Internet enabled
UPS-1000R	1000VA	critical / non-critical bank	w/ optional UPS-IPCARD
UPS-1000R-IP	1000VA	critical / non-critical bank	yes
UPS-1000R-8	1000VA	individual outlet	w/ optional UPS-IPCARD
UPS-1000R-8IP	1000VA	individual outlet	yes
UPS-2200R	2150VA	critical / non-critical bank	w/ optional UPS-IPCARD
UPS-2200R-IP	2150VA	critical / non-critical bank	yes
UPS-2200R-8	2150VA	individual outlet	w/ optional UPS-IPCARD
UPS-2200R-8IP	2150VA	individual outlet	yes

		UPS-1000R Series	UPS-2200R Series
Input	Nominal Input Voltage	120 V	120 V
	Input Voltage Range	80VAC – 145VAC	80VAC – 145VAC
	Input Frequency	60 Hz +/- 3 Hz (auto sensing)	60 Hz +/- 3 Hz (auto sensing)
	Input Protection Type	Resettable thermal fuse	Resettable thermal fuse
	Cord Length / Cord Type / Plug Type	9 ft. / 14/3 / NEMA 5-15P	9 ft. / 12/3 / NEMA 5-20P
Output	Green Mode Consumption	Less than 9W at full battery capacity	Less than 9W at full battery capacity
	Nominal Output Voltage	120 V	120 V
	Capacity (VA)	1000VA	2150VA
	Capacity (Watts)	750W	1650W
	Waveform	Pure Sine Wave	Pure Sine Wave
	On Line Output Frequency	57 - 63 Hz for 60 Hz nominal	57 - 63 Hz for 60 Hz nominal
	On Battery Output Frequency	60 Hz +/- .1 Hz	60 Hz +/- .1 Hz
	Transfer Time (Typical)	4 ms typical line to battery / battery to line	4 ms typical line to battery / battery to line
	Overload Protection (on line mode)	100%≤ Load< 110% warning, 120 sec shutdown 110%≤ Load< 125% warning, 40 sec shutdown 125%≤ Load warning, 10 sec shutdown	100%≤ Load< 110% warning, 120 sec shutdown 110%≤ Load< 125% warning, 40 sec shutdown 125%≤ Load warning, 10 sec shutdown
Total Harmonic Distortion (THD) *typical 120V power with 2%-4% THD	Overload Protection (on battery mode)	100%≤ Load< 110% warning, 30 sec shutdown 110%≤ Load< 125% warning, 10 sec shutdown 125%≤ Load warning, 3 sec shutdown	100%≤ Load< 110% warning, 30 sec shutdown 110%≤ Load< 125% warning, 10 sec shutdown 125%≤ Load warning, 3 sec shutdown
	Total System Load	0%                      20%	60%                      100%
	Utility Mains* THD	2.0%                      2.0%	2.0%                      2.0%
Surge Protection & Filtering	Battery Backup THD	1.9%                      1.3%	1.5%                      5.2%
	Lightning / Surge Protection	L-N=>381 J (127J x 3) Clamp voltage 270V (Max energy 10 / 1000 μs)	L-N=>381 J (127J x 3) Clamp voltage 270V (Max energy 10 / 1000 μs)
Physical	RJ11 / RJ45 Protection	Sidactorx1 Clamp Voltage 275V Fuse (.75A / 250V) x 2	Sidactorx1 Clamp Voltage 275V Fuse (.75A / 250V) x 2
	Output Receptacles	(8) NEMA 5-15R	(8) NEMA 5-20R
	Dimensions (in.)	19.00" [423] W x 3.50" [89] H x 19.29" [490] D	19.00" [423] W x 3.50" [89] H x 19.29" [490] D
Battery	Weight (lb.)	68 lbs.	77 lbs.
	Rating	12V / 9.0 AH x 4	12V / 9.0 AH x 4
	Auto Charger	1A	1A
	Hot Swappable External Battery	Yes	Yes
	Run Time at Half Load	26 minutes	13 minutes
Warning Diagnostics	Run Time at Full Load	13 minutes	6.4 minutes
	Control Panel	LCD Display Indicators, Power On	LCD Display Indicators, Power On
Environmental	Audible Alarms	On Battery, Low Battery	On Battery, Low Battery
	Operating Temperature	32°F to 104°F ( 0°C to 40°C)	32°F to 104°F ( 0°C to 40°C)
	Operating Relative Humidity	0 to 95% Non-Condensing	0 to 95% Non-Condensing

		UPS-1000R Series	UPS-2200R Series
Communication	Software	Middle Atlantic Power Manager™	Middle Atlantic Power Manager™
Management	Self-Test	Manual Self-Test via front panel	Manual Self-Test via front panel
	Auto-Charger/ Auto-Restart	yes	yes
	COM Interface	Primary: - RS232 Communication + Control - Analog Status Notification + Control Secondary: - Analog status notification only	Primary: - RS232 Communication + Control - Analog Status Notification + Control Secondary: - Analog status notification only
	Built-in USB Interface	yes	yes

Estimated Run Times UPS-1000R Series								
Load (VA)	120	240	360	480	600	720	840	960
Load (W)*	84	168	252	336	420	504	588	672
Load (A)	1	2	3	4	5	6	7	8
# of expansion batteries	Estimated Run Time (Minutes)							
UPS only	102	51	34	26	20	17	15	13
1	561	283	190	143	114	94	80	69
2	1020	515	345	260	207	171	145	125
3	1479	747	501	377	300	249	211	181
4	1938	979	657	494	394	326	276	238
5	2397	1211	813	611	487	403	341	294
6	2856	1443	968	728	580	480	407	350
7	3315	1676	1124	845	674	557	472	406
8	3774	1908	1280	962	767	635	537	463
9	4233	2140	1435	1079	860	712	603	519
10	4692	2372	1591	1196	954	789	668	575

\*Assuming a Power Factor of .7

Estimated Run Times UPS-2200R Series																
Load (VA)	120	240	360	480	600	720	840	960	1080	1200	1320	1440	1560	1680	1800	1920
Load (W)*	90	180	270	360	450	540	630	720	810	900	990	1080	1170	1260	1350	1440
Load (A)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
# of expansion batteries	Estimated Run Time (Minutes)															
UPS only	102	51	34	26	20	17	15	13	11	10	9	9	8	7	7	6
1	561	283	190	143	114	94	80	69	60	53	47	42	37	33	29	26
2	1020	515	345	260	207	171	145	125	109	96	84	75	66	58	51	45
3	1479	747	501	377	300	249	211	181	158	139	122	108	95	84	74	64
4	1938	979	657	494	394	326	276	238	207	181	160	141	124	109	96	84
5	2397	1211	813	611	487	403	341	294	256	224	197	174	153	135	118	103
6	2856	1443	968	728	580	480	407	350	305	267	235	207	182	161	141	122
7	3315	1676	1124	845	674	557	472	406	353	310	272	240	212	186	163	142
8	3774	1908	1280	962	767	635	537	463	402	352	310	273	241	212	185	161
9	4233	2140	1435	1079	860	712	603	519	451	395	348	306	270	237	208	181
10	4692	2372	1591	1196	954	789	668	575	500	438	385	339	299	263	230	200

\*Assuming a Power Factor of .75

## 2.14 FOUR COLOR MIXING LIGHT EMITTING DIODE WASH FIXTURE: REFERENCED PRODUCT ETC COLORSOURCE PAR LED

### A. General

1. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a ColorSource Par as manufactured by Electronic Theatre Controls, Inc. or approved equal.
2. All LED fixtures shall be provided by a single manufacturer to ensure compatibility
3. The fixture shall be UL 1573 listed for stage and studio use
4. The fixture shall comply with the USITT DMX-512 A standard

### B. Physical

1. The fixture shall be contained in a rugged all-metal die-cast housing, free of burrs and pits.
2. The housing shall have a rugged black powdercoat finish
  - a. White or silver/gray powdercoat finishes shall be available as color options
  - b. Other powdercoat color options shall be available on request
3. Power supply, cooling and electronics shall be integral to each unit.
4. Fixture housing shall provide two easy-access slots for secondary lenses and other accessories

- a. Slots shall be equipped with locking retaining clip
- 5. The unit shall ship with:
  - a. Theatrical-style hanging yoke as standard
  - b. 5' power lead with Edison connector as standard
- 6. Available options shall include but not be limited to:
  - a. Floor stand conversion Kit
  - b. Bare-end, Stage-Pin or Twist-lock type-equipped power leads
  - c. PowerCon to PowerCon cables for fixture power linking
  - d. Multiple secondary lens options to include multiple angles in the following patterns:
    - 1) Linear
    - 2) Round
    - 3) Oblong
- 7. Light output shall be via a round aperture
  - a. Aperture and accessory slots shall accommodate standard 7.5" accessories such as used in other similar-sized fixtures
  - b. Accessories available as options shall include but not be limited to:
    - 1) Gel/diffusion frames
    - 2) Top hats
    - 3) Barndoors
    - 4) Egg crate louvers
    - 5) Concentric ring louvers
    - 6) Multiple secondary lensing options
- C. ENVIRONMENTAL AND AGENCY COMPLIANCE
  - 1. The fixture shall be UL and cUL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
  - 2. The fixture shall be UL LISTED to the UL1573 standard for stage and studio use
  - 3. The fixture shall be rated for IP-20 dry location use.
- D. THERMAL
  - 1. The fixture shall be cooled with a variable speed fan.
  - 2. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 20,000 hours of use
    - a. Thermal management shall include multiple temperature sensors within the housing to include:
      - 1) The LED array
      - 2) The control board
  - 3. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40°C (104°F) maximum ambient temperature.
- E. ELECTRICAL
  - 1. The fixture shall be equipped with 100V to 240V 50/60 Hz internal power supply
  - 2. The fixture shall support power in and thru operation
    - a. Power in shall be via Neutrik® PowerCon™ input connector
    - b. Power thru shall be via Neutrik® PowerCon™ output connector
    - c. Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker
  - 3. The fixture requires power from non-dim source
  - 4. Power supply outputs shall have self-resetting current limiting protection
  - 5. Power supply shall have power factor correction
- F. LED Emitters
  - 1. The fixture shall contain 4 different LED colors to provide color characteristics as described in Section H below.

2. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
    - a. Fixture shall utilize Luxeon® Z™ LED emitters
  3. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
  4. LED emitters should be rated for nominal 20,000 hour LED life to 70% intensity
  5. All LED fixtures (100% of each lot) shall undergo a minimum three-hour burn-in test during manufacturing.
  6. LED system shall comply with all relevant patents
- G. CALIBRATION
1. Fixture shall be calibrated at factory for achieve consistent color between fixtures built at different times and/or from different LED lots or bins
    - a. Calibration data shall be stored in the fixture as a permanent part of on-board operating system
    - b. All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency
    - c. Fixtures not offering LED calibration shall not be acceptable
- H. COLOR
1. The fixture shall utilize an minimum of 40 LED emitters
    - a. These emitters shall be made up of Red, Green, Blue and Lime
- I. DIMMING
1. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
  2. The dimming curve shall be optimized for smooth dimming over longer timed fades.
  3. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)
  4. LED control shall be compatible with broadcast equipment in the following ways:
    - a. PWM control of LED levels shall be imperceptible to video cameras and related equipment
    - b. PWM rates shall be adjustable by the user via RDM to avoid any visible interference to video cameras and related equipment
- J. CONTROL AND USER INTERFACE
1. The fixture shall be USITT DMX 512A-compatible via In and Thru 5-pin XLR connectors
  2. The fixture shall be compatible with the ANSI RDM E1.20 standard
    - a. All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console
    - b. Temperature sensors within the luminaire shall be viewable in real time via RDM
    - c. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
  3. The fixture shall be equipped with a 7-segment display for easy-to-read status and control
  4. The fixture shall be equipped with a three-button user-interface
  5. The fixture shall offer RGB control
  6. The fixture shall operate in Regulated mode for droop compensation
  7. The fixture shall offer stand-alone functionality eliminating the need for a console
    - a. Fixture shall ship with 12 preset colors accessible as a stand-alone feature
    - b. Fixture shall ship with 5 Sequences accessible as a stand-alone feature
    - c. Each color and sequence can be modified by the end user
    - d. Fixtures can be linked together with standard DMX cables and controlled from designated master fixture
      1. Up to 32 fixtures may be linked
    - e. Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming

- f. Fixtures without stand-alone operation features described in a, b, c, d, and e shall not be acceptable.

## **2.15 4-COLOR MIXING LIGHT EMITTING DIODE ELLIPSOIDAL ZOOM FIXTURE: REFERENCED PRODUCT ETC COLORSOURCE SPOT JR. LED**

### **A. General**

1. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a ColorSource Spot Jr. or ColorSource Spot Jr. Deep Blue as manufactured by Electronic Theatre Controls, Inc. or approved equal.
2. All LED fixtures shall be provided by a single manufacturer to ensure compatibility
3. The fixture shall be UL 1598 listed
4. The fixture shall comply with the USITT DMX512-A standard
5. The fixture shall be provided with the minimum warranty of 5 years full fixture coverage and 10 years LED array coverage
6. ColorSource Spot Jr. and ColorSource Spot Jr. Deep Blue
  - a. The fixture shall have LM-80 testing for all LEDs with a L70 rating of no less than 54,000 hours

### **B. Physical**

1. The unit shall be constructed of rugged Acrylonitrile butadiene styrene (ABS) plastic
2. The unit shall utilize a 7-segment display for settings and operation
3. The following shall be provided:
  - a. 0.024" full hard 301 stainless steel shutters
  - b. Rugged steel yoke with two mounting positions allowing 300+ rotation of the fixture within the yoke
4. The housing shall be available in black or white
5. Power supply, cooling and electronics shall be integral to each unit.
6. The unit shall ship with:
  - a. Theatrical style hanging yoke as standard
  - b. 5' cable with Neutrik powerCON connector as standard
7. Available options shall include but not be limited to:
  - a. Bare-end, Stage-Pin or Twist-lock type-equipped power leads
  - b. PowerCON to powerCON cables for fixture power linking
  - c. Smooth Wash Diffuser for overlapping beams of light from multiple fixtures
  - d. Accessory holder

### **C. Optical**

1. The light beam should have a 2-to-1 center-to-edge drop-off ratio
2. The unit shall provide, but not be limited to:
  - a. Low gate and beam temperature
  - b. Sharp imaging through a three-plane shutter design
3. The unit shall provide, but not be limited to:
  - a. Sharp shutter cuts without halation
  - b. Shutter warping and burnout in normal use shall be unacceptable
  - c. Adjustable hard and soft beam edges
4. The unit shall have a 55mm gate
  - a. Shall utilize an M-sized pattern holder
5. Environmental and Agency Compliance
6. The fixture shall be ETL and cETL LISTED and/or CE rated and shall be so labeled when delivered to the job site.
7. The fixture shall be ETL LISTED to the UL1598
8. The fixture shall be rated for IP-20 dry location use.
9. Thermal
10. Fixture shall be equipped with a cooling fan.

11. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 54,000 hours of use
    - a. Thermal management shall include multiple temperature sensors within the housing to include:
      - 1) LED array circuit board temperatures
      - 2) Fixture ambient internal temperature
  12. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40°C (104°F) maximum ambient temperature.
- D. Electrical
1. The fixture shall be equipped with a 100V to 240V 50/60Hz internal power supply
  2. The fixture shall support power in and thru operation
    - a. Power in shall be via Neutrik® powerCON™ input connector
    - b. Power thru shall be via Neutrik® powerCON™ output connector
    - c. Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker
  3. The fixture requires power from a non-dim source
  4. Fixtures shall have droop compensation to prevent thermal shift of color or intensity
  5. Power supply outputs shall have self-resetting current-limiting protection
  6. Power supply shall have power factor correction
- E. LED Emitters
1. The fixture shall contain a minimum of four different LED colors to provide color characteristics as described in the Color Section below
  2. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
    - a. Fixture shall utilize Luxeon® C LED emitters
  3. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
  4. LED emitters should be rated for nominal 54,000-hour L70
  5. LED system shall comply with all relevant patents
  6. Calibration
  7. Fixture shall be calibrated at factory to achieve consistent color and intensity output between fixtures built at different times and/or from different LED lots or bins
    - a. Calibration data shall be stored on the control card as a permanent part of on-board operating system
    - b. All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency
    - c. Fixtures not offering LED calibration shall not be acceptable
- F. Color
1. The fixture shall utilize a minimum of 52 LED emitters
    - a. These emitters shall be made up of Red, Green, Blue and Lime for ColorSource Spot Jr.
    - b. These emitters shall be made up of Red, Green, Indigo and Lime for ColorSource Spot Jr. Deep Blue
- G. Dimming
1. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
  2. The fixture shall utilize an Incandescent dimming curve
  3. Dimming curve shall be optimized for smooth dimming over longer timed fades.
  4. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)
  5. LED control shall be compatible with broadcast equipment in the following ways:
    - a. PWM control of LED levels shall be imperceptible to video cameras and related equipment



- b. PWM shall be capable of being set via RDM to 25,000hz
- H. Control and User interface
  - 1. The fixture shall be USITT DMX512-A compatible via In and Thru 5-pin XLR connectors
  - 2. The fixture shall be compatible with the ANSI RDM E1.20 standard
    - a. All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console
    - b. Temperature sensors within the luminaire shall be viewable in real time via RDM
    - c. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
  - 3. The fixture shall be equipped with a 7-segment display
  - 4. The fixture shall be equipped with a three-button user-interface
  - 5. A variable-rate strobe channel shall be provided
  - 6. The fixture shall offer stand-alone functionality eliminating the need for a console
    - a. Fixture shall ship with 12 preset colors or color temperatures accessible as a stand-alone feature
    - b. Fixture shall ship with 5 sequences accessible as a stand-alone feature
    - c. Each color and sequence can be modified by the end user via RDM
    - d. Fixtures can be linked together with standard DMX cables and controlled from designated master fixture
      - 1) Up to 32 fixtures may be linked
    - e. Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming
    - f. Fixtures without stand-alone operation features described above shall not be acceptable.

## **2.16 SINGLE PORT DMX ETHERNET NODE: REFERENCED PRODUCT PATHWAY CONNECTIVITY PATHPORT UNO**

- A. General
  - 1. The Pathport Uno shall be a single-port TCP/IP-compliant gateway node to encode, route and decode DMX data over Ethernet.
  - 2. The node shall support the following protocols for DMX-over-Ethernet transport: Pathport, streaming ACN (Net 3), Strand Shownet, ArtNet. The node shall support, as an output device only, ETC Net2.
  - 3. The node shall incorporate one 5-pin XLR connector mounted on the front face. A female connector shall be used on a nominal output node. A male connector shall be used on a nominal input node.
  - 4. The node shall incorporate one female RJ45 connector mounted on the circuit board for connection to standard Ethernet wiring.
  - 5. The node shall operate as a 10MB device.
- B. Appearance
  - 1. The node shall be mounted on a mild steel, single-gang Decora-style faceplate and shall fit a standard, deep back box.
  - 2. Finish shall be matte black or stainless steel.
  - 3. The node shall be of pleasing appearance, suitable for high-visibility architectural locations.
  - 4. There shall be two status LED's on the face: one blue LED shall indicate an active network link; one green LED shall indicate active DMX.
  - 5. There shall be an "identify" function available through management software that shall flash the two LED's together at twice their normal brightness.
- C. Power
  - 1. The node shall only operate on IEEE 802.3af Power-over-Ethernet, supplied by an IEEE 802.3af compliant Ethernet switch (by others) or in-line power supply.

2. The node's DMX port shall withstand fault voltages of up to 250VAC without damage.

D. Configuration

1. The node shall be available in DMX input and DMX output versions.
2. The node shall be fully and remotely configurable using Pathport Manager software running on a Java-enabled PC or Mac connected to the Ethernet network. Pathport Manager software shall not be required for regular operation of the node. Configuration shall include but not be limited to:
  3. Each node shall accept a user-defined name and IP address.
  4. Port direction shall be reversible.
  5. DMX output refresh rate shall be user-selectable.
  6. Each node shall manage up to 128 DMX universes.
  7. Custom channel patches shall be possible, allowing the routing of any input universe or channel to any output location in any order.
  8. HTP merging and/or signal prioritizing shall be possible of up to eight input channels to create one output channel.
  9. DMX-over-Ethernet transmit and receive protocols shall be user-selectable.
  10. Each node's configuration, patching and routing shall be stored locally in the node in non-volatile memory. The node shall recover from power interruption without use of configuration software.
  11. Multiple nodes on the same network may be remotely configured over the same Ethernet connection.
  12. Each node shall incorporate a four-position jumper switch for hard selection of DMX universes one through four.

E. Compliance

1. The Pathport Uno shall be ETL-listed as a conforming low-voltage device.
2. The Pathport Uno shall be compliant with the RoHS directive.
3. The Pathport Uno shall be a conforming CE device.
4. Each node shall be fully compliant with ANSI E1.11 DMX512A and ANSI E1.20 Remote Device Management standards.

## **2.17 NETWORK DATA DISTRIBUTION DEVICE: REFERENCED PRODUCT ETC NET 3 TWO-PORT GATEWAY**

A. General

1. The lighting control gateway shall be a microprocessor-based unit specifically designed to provide DMX-512 control of stage, studio and entertainment lighting systems. The gateway shall permit DMX-512 data to be encoded, routed over Ethernet and decoded back to DMX-512. The unit shall be a Net3 DMX 2-port Gateway as provided by ETC, Inc.
2. Gateways shall communicate over Ethernet directly with at least ETC, Inc.'s entertainment and architectural lighting control products and other Ethernet interfaces.
3. Connections shall be made between gateways, consoles, architectural systems, and PCs over standard Ethernet distribution systems using 10/100BaseT.
4. The unit shall support ESTA ACN and Streaming ACN
5. The unit shall support the ETCNet2 protocol suite.
6. The unit shall be tested to UL standards and labeled ETL Listed.
7. The unit shall be RoHS Compliant (lead-free).
8. The unit shall be CE compliant.
9. The gateway shall have a backlit graphic LCD display for identification (soft-labeling) and status reporting. Labeling shall be user configurable using Gateway Configuration Editor (GCE). Each gateway shall also have power and network activity LED's on both the front and rear of the unit. The LCD display shall show DMX port configuration indication as well as indicate the presence of valid DMX/EDMX signal. Units that do not indicate port configuration (input/output) and valid DMX/EDMX data shall not be allowed.

**B. DMX Ports**

1. DMX Ports shall comply with the requirements of the USITT DMX512 and ANSI E1.11 DMX512-A standards.
2. The DMX port shall be software-configurable for either input or output.
3. Hardware configuration override setting shall be provided on the gateway.
4. DMX input shall be fully opto-isolated from the gateway electronics.
5. DMX output shall be earth-ground referenced.
6. DMX Port shall be capable of withstanding fault voltages of up to 250VAC without damage.
7. Each port shall incorporate one 5-pin XLR type connector. A DMX Output port shall utilize female connectors and a DMX input port shall utilize male connectors.

**C. Processor**

1. Each gateway shall have sufficient processing power to manage up to 64,279 DMX universes (32,910,848 DMX addresses).
2. Maximum delay time from input to output shall not be greater than one packet time (approximately 22 msec.).
3. A minimum DMX update rate of 40Hz shall be sustained under all conditions unless specifically configured for a slower rate for the sake of compatibility of older 3<sup>rd</sup> party DMX devices.

**D. Mechanical**

1. Wall Mount/Portable gateway
  - a. The Wall mount Gateway will be fabricated of .16-gauge steel, finished in fine-texture, scratch-resistant, black powder coat. Suitable enclosures for the gateway shall include 2-gang standard or deep backbox.
  - b. The weight of the gateway shall be 2.5 lbs (1.1 kg).

**E. Power**

1. Power for the gateway shall be provided either over the Category 5 (or better) cable, from 48V IEEE 802.3af compliant Power over Ethernet distribution equipment, or via conventional switches together with isolated in-line power supplies capable of an operating range of 8-28vDC provided by the gateway manufacturer. Power consumption shall not be greater than 5 watts.
2. The gateway electronics shall be electrically isolated from the power supplied over the Cat5 cable.
3. Power may be provided from IEEE 802.3af compliant power-over Ethernet distribution equipment, or by using conventional switches together with isolated in-line power supplies as provided by gateway manufacturer.

**F. Configuration**

1. Each gateway on the network shall be individually configurable using ETCNet 3 Gateway Configuration Editor, running on a PC connected to the network. The PC shall only be required for configuration, labeling and signal routing, and shall not be required for normal operation of the system.
2. Each DMX gateway shall control up to 512 DMX addresses, within the confines of 64,279 DMX "universes". The specific DMX data input or output by the gateway shall be freely configurable by the user. Duplicate outputs of DMX lines (DMX splitter) and discrete outputs shall be fully supported.
3. Any number of DMX universes may be configured with any length up to 512 addresses as long as the total does not exceed 32,767. Any range of DMX addresses may be selected for each. Multiple sources may be combined and a priority may be assigned to each source. Each DMX line may have its own start address and offset for ease of use.
4. All relevant routing information shall be stored in non-volatile memory at each gateway. The system shall recover from a power outage without requiring the PC to be online.

**G. Network**

1. Communications physical layer shall comply with IEEE 802.3i for 10BASE-T, 802.3u for 100BASE-TX and 802.3af for Power over Ethernet specifications.
  2. All network cabling shall be Category 5 or better (for 5e and Category 6), conforming to TIA-568A/B, and shall be installed by a qualified network installer.
  3. Data transport shall utilize the TCP/IP suite of protocols to transfer the DMX data.
  4. ESTA ACN and streaming ACN shall be supported.
  5. Switches shall comply with power-over-Ethernet IEEE802.3af, unless a separate in-line power supply is provided.
  6. Multiple DMX signal routing patches and multiple facilities shall be specifically supported and limited only by the file storage capacity of the computer with ETC Network Configuration Editor Software installed.
  7. Each DMX gateway shall control up to 512 DMX addresses, per port within the confines of up to 64 DMX (32,767 EDMX addresses) "universes" when using EDMX and 64279 "universes" (32,910,848 DMX addresses) when using Streaming ACN. Any range of DMX addresses may be selected for each. Multiple sources may be combined and a priority may be assigned to each source. Each DMX line may have its own start address and offset for ease of use.
  8. Units shall have built in DMX merger on a universe or channel-by-channel basis.
  9. Units shall have built in prioritizer on a universe or channel-by-channel basis.
- H. Environmental
1. The ambient operating temperature shall be 0° to 40°C (32° to 104°F).
  2. The storage temperature shall be -40° to 70°C (-40° to 158°F).
  3. The operating humidity shall be 5% - 95% non-condensing.
- I. Accessories - Provide the following:
1. Net3 Gateway Configuration Editor (GCE) software
- J. System Requirements
1. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by Electronic Theatre Controls Inc. of Middleton, WI.
  2. Provide Ethernet switches and power supplies as scheduled and as shown on drawings.
  3. Provide a current generation PC with Windows operating system and a 10/100 Ethernet card.

## 2.18 POWER DISTRIBUTION EQUIPMENT:

- A. General
1. Connectors available are 20A, 50A and 100A grounded stage pin, 20A twist lock and 20A "U" ground (dual rated "T-slot"); other connectors available as specified. Pigtails shall be three-wire type "SOW" rubber jacketed cable sized for the circuit ampacity. Internal wiring shall be sized to circuit ampacity and shall be rated at 125°C.
    - a. 20 amp cable mount stage pin connectors shall be 12 gauge 4 way indent crimp (with inspection window) type where the wire is inserted and crimped directly in the socket.
  2. Terminations shall be at one end using feed through terminals individually labeled with corresponding circuit numbers. 20 amp circuits shall use screwless tension clamp or standard screw-type/barrier strip U-style terminals listed for 20 – 8 gauge wire. 50 amp circuits shall use compression terminals listed for 10 – 1 gauge wire and 100 amp circuits shall use compression terminals listed for 8 – 2/0 gauge wire. Terminals that place a screw directly on the wire are not acceptable.
  3. Equipment, except for wall-mounted boxes, shall be supplied with appropriate brackets and hardware for mounting as shown on the drawings. Connector strips shall have brackets on 5' centers. Brackets shall be 1½" x .188" ASTM A 36 steel and hardware shall be ASTM A307 grade 5.

4. A low voltage distribution system for DMX or Network (or other protocols as specified) shall be available, incorporated in the connector strip, locations and methods to be per print. Connector strips shall have a voltage barrier installed to accommodate these systems. Distributed DMX or Network systems shall use pass through assemblies consisting of a 6" panel with the following: one DMX or Network Output Connector, one DMX or Network Input (Pass Through) connector, one DMX or Network Pass Through (Bypass) Switch, and a label detailing the use of the pass-through assembly. The bypass switch shall be used when no DMX or Network devices are present at that location. When activated, the pass-through switch shall pass DMX or Network directly through to the next DMX or Network panel on the strip. The pass-through switch shall have a mechanical indicator to show the operator that it has or has not been engaged. Low Voltage signals shall enter the connector strip via a strain relief or connector mounted in a separate DMX or Network terminal box at the specified end of the connector strip.
  5. Power distribution equipment shall be Underwriter Laboratories (UL) Listed.
- B. Connector Strips
1. Connector Strips shall be fabricated from 18-gauge galvanized steel 6.25" H x 3.3" D with length specified in increments of 6" and shipped fully wired in a minimum of 6'0" sections with all splicing hardware included. They shall be finished with fine-textured, scratch-resistant, black powder coat. Circuits shall be labeled on one side of the connector strip with 2" white lettering on black background labels. Pigtails and outlets shall be spaced on 18" centers, or as otherwise specified. Outlets shall be mounted on individual 3" panels and there shall be no external terminal boxes for units with 28 or fewer circuits unless otherwise specified.
    - a. Connector strip circuit number labeling:
      - 1) Circuits shall be labeled on one side of the connector strip with 2" white lettering on black background labels.
- C. Junction Boxes
1. Gridiron Junction Boxes shall be fabricated from 16-gauge cold rolled steel with 14-gauge end panels. They shall be finished with fine-textured, scratch-resistant, black powder coat. For 30 circuits and less they shall be 14" H x 14" W x 4" D and for 31 to 60 circuits they shall be 14" H x 28" W x 4" D. Cover(s) shall be attached with machine screws and Tinnerman retainer nuts. Cover(s) shall be 16-gauge cold rolled steel. Cover(s) shall be hinged, and mounting should allow installer to orient the hinged door to open in any direction.
- D. Outlet and Pigtail Boxes
1. Outlet and Pigtail Boxes shall be fabricated from 18-gauge cold rolled steel with 16 gauge covers. They shall be finished with fine-textured, scratch-resistant, black powder coat. Circuit numbers shall be 2" or 3/4" labels with white letters on black background (sized to match product). Pigtails and outlets shall be spaced on 3" centers, or as otherwise specified.

## **2.19 WIRING DEVICES (DISTRIBUTION EQUIPMENT): SEE DRAWINGS FOR DETAILS**

- A. Wiring devices shall be fabricated from 16 gauge cold rolled steel, in 6' 0" sections as required. Devices shall be properly cleaned, primed and painted with fine-textured, scratch resistant, black powder coat. Circuit numbers shall be 3/4" Lexan tags with white letters on black background.
- B. Individual pigtails and outlets shall be evenly spaced, on 12" centers in connector strips, or as otherwise specified. Where a circuit would fall on a joint it shall be moved 3" towards the junction box end of the strip.
- C. All connectors shall be flush mount 20 Amp 2P&G unless otherwise noted.

- D. Devices except for wall-mounted boxes shall be supplied with appropriate hardware for mounting as shown on the drawings. Connector strips shall have brackets on 5' centers. Connector strips shall have a terminal block on one end as shown on the drawings.
- E. Wiring devices shall be UL Laboratories Listed.

## **2.20 DIN RAIL SYSTEM: REFERENCED PRODUCT PATHWAY CONNECTIVITY DIN RAIL SYSTEM**

### **A. eDIN #1103 Rack Mount Panel Kit:**

- 1. Features:
  - a. Blank steel rack panel with solid bottom pan (on which to mount DIN rail) with a black powder coat finish. Made in single piece construction.
  - b. Integral cable management system.
  - c. Face dimensions: Standard EIA 19" (482mm) x 3.5" (2RU height that will accommodate all eDIN modules).
  - d. Tray dimensions (solid bottom pan) – 17" W x 10" D (430mm x 254mm).
  - e. DIN Rail Supplied: Two sections 16.5" (420mm) long each, 5.1 lbs (2.3 kg).
  - f. DIN rail made from cold rolled carbon steel sheet with a electrolytic zinc plating or chromated bright surface finish.
  - g. DIN rail: Standard 35 mm x 7.5 mm.
  - h. DIN rail is a mounting system only and does not carry voltage.
  - i. Complies with DIN 50045, 50022 and 50035 Standards.

### **B. Power Supply:**

- 1. Provide a power supply with the following features:
  - a. 1001-30: Power supply suitable for use with Rack Mount Panel Kit.
  - b. Mount power supply neatly, so that it does not interfere with the DIN rail system or any DIN rail mounted devices and per all applicable codes.
  - c. Provide additional power supplies as required in order to power all necessary DIN rail mounted devices.
  - d. Provide separate UL listed enclosures, etc. as necessary for power supplies.
  - e. Do not power the DIN rail themselves. Power only the DIN rail devices.
  - f. Protect all power cabling from becoming inadvertently shorted or routed to improper areas, terminals, etc.

### **C. Calculate required DIN rail mounted devices necessary for this project and provide as many DIN rail rack mount panel kits, power supplies and accessories as is required in order to mount and power all DIN rail equipment.**

- D. Do not drill face/tray of DIN rail rack mount kit in order to route wiring. All wiring shall remain concealed behind face and routed as required to other devices.

## **2.21 WIRE STANDARDS: ALL WIRE IN OR OUT OF CONDUIT WILL BE TYPE CL2-CL3 UNLESS OTHERWISE REQUIRED BY NEC AND JOB SITE CONDITIONS. PORTABLE CABLE EXCLUDED.**

### **A. WIRE – PORTABLE CONTROL CABLES (those cables for use with DMX512-A and USITT DMX512/1990 Systems):**

- 1. The data transmission rate (250 kbits/s) used by DMX512 requires the selection of a portable DMX512 cable that does not significantly distort the signal or give rise to spurious signal reflections. Cables intended for use with audio systems (such as microphone cables), while having the convenience of flexibility, availability and relative low cost, may not be suitable for use with DMX512 because of their high capacitance and incorrect characteristic impedance; at DMX512 data rates this will give rise to bit time distortion and signal reflections/overshoot.
- 2. Maximum and minimum cable lengths

- a. Maximum and minimum run lengths are specifically omitted due to a number of factors, including signal quality, device operating characteristics including capacitive values, and installation environment. Maximum distance runs without repeaters, therefore, shall be determined by standard industry practices of approx. 330 feet. Regardless of the overall run lengths, the system shall run properly, reliably and without errors, glitches, etc. due to improper use of installed/portable cabling or connectors, terminations, etc.
3. Construction
  - a. Portable DMX512 cables shall use twisted pair conductors. Conductors shall be of stranded construction. The raw cable used for a DMX512 cable assembly shall be declared by its manufacturer as suitable for use with EIA-422/EIA-485/EIA-485-A systems. Shielding shall be on individual pairs or overall shielding of pairs or both. The portable cable itself shall be flexible and rugged enough for the repeated coiling and uncoiling to which it will be subjected.
    - 1) Cables implementing only the Primary Data Link shall consist of at least one twisted pair and be marked according to ANSI E1.27-1, Clause 7.1.
    - 2) Cables implementing both Data Links shall consist of at least two twisted pairs and be marked according to ANSI E1.27-1, Clause 7.1.
    - 3) Cables implementing only the Secondary Data Link shall not be allowed.
4. Impedance
  - a. Portable DMX512 cables shall have a characteristic impedance in the range 100 to 120 ohms. Due to the characteristic impedance of 120 ohms in EIA-485 systems, 120 ohms is preferred.
5. Capacitance
  - a. Capacitance between conductors within a shield shall not exceed 19.8 pF/ft (65 pF/m). Capacitance between any conductor and the shield shall not exceed 35 pF/ft (115 pF/m).
6. Dielectric Withstanding Protection
  - a. Dielectric rating for portable DMX512 cables shall conform to prevailing electrical codes.
7. Connection Methods - Required Connector
  - a. Portable cables shall use 5-pin XLR connectors. The physical pin designations of the 5-pin XLR shall be in accordance with Table 1 (see below).
  - b. Any use of alternate connectors shall comply with ANSI E1.11.
8. Electrical Specifications and Physical Layer
  - a. General
    - 1) The physical layer of a DMX512 data link is constrained by earth grounding practices, termination methods, signal levels, EMI, and accidental damage by connection to other devices. Where a conflict exists, DMX512-A shall govern.
  - b. DMX512 Portable Cables
    - 1) General
      - i) A DMX512 Portable Cable is a digital data transmission cable designed for the provisional interconnection of two DMX512 devices. Portable cables shall each have two prescribed connectors, a male 5-pin XLR at the end nearest the transmitting device and a female 5-pin XLR at the end nearest the receiving device. Pins shall be designated 1 through 5. There shall be no connection to the shell.
9. Data link common and grounding topologies
  - a. In all cases Pin 1 of DMX512 portable cable connectors shall act as Data Link Common. The wire connected to Pin 1 shall be no smaller than the wire used for the twisted pairs in the cable.
10. Each data link shall consist of a separate twisted pair.
11. Terminations

- a. All DMX cabling shall be terminated per applicable standards and so that all devices in any given data run work properly. Use DMX terminators where and as needed and recommended by equipment manufacturers.
- b. 5-Pin XLR Cabling:

Table 1 – Signal Designations Summary		
Use	5-Pin XLR Pin	DMX512 Function
Common Reference	1	Data Link Common
Primary Data Link	2	Data 1-
	3	Data 1+
Secondary Data Link	4	Data 2-
	5	Data 2+

- c. CAT5 Pinout DMX Cabling: \*

Wire Color & #	Function	Equivalent XLR Pin #
1 (White/Orange)	Data + (pair 1 true)	3
2 (Orange)	Data – (pair 1 complement)	2
3 (White/Green)	Optional Data + (pair 2)	5
6 (Green)	Optional Data – (pair 2)	4
4 (Blue)	Unassigned	--
5 (White/Blue)	Unassigned	--
7 (White/Brown)	Common for pair 1	1
8 (Brown)	Common for pair 2	1

\* The above table is shows the ANSI E1.27-2 standard DMX pinout when using Category 5 (or higher) wire and an RJ45 connector.

The above table is intended for DMX512 cabling only - **NOT** DMX-over-Ethernet cabling. Great care must be taken to prevent the accidental connection of DMX equipment to non-DMX equipment. The connection of DMX equipment to non-DMX equipment such as Ethernet switches or telephone equipment may result in serious equipment damage and/or personal injury, as pins 4 and 5 may carry voltages of up to 48VDC or greater.

Category wire is not recommended for loose or temporary cabling. The use of RJ45 connectors for DMX equipment should be restricted to patch bays in access controlled rooms and should not be used for the direct connection of portable equipment.

Please be aware that some non-standard pin-outs are also in use (i.e. Color Kinetics, etc.) and that custom cabling, connectorizations, etc. may be required in order to interface non-standard pin-outs with the specified system.

## 2.22 RACKS AND HARDWARE

### A. SWING OUT WALL RACK: DWR



1. EIA compliant 19" wall mount rack shall be Middle Atlantic Products model # DWR-\_\_-\_\_ (refer to chart). Overall dimensions shall be 23.4" W x \_\_" H x \_\_" D (refer to chart). Weight capacity shall be \_\_ lbs. Tool-Free Quick-Mount™ system enables one-person installation. Useable depth shall be \_\_" (refer to chart) and shall extend into the back pan 3.5". Center section and back pan shall be 16-gauge steel, phosphate pre-treated and finished in a black textured powder coat. Rackrail shall be constructed of 11-gauge steel with tapped 10-32 mounting holes in universal EIA spacing with black e-coat finish and marked rack spaces. Rack shall be constructed to swing open for component cabling access, center section shall pivot for either left or right opening. Rack shall have a rear knockout panel with 1/2", 3/4", 1", 1-1/2", 2" and 3" electrical knockouts installed in base, and a rear knockout panel with 1/2", 3/4", 1", 1-1/2", 2" and 3" electrical knockouts, four Decora® cutouts, and BNC knockouts for UHF/VHF antennas installed in top. Large laser knockout on back pan shall have a 12-1/2" x 12-1/2" cutout for electrical pull-box. Fan knockouts on top and bottom shall allow for installation of up to four 4-1/2" fans. Rack shall have 2" knockouts, 4" knockouts for Wiremold 4000® Series raceways, and knockouts for UCP Series universal connector panels on the side. Top, bottom and sides shall feature vertical vent pattern. DWR Series enclosures shall satisfy the 2007 & 2010 CBC; 2006, 2009 & 2012 IBC; ASCE 7-05 (2005 Edition) & ASCE 7-10 (2010 Edition) and the 2006 & 2009 editions of NFPA 5000 for use in areas of high seismicity, Seismic Use Group III, Zone 4 or Seismic Design Category (SDC) "D" with lateral force requirements for protecting 140 lbs. of essential equipment in locations with the highest level of seismicity and top floor or rooftop installations with an Importance factor (Ip) of 1.5 when used with DWRSR-ZL Latch. Rack shall be UL Listed in the US and Canada to the UL-2416 (NWIN) Category when used with optional bonding kit, model # PET-K-\_\_. DWR Series shall meet all enclosure requirements towards PCI DSS (Payment Card Industry Data Security Standard) Compliance. Rack shall be GREENGUARD Gold Certified. Rack shall comply with the requirements RoHS EU Directive 2002 / 95 / EC. Rack shall be manufactured by an ISO 9001 and ISO 14001 registered company. Rack shall be warranted to be free from defects in materials or workmanship under normal use and conditions for the lifetime of the rack.
2. Options
  - a. Front doors shall be reinforced 16-gauge steel, model # FD-XX (solid), VFD-XX (vented, 25% open area), LVFD-XX (vented, 64% open area), PFD-XX (plexi), (XX= # of rackspaces of DWR rack)
  - b. Keyless Latch replaces keylock, fits front & rear doors, shall be models # LATCH
  - c. Rear rail kit 11-gauge, 10-32 threaded, sold in pairs, hardware included, shall be model # DWR-RRXX
  - d. Fan kits with two 4-1/2" exhaust fans, fan guards and vent blockers, shall be model # DWR-FK17 (fits DWR-xx-17), DWR-FK22 (fits DWR-xx-22), DWR-FK26 (fits DWR-xx-26), DWR-FK32 (fits DWR-xx-32)
  - e. Vent Blockers used to promote active thermal management, shall be model # VBK-D17 (fits DWR-XX-17), VBK-SD22 (fits DWR-XX-22), VBK-E20 (fits DWR-XX-26)
  - f. Optional cover plate / shelf kit shall be model # DWR-CVR • Minimum-clearance latch shall allow side-by-side or corner mounting, shall be model # DWRSR-ZL
  - g. Optional bonding kit for UL-2416 (NWIN) compliance shall be Middle Atlantic Products PET-K-D/EWR (for backpan to center section), PET-K-D/EWRD (for backpan to center section to front door), PET-K-FD (for front door to center section)
- B. RACK DRAWERS: REFERENCED PRODUCT MIDDLE ATLANTIC AUDIO D SERIES.
  1. Provide ONE rack drawer for each CR rack. Locate system as-built drawings and manuals inside this drawer.

2. EIA compliant 19" rackmount drawer shall be Middle Atlantic Products model # DX or TDX (X = # of rackspaces required, refer to chart). Drawer shall have an overall height of \_\_\_" (refer to chart), and useable depth of 14-1/2". Drawer base shall be 20-gauge steel, top and sides shall be 16-gauge steel. Drawer faceplate shall be .090" thick aluminum with a \_\_\_ (black brushed & anodized or black textured powder coat) finish (refer to chart). Drawer shall use full extension, ball bearing slides. Grommet shall be provided for safely passing cables through the cable entry point at the rear of the drawer on 2, 3 and 4 space models. 2, 3 and 4 space drawers shall include a no-slip drawer mat. Drawer shall have a 50 lb. weight capacity.
3. Drawer shall be warrantied to be free from defects in materials or workmanship under normal use and conditions for a period of three years. Drawer shall be UL Listed in the US and Canada.
4. Drawer shall be GREENGUARD Indoor Air Quality Certified for Children and Schools. Drawer shall be RoHS EU Directive 2002/95/EC compliant. Drawer shall be manufactured by an ISO 9001 and ISO 14001 registered company.

C. POWERCOOL

1. EIA compliant 19" PowerCool™ Rackmount power distribution and cooling unit shall be Middle Atlantic Products model # PD-COOL-\_\_\_(refer to chart), with a \_\_\_ (15, 20 refer to chart) amp capacity, 2 stage, normal mode (Line to Neutral) spike and surge suppression with dry contact and LED status indicators and EMI filtering. PowerCool shall activate at 87°F (30.5°C), reach full speed at 95°F (35°C) and switch off at 85°F (29.4°C). PowerCool shall displace 50 CFM with a maximum decibel level of 29 dB (measurements made 1 meter from source, centered horizontally and vertically). PowerCool shall operate at a static pressure of .031 in. H2O. PowerCool shall have a removable 10" temperature probe. PowerCool shall have a normally open contact closure for remote surge suppression status notification to customer supplied monitoring device shall operate on 120 volt AC/60Hz nominal power. PowerCool shall have a removable 6' \_\_\_A (14-3) IEC SignalSAFE™ power cord with IEC C-(14 or 20) receptacle (refer to chart). PowerCool shall have \_\_\_(0,1) front and 10 NEMA 5-\_\_\_R outlets, and (circuit breaker switch with switch guard, keyswitch, always on, refer to chart) located on the front of the unit. "Clean ground" surge suppressor design shall not pass noise contamination to the ground. PowerCool shall occupy one rackspace with a (flat black, black brushed and anodized finish, refer to chart). PowerCool shall comply with the requirements of RoHS EU Directive 2002/95/EC. PowerCool shall be manufactured by an ISO 9001 registered company. PowerCool shall be warrantied to be free from defects in materials and workmanship under normal use and conditions for a period of 3 years. PowerCool shall be ETL listed to UL standard 1419 in the US and CAN/CSA C22.2 #60065 in Canada.

D. MODULAR POWER RACEWAYS: REFERENCED PRODUCT MIDDLE ATLANTIC MPR RACEWAYS. SEE DRAWINGS FOR CIRCUIT QUANTITIES AND CONFIGURATION.

1. MPR modular raceways shall be Middle Atlantic Products model # MPR-6. Power modules shall be M-20. Isolated ground outlets shall be available, suffix part with IG (ex. RLM-20IG). Stand-alone power modules shall be RLM-xx-1C and shall include a 9' power cord with NEMA 5-15P plug or 5-20P plug. MPR components shall be warrantied to be free from defects in material and workmanship under normal use and conditions for a period of 3 years. MPR components shall be UL Listed separately and as a system in the US and Canada.
  - a. Modules on the same circuit shall interconnect using J series jumpers, which feature #12 (20 amp) wire with genderless 30 amp connectors at both ends and require no hard wiring.
  - b. All modules on separate circuits shall connect using T series tails, which feature #12 (20 amp) wire with genderless appliance-grade 30 amp connector on one end and wire tails for J-box connection on the other.
  - c. Two separate circuits can feed two duplexes on M-2X modules. Remove the factory-installed jumpers (line & neutral) and feed each duplex using two T series tails.

- d. Isolated ground outlets shall not be mixed with non-isolated ground modules on the same circuit.
  - e. Module chassis shall be constructed of 18-gauge steel finish in a durable black powdercoat.
  - f. The modules shall be attached to MPR raceways using two conveniently located screws.
- E. BLANK PANELS: REFERENCED PRODUCT MIDDLE ATLANTIC AUDIO BL SERIES.
- 1. EIA compliant 19" blank panels shall have a black powdercoat finish. Blank panels shall be constructed of 16-gauge aluminum.
- F. VENT PANELS: REFERENCED PRODUCT MIDDLE ATLANTIC AUDIO VT SERIES.
- 1. EIA compliant 19" vent panels. Vent panel shall be constructed of 16-gauge aluminum and shall have a black powder coat finish.
    - a. VT perforation pattern shall be: 5/32" dia. hole, with 3/16" staggered centers. Open Area 63%
- G. RACK DRAWERS: REFERENCED PRODUCT MIDDLE ATLANTIC AUDIO D SERIES.
- 1. EIA compliant 19" rackmount drawer shall have an overall height of X", and useable depth of 14-1/2". Drawer base shall be 20-gauge steel, top and sides shall be 16-gauge steel. Drawer faceplate shall be .090" thick aluminum with a black brushed & anodized finish. Drawer shall use full extension, ball bearing slides. Laser knockout shall be provided for passing cables through the rear of the drawer. Drawer shall be UL Listed in the US and Canada. Provide all drawers with keylock option.

## 2.23 LED RACK WORK LIGHT: REFERENCED PRODUCT MIDDLE ATLANTIC LT SERIES

### A. Features:

- 1. LT series shall have an adjustable width of 17.73" to 21", a height of 1.75" and a depth of 1.72".
- 2. LT series shall have a light temperature of 2,700-6,500K, and provide \_\_\_lm (refer to chart).

	Light Qty	Interconnect Cable / Length	Light Temperature	Lumens
LT-CABUTL-SINGLE	1	no	2700-6500K	480-540lm
LT-CABUTL-DUAL	2	yes / 118 [3000]	2700-6500K	960-1080lm

- 3. LT series light bar shall have an adjustment range of 100°. LT series shall have a cord length of 59", and the interconnect cable (LT-CABUTL-DUAL only) shall be 118".
- 4. LT Series shall include power adaptors for US, BS, SAA and EU. LT Series shall have a UL Listed power supply that meets US DOE Level VI requirements with an output of 12VDC, 2 Amps.
- 5. LT Series shall have an input voltage range of 90VAC to 260VAC, an input frequency range of 50/60Hz, and a max AC current draw of 800mA AC.
- 6. LT Series shall meet the EU RoHS Directive 2011/65/EU. LT Series shall be warrantied to be free from defects in materials and workmanship under normal use and conditions for a period of 3 years.
- 7. LT Series shall be CE Marked (single light only) and FCC Part 15, Class B.

### B. Technical Specifications:

TECHNICAL SPECIFICATIONS	LT-CABUTL-SINGLE	LT-CABUTL-DUAL
INPUT (AC/DC ADAPTER)		
Input Voltage Range	90VAC - 260VAC	
Input Frequency Range	50/60Hz	
Max AC Current Draw @ Full Load	800mA AC	
OUTPUT (AC/DC adapter)		
Nominal DC Output Voltage	12VDC	
DC Output Voltage Range	11.4VDC - 12.6VDC	
Typical DC Current Draw	Single Light 0.6ADC, Dual Light 1.2ADC	
Max DC Load Current	2.0ADC	
Short Circuit Protection	Yes	
DC Output Connector	3.5mm x 1.35mm x 12mm, Center Positive	
PHYSICAL (AC/DC adapter)		
Dimensions	1.8 x 3.5 x 1.5 in (45.5mm x 88mm x 38mm)	
AC Receptacles	Four (4) Interchangeable: US, BS, SAA, EU	
Weight Lb. (G)	0.39lb (175g)	
REGULATORY(AC/DC adapter)		
Safety	UL, cUL, CE	UL, cUL
EMI (Adapter and Lights)	FCC Class B, CE	FCC Class B
Efficiency	Meets US DOE Level VI requirements	
ENVIRONMENTAL (lights and AC/DC adapter)		
Operating Temperature	32F TO 104F (0C TO 40C)	
OPERATING RELATIVE		
Humidity	0 TO 90% NON-CONDENSING	

## 2.24 BILL OF MATERIALS

- A. Lighting system equipment, console and all accessories and controls - see drawings for equipment, quantities and required coordination with other related trades.
- B. Lighting fixtures: See drawings for quantities, types, lamps, locations, installation requirements, etc.
- C. Provide all theatrical fixtures with C-clamp, safety cable, lamp, gel frame and connector as called for on the contract drawings and/or to match existing devices (provide adapters as necessary for all fixtures that require them in order to interface with any existing and reused system equipment). Swap out connectors as required when reusing existing system equipment. Do not provide C-clamps for fixtures mounted directly to Unistrut.
- D. Every portable cable shown or referenced on the TL series drawings shall have one 24" piece of black tie-line (Samson black braided tie cord/sash cord or equal - breaking strength 100 lbs./WLL 15 lbs., rip-tie hook & loop black Velcro or equal) choked onto one end (near connector). Provide two full 500'/600' rolls for this project and leave the remainder on site for the owner's future use upon project completion (or at least 1/2 roll, whichever is more). This does not include two-fer cables under 5' long in overall length. Provide 16" tie line for portable cables under 8' in overall length.
- E. Theatrical Fixtures: Swap out, at no additional cost to the owner, any different lenses or fixture barrels for the specified fixtures that may be needed due to field conditions, focus plot intents, etc. per the owner's directive. If there are no specific lenses called out on the drawings, then provide lenses dictated by the field conditions, focus plot, owner and/or the consultant. If the specific fixture barrels called out on the drawings do not provide the intended patterns, etc. that are needed and desired by the focus plot intents of the owner, then provide barrel swaps for all affected fixtures so that the focus plot functions as intended –this will be only one barrel per fixture.

- F. Furnish all portable cables shown on the bid drawings plus any and all additional portable cabling, adaptors, turn-arounds, termination devices or misc. interface devices needed in order to present the owner with a complete, fully-functioning system (even if those devices or cabling do not specifically appear on the drawings but are required for the system to function).
- G. Provide all DMX terminators as necessary for all DMX controlled equipment.

## PART 3 EXECUTION

### 3.1 GENERAL:

- A. All liability for rigging, fastening, wiring and other installation methods shall be borne by the contractor alone. If the contractor has a reason to believe that safety will be compromised in the installation of any specified equipment in the locations specified, they must note this at the time of bid and offer alternatives in writing.
- B. Assess life safety implications of all installation methods and verify there is no compromise of life safety issues.
- C. Any dangerous work areas must be marked or roped off in a manner that will inform all persons as to potential danger, regardless of that person's sensory handicaps.
- D. Maintain M.S.D.S. for all materials used where applicable and submit same if requested upon completion.
- E. Maintain the integrity of all fire-walls and doors during construction and upon completion.
- F. Take all precautions necessary to guard against electromagnetic interference, electrostatic hum and RF interference, especially into the audio and video systems.
- G. The contractor shall supply adequate ventilation and will install all equipment for the maximum safety of the operator.
- H. The contractor shall verify all on site dimensions prior to the ordering or installation of critically dimensioned equipment and wiring. In a case of discrepancy between these documents and attached drawings, construction documents and actual on-site dimensions, the contractor will notify the owner and consultant in writing before making any changes in intended work. The owner and consultant will determine the correct modification to the work that needs to be done.
- I. All methods must be cosmetically acceptable to the owner. All equipment shall be installed neatly, with respect to level & plumb, sight lines and finish. All wiring must be neatly run and concealed in an orderly fashion and attached to appropriate support structures.
- J. Identify any equipment requiring licensing and initiate licensing procedures for all such equipment.
- K. Coordinate all work with other on-site trades in order to achieve a coordinated progress at all times.
- L. All RDM fixtures (remote device management) shall incorporate the latest RDM standard in fixture addressing, remote management, reporting, etc. (must be ANSI E1.37.2 or later compliant).

### 3.2 WIRING AND RACKS:

- A. All CR (communications rack) wiring shall be neatly tie wrap bundled (or as indicated otherwise on contract drawings) with wires parallel and perpendicular to rack sides and backs. All wiring shall be properly strain relieved as it exits the rear connection points on the related equipment, shall be routed out to lacing bars, shall be routed out along lacing bars to rack side areas and shall be tie wrapped to the lacing bars. All rack wiring shall be performed as noted. Loose, haphazard or otherwise poorly managed wiring without proper strain relief shall not be allowed.
- B. Provide all internal network/DMX style wiring, etc. Needed inside the relay panel & all required interconnections & feeds to external equipment.

- C. Control hookup is provided by the factory technician.
- D. Within the dimmer/relay rack all wiring splices must utilize butt style line insulated splices crimped with a controlled cycle termination tool. Referenced style Panduit BSV10X-D or equal. Size splices per gauges of wiring to be spliced. See written specifications for more info.
- E. All wiring that is not in conduit shall be plenum rated wiring (Belden 1585A or equal).
- F. No undue stress shall be placed on any connection by a lack of support of the wiring within the rack.
- G. Any wiring splices necessary must utilize butt style inline insulated splices crimped with a properly adjusted controlled cycle termination tool. Referenced style Panduit BSV10X-D or equal. Size splices per gauges of wiring to be spliced & provide as required. No incorrectly sized splices shall be allowed.
- H. Any equipment having accessible controls that are not normally used during system operation will have its controls capped or otherwise locked such that they are not adjustable. If no other means is feasible the use of security covers is mandated. Rack doors are not acceptable as means of tamper resistance for controls.
- I. Wiring Standards - Plenum Rated Cable: Unless specifically noted on the drawings, all low voltage wiring is to be CL2/CL3 wiring.
- J. No rack rails will be allowed for equipment mounting in the rear of the rack unless otherwise noted in this specification.
- K. All conduits indicated on the drawings shall terminate directly into racks as shown – top, bottom or at any of the provided knockout locations (unless otherwise and specifically indicated on the drawings as otherwise) and so as not to obstruct access to the racks or adjacent walkways or approaches.
- L. Route conduits into racks with as few bends as possible – use sweep elbows where necessary. All wiring shall be protected in conduit until it has reached the internal space of the indicated rack(s).
- M. All lighting system related racks shall be mounted vertically and as intended by the manufacturers. No racks shall be allowed to be mounted horizontally.
- N. ELECTRICAL & GROUNDING:
  - 1. Grounding of shields and chassis will adhere to industry standard practice and as required by the dimming & control systems manufacturer.
  - 2. Verify that all hot, neutral and ground conductors are tightened at least 5 days after initial installation and landing of line & load conductors.
  - 3. Any AC service shall be installed to standard Edison U-Ground style outlets at the locations noted on the electrical drawings. Where racks are located the service is to be run to the interior of the rack. Two U-ground outlets will be available for each 20-amp, single-phase circuit unless otherwise indicated or terminated into MPR style devices.
  - 4. Internal rack AC distribution is the responsibility of the contractor. Acceptable methods: Rack mount power strips, rack mounted power distribution devices, Wiremold style outlet strip.
  - 5. Install all internal AC rack power with all switches and controls carrying hazardous voltage housed in steel enclosures within the rack. Provide positive electrical grounding for all steel enclosures. All AC service will incorporate separate hot, neutral and ground for each device. All grounds and neutrals will be appropriately bonded and connected to earth as required by codes and normal practice.
- O. CONDUITS:

1. Use separate conduits for data and other control cabling. Control power and ground may be run with data for the same devices.
2. All conduits shall be concealed unless the owner has been notified in writing and accepts by written approval the location of all exposed conduits.
3. A pull string shall be left in place by the installing contractor after pulling all wiring through each conduit. This pull string shall be tied off at both ends and left for future use.
4. All lines, cabling or wiring in any conduit run must be free from any splices or junction points.
5. All lines, cabling or wiring must be free from damage. Any that exhibits stress, damage, intermittent signal problems, data errors or other anomalies due to excessive pull torque shall be replaced.

**P. JUNCTION/GANG BOXES:**

1. Unless otherwise specified all controls, receptacles, user interface stations, plugs and outlets shall be located in an appropriately sized gang box. No multi-gang backboxes with raised, tile ring, extension ring or mud ring style reducers to obtain the specified faceplate gang size shall be acceptable in lieu of the indicated device backbox.
2. Any junction (i.e. terminal blocks, punch down blocks etc.) shall be housed in metal enclosures with an attached ground. No such connections may be made in ceiling spaces or other areas without the use of a steel enclosure.
3. Any field added junction boxes shall be sized and located for ease of troubleshooting access and all connections within shall be connected on terminal strips, which are clearly identified, in a logical, consistent & permanent manner.

**3.3 ASSEMBLY AND PRE-TEST:**

**A. LIGHTING FIXTURES:**

1. Install connectors as required on fixtures prior to bench test and focus.
2. Attach all safety cables to fixtures by removing one yoke bolt and sliding the fixed end loop of the safety cable over the yoke. Reinstall the yoke bolt.
3. All incandescent lamps shall be burned in for at least 8 hours to check for defective lamps. Replace any lamps that fail and burn those lamps in for at least 8 hours.
4. Adjust incandescent lamp center for highest output flat field (bench focus). This is required for any new and/or existing to remain and be reused fixtures.
5. All LED fixtures shall be DMX addressed, set up in the proper color mode, have fan speeds set to quietest mode of operation, etc. and tested with addressing in place.
6. Each LED fixture shall be turned on and "burned in" at full for (2) weeks in the contractor's shop in order to check for defective power supplies, drive electronics packages or other fixture anomalies.
7. See TL series drawings for a more complete description of the procedures recommended for bench focusing of fixtures.

**B. LIGHTING EQUIPMENT (OTHER THAN FIXTURES):**

1. All new equipment shall be turned on/burned in and tested prior to delivery to the site. No equipment may be delivered to the site without being fully tested off-site. The equipment does not need to be under load during this period. This includes, but is not limited to, the lighting control console, fader wing panels, video displays/monitors, remote focusing units, Blues System power supplies, portable network gateways/nodes, architectural control processors, followspot fixtures and related power supplies, network switches, portable dimmer devices and any other lighting related portable equipment. Burn in requirements do not apply to installed dimmer racks, grid iron junction boxes, individual dimmer modules or DMX distribution racks.

**3.4 FINISHES & CLEANING:**

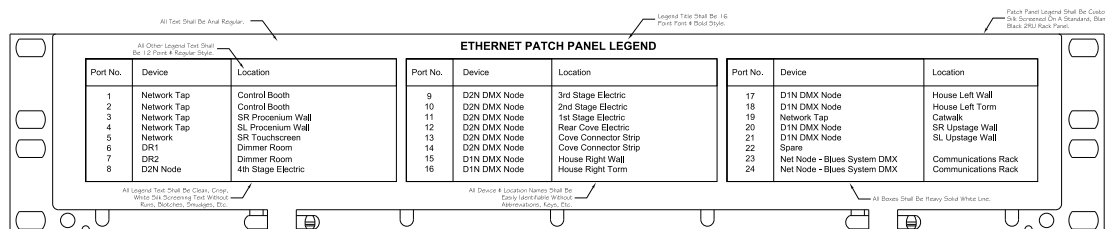
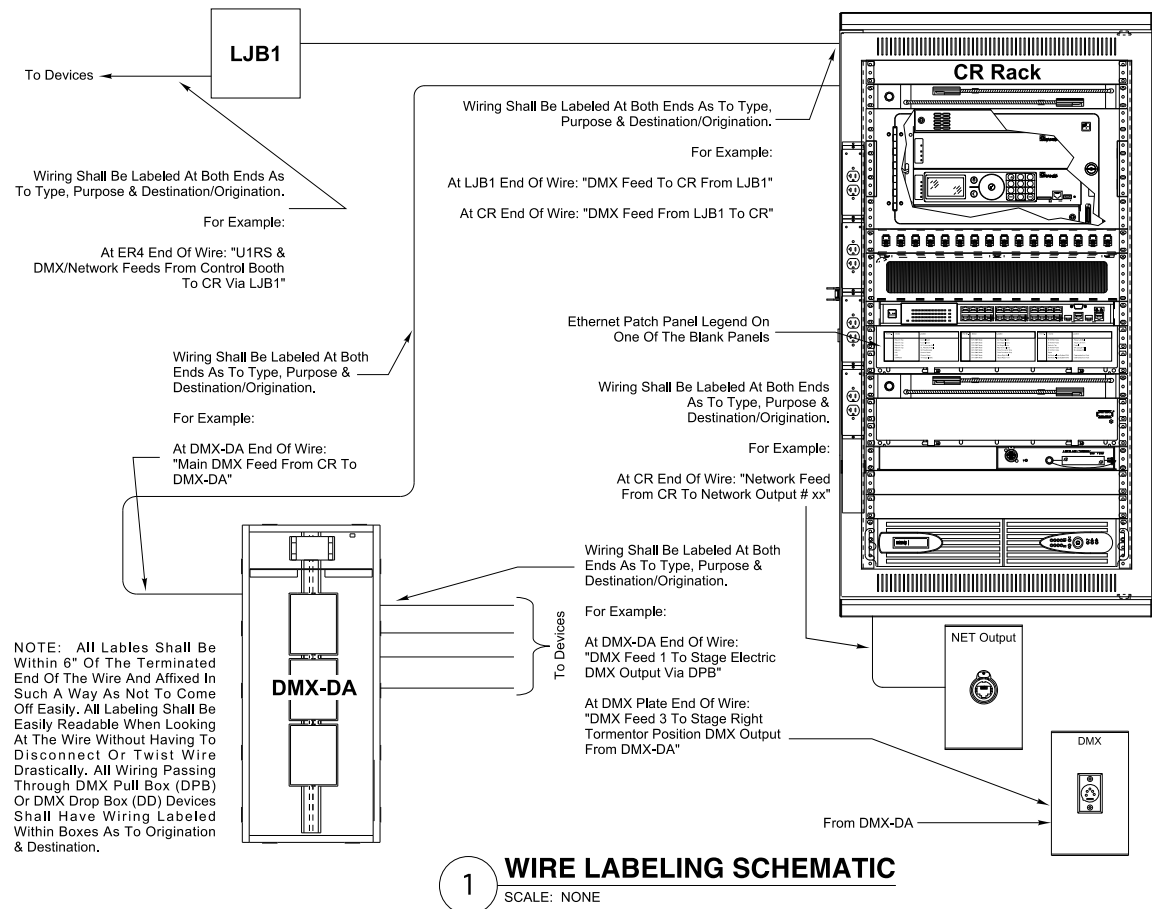
- A.** All finishes shall be returned to their original finish and condition after any temporary machining or other work.

- B. Cover any walls, furniture, finished floors and carpeted areas to catch all metal particles, grit, etc. that may occur during installation.
- C. Cover and protect all equipment left or installed on site during construction.
- D. Provide thorough cleaning of all work areas including vacuuming, spray cleansers and dust removal as required. Clean all equipment fan filters before final acceptance tests.
- E. Provide a thorough cleaning of all lighting system and related devices, including but not limited to, fixtures, housings, racks, cables/cordsets, data lines, reflectors, lenses, modules, mounting pipes, controls, consoles, etc. regardless of status (new or existing to remain/reuse). Cleaning shall be after all dust/dirt creating work has been completed and just prior to walk-through/punch list and turnover to the owner.
- F. Maintain clean work areas, removing all debris daily.

### 3.5 LABELING:

- A. All switches, cables, wire, controls and outlets will be permanently and logically marked during installation. Submit to the consultant for approval a listing of intended nomenclature. Where possible engrave directly upon plates and assemblies. Where disassembly would be required the use of adhesive or screw on engraved labels will suffice. Engravings will be paint filled for best contrast with black or white paint.
- B. Do not use Dymo style labels or hand lettering. No cables shall be labeled with masking tape, gaffer tape or other material subject to degradation. Such labeling may be done on a temporary basis during installation so long as all such labels are removed and their adhesive cleaned off when final labeling is applied. Self-laminating labels are preferable for the final labeling system.
- C. Permanently mark cables with an identifying label at each end in a consistent, logical manner.
- D. Color-coding of the entire system shall be logical and adhere to accepted industry standards.
- E. The contractor shall provide the owner with a laminated hard copy chart (Microsoft Excel style) of the dimmer channel assignments and locations along with any soft patched devices, DMX assignments, Network assignments, house, accent and worklighting channel assignments, submaster assignments, etc. to be left at the control console location.
- F. The following schematic diagrams have been provided as examples of acceptable and intended wiring & patch panel legend labels to be included for all racks, wiring destinations & originations: (these schematic drawings are diagrammatic only and do not reflect all of the actual parts and/or components, etc. designed into this project.) Contractors (Both EC and lighting contractors) shall use these schematic diagrams as guides and references and label or wire all related and additional devices in a similar manner to those shown here. These diagrams are typical of all lighting related devices, communications racks, etc. designed into this project. The intent is for all portions of this project to be labeled in a concise, intelligent and consistent manner.





### 3.6 RIGGING:

- A. The following minimum standards apply in addition to the standards referenced elsewhere in this specification. These guidelines do not negate the standards referenced elsewhere in this specification.
- B. All equipment not described as portable in this specification will be rigidly held in place as per the manufacturer's recommendations or as indicated.
- C. All equipment (except luminaires) will be supported at a minimum of three points plus a backup. Each point shall be able to carry the entire rated load with a safety margin of at least five (5) times the rated load. All methods shall incorporate an independent safety backup with a safety margin of at least five (5) times the rated maximum load as installed.

in case of failure of any rigging component. All safety cables shall be installed so that they have little to no slack in order to reduce shock loading in the event of a catastrophic failure of the primary rigging attachments.

- D. Theatrical lighting fixtures will be supported by their primary attachment point, either C clamp or factory supplied or other specified clamp (such as a Megaclaw style clamp for motorized lighting fixtures). A safety cable rated for at least 10 times the rated static weight of the fixture will be utilized as a safety backup in case of a failure of the primary attachment point.
- E. All rigging and related fastening methods must be treated as permanent. All threads shall be treated with vibration compounds such as Vibratite or Loctite as per manufacturer's recommendations and shall be visible upon inspection.
- F. All rigging hardware shall be load rated with the load rating or approval stamped on each piece of hardware.
- G. No chain of any type will be acceptable for the hanging or backup support of any equipment except in the case of trim chains.
- H. All trim chain shall be Peerless black theatrical chain type or equal.
- I. No fabric or plastic devices of any type will be considered as acceptable methods of hanging of any equipment.
- J. No stainless steel or galvanized wire rope shall be secured with Crosby clamps or other threaded type fittings alone. Compression type closures such as Nicopress with thimbles and copper sleeves ONLY must be utilized for all wire rope terminations. Each closure must have a backup closure. All wire rope is to have strain relief thimbles installed where it attaches to other rigging components. The contractor shall never violate the minimum bend radius when using or installing wire rope.
- K. All loose ends of the wire rope will be neatly taped down after Nicopress is installed and crimped. No frayed rope ends will be allowed under this specification. This includes safety cables.
- L. All Nicopress or equal compression connections and wire rope swaging products utilized on this project shall be required to pass field gauge tests as to their proper terminations and compression (typically referred to as go-no-go gauge tests). Due to the sheer quantity of manufacturer's and the varying types/styles of compression tools in use, this will require the contractor to provide the proper go-no-go gauge during acceptance testing (punch list) for each different compression tool utilized on the project (typically a specific gauge is provided with each tool purchased). This gauge will be turned over to the consultant for use in verifying that the correct compression has been performed on the oval sleeves. It is understood that the consultant cannot test every single oval sleeve but will, instead, check a random percentage of sleeves that will be assumed to be typical of all similar compression fittings on this project. It is the contractor's responsibility to verify, during installation, that every oval sleeve has been compressed properly and that it passes the go-no-go gauge test.
- M. All Nicopress or equal compression connection thimbles shall be loaded (mounted) only on a round shaft. Thimbles through a punched hole or other where the thimble encounters an edge shall not be allowed.
- N. Nothing shall be allowed into the interior of any Nicopress or equal compression connection oval sleeves except the wire rope itself. Any taping of wire rope ends shall be performed only after all compression connections are properly swaged.

### 3.7 ROUGH-IN:

- A. Due to small scale of Drawings, it is not possible to indicate all offsets, fittings, changes in elevation, etc. Verify final locations for rough-ins with field measurements and with the equipment being connected. Verify exact location and elevations at work site prior to any

rough in work. DO NOT SCALE PLANS. If field conditions, details, changes in equipment or shop drawing information require a significant change to the original documents, contact the owners representative for approval before proceeding.

- B. All equipment locations shall be coordinated with other trades to eliminate interference with required clearances for equipment maintenance and inspections.
- C. Coordinate work with other trades and determine exact routing of all duct, pipe, conduit, etc., before fabrication and installation. Coordinate with Architectural Drawings. Verify with Owner's Representative exact location and mounting height of all equipment in finished areas, such as thermostats, fixtures, communication and electrical devices, including panels. Coordinate all work with the architectural reflected ceiling plans and/or existing Architecture. Mechanical and electrical drawings show design arrangement only for Diffusers, grilles, registers, air terminals, lighting fixtures, sprinklers, speakers and other items. Do not rough-in contract work without reflected ceiling location plans.
- D. Before roughing for equipment furnished by Owner or in other contracts, obtain from Architect and other Contractors, approved roughing drawings giving exact location for each piece of equipment. Do not "rough in" services without final layout drawings approved for construction. Cooperate with other trades to insure proper location and size of connections to insure proper functioning of all systems and equipment.
- E. For equipment and connections provided in this contract, prepare roughing drawings as follows:
- F. Where more than one trade is involved in an area, space or chase, the contractor shall cooperate and install their own work to utilize the space equally between them in proportion to their individual requirements.
- G. Provide code mandated clearances at controllers, motor starters, valve access, and other equipment requiring maintenance and operation.
- H. Existing equipment being relocated: Measure the existing equipment and prepare drawings for installation in new location. Submit as part of submittal package prior to installation. Do not install prior to written approvals.
- I. New equipment: Obtain equipment roughing drawings and dimensions, then prepare rough-in drawings. Submit as part of submittal package prior to installation. Do not install prior to written approvals.

### **3.8 CUTTING AND PATCHING:**

- A. Each trade shall include their required cutting and patching work unless shown as part of the General Construction work on the architectural drawings. Refer to "General Conditions of the Contract for Construction" for additional requirements. Patch all cut or abandoned holes left by removals of equipment or devices. Patch adjacent existing work disturbed by installation of new work including insulation, walls and wall covering, ceiling and floor covering or other finished surfaces. Patch openings and damaged areas equal to existing surface finish (i.e. "patch to match existing"). If no instructions exist in the contract documents addressing these issues, then the contractor shall contact the architect and construction manager in writing prior to proceeding with any work in order to obtain written instructions regarding this type of work.

### **3.9 CONCEALMENT:**

- A. Conceal all contract work above ceilings and in walls, below slabs and elsewhere throughout building (this does not include lighting fixtures, control consoles, user interface stations, etc.). If concealment is impossible or impractical, notify Owner's Representative before starting that part of the work and install only after his review and written authorization and instructions on how to proceed.

### **3.10 PERFORMANCE:**

- A. The systems will be utilized for lighting various types of performances from solo artists to large groups. The intent is for the preset lighting controls to accommodate most of the general lighting needs. The owner will compile a list of presets to be loaded into the control system. These presets will consist of a prefocused aiming of all lighting instruments.
- B. All LED fixtures shall exhibit quiet operation (the preference is for all fixtures to be convection cooled). Audible requirements for ALL LED fixtures is as follows:
1. No LED fixture shall be allowed that exceeds an NC10 noise curve as measured 4' – 0" from any point of the fixture.
  2. NC measurements shall be dBA and measured in 1/3<sup>rd</sup> octave resolution.
  3. For fan cooled devices, the fans are normally to be set up and operated in auto mode.
  4. Any fixtures and fixture fans that exhibit that develop a tonality within the first 12 months of use shall be replaced by the contractor at no additional cost to the owner and within a reasonable amount of time (typically less than 2 weeks).  
\*\* Tonicity shall be defined as any frequency or frequency bands that are narrower than 1/3<sup>rd</sup> of an octave that exceed the average adjacent background level by more than 3 dB as measured on an FFT style trace. This is typical of both fundamental frequencies as well as any related harmonics.
- C. Program all theater lighting presets to maintain the minimum required egress levels of lighting at all times and in all cues based upon life safety code nfpa101 & local building codes. The minimum egress lighting level is .2 fc.
- D. Provide the consultant, owner and architect with the following files as it regards the lighting system, control console, paradigm system, misc. Devices and controllers. All project related final lighting system files shall be provided in both compiled and uncompiled (editable) formats and in the current software/firmware format. All files must be named so that identification as to project, file type/intent, etc. Is readily identifiable from the name alone. Provide all files saved to a thumb drive:
1. ETC Paradigm Lightdesigner config file
  2. ETC concert config file
  3. ETC console config file
  4. All console template files
  5. Network system config files
- E. LED fixtures: all fan-cooled LED fixtures must have the ability to be run at full light output (typically full white) for a 4 hour minimum without light output reduction and without the fan speed ramping up to a level noticeable to a listener from a distance of 6' - 0" away. Fan speeds must be assigned to a DMX channel, configured by the setup technician and locked so that they are at the lowest fan speed setting possible while still maintaining full light output out of the fixtures. The cumulative fan acoustic output must be inaudible in the seating area, no matter how many LED fixtures are on. This configuration must be field verified on site for an 8 hour minimum - (2) 4 hour cycles. The total light output shall, at no point in time, be allowed to automatically dip below 90% overall output (unless specifically being dimmed for a theatrical reason) in order to enter a "self-protection" mode or other automated cycle designed to prevent the fixture from overheating. See written specifications for more information and noise curve requirements for all LED fixtures.
- F. Provide the owner with a copy of the pathway Pathport manager gateway configuration editor (5.3 or later), via manager software (if applicable) DMX/RDM device configuration softwares and 12 hours of additional training on those platforms (in addition to training noted elsewhere on the drawings or in the written specifications) so that the owner or owner's designated operators will have a full working knowledge of how to address, readdress, maintain, troubleshoot and reconfigure the network gateways located within this system.
- G. Post a complete copy set of the lighting system one-line diagram, system as-built drawings, laminated excel spreadsheets of all circuit & DMX/network assignments, etc. as listed on TL

flow diagrams) in the CR rack drawer. Provide an additional laminated circuit assignments sheet for the lighting console position.

H. Training & Instruction:

1. Provide all on-site owner training, software training, architectural system preset programming (including pushbutton & LCD stations), edited DVD training video, bench & field focus of fixtures, etc. As detailed on the bid drawings and in written specifications. (training, DVD, focus and programming time is extensive and detailed). See specs for total quantity of hours of training, focus and software programming requirements that the owner is entitled to as part of this bid package. All items shall be provided as a part of his bid at no additional cost to the owner after bid. Owner is not obligated to receive all training time; however, all training time, etc. As listed above, in written specifications and on the bid drawings is the sole responsibility and obligation of the contractor to provide. All training shall be at times and in duration as directed by the owner and shall be held on-site at the owner's facilities.
2. Give the owner detailed and specific instructions on powering/depowering and the insertion/removal of PowerCon power connectors for any LED fixtures included in this project. Since the PowerCon connector is a connector without breaking capacity, these connectors should not be inserted or removed under load or when live. Per the manufacturer's instructions, the user is to disconnect the end of the power cable that is plugged into the wall outlet/distribution first and prior to insertion/removal of any PowerCon connectors. Failure to do so may damage, pit or char the contacts inside of the PowerCon connector, rendering them unable to make proper contact and unusable without replacement of the PowerCon connectors. Any such damage to the PowerCon connectors due to failure to disconnect the fixtures from power first will result in factory repairs that will not be covered under warranty.
3. Give the owner detailed and specific instructions on (as well as turning over a copy of the manufacturer's safety notice data sheet) on the hazards that may be associated with the improper use of Neutrik PowerCon True1connectors.

I. LIGHTING SYSTEM NETWORK:

1. Provide all ethernet style switches to be power over ethernet switches with all ports/outputs powered. Provide quantity of switches and outputs in order to output signal to all lighting system network devices.
  2. After final system setup and configuration, provide the owner with a usb flash memory drive (memory stick or thumb drive) device with a complete copy of the "as built" system configuration stored on it - including electronic as built drawing set (4 GB drive - in addition to other drives noted).
  3. Instruct the owner on how to make basic system and preset setup changes with a standard web browser (via Lightdesigner access).
  4. The lighting system network shall not be hardwired to or capable of being interconnected with the building-wide network or direct access to a gateway providing internet (world wide web) access. The lighting system network is comprised of simple network devices that do not have the capability or protection to remain immune to viruses, etc. The lighting system network must remain a stand-alone network. Failure to segregate the lighting system network from the building-wide network and internet access could result in a catastrophic failure of the entire lighting network and loss of vital data (including show files, system patch, fixture profiles, default system setup, etc.) If infected with a computer virus, and which would result in the need for a total system reboot back to factory defaults (all "as built" system configuration files would then need to be recreated from scratch).
- J. Verify the load requirements for all PoE switch outputs and the related devices being powered via the network switch. Provide a switch that is capable of powering all network devices & outputs indicated per the manufacturer's recommendations.
- K. Perform all DMX and network programming, device addressing and related software/firmware setup, LED setup, modes and addressing, etc. All LED fixtures, network gateways,

housetlighting fixtures and RDM setups and any other DMX/network/RDM addressable devices shall be addressed in an intelligent, consecutively numbered, individually addressed manner prior to completion of the project and final acceptance tests.

- L. Work closely with related trades in setting up, testing, verifying and tweaking the houselighting system, lamps, etc. In order to get consistent and acceptable results. This includes DMX/RDM setup of houselighting fixtures, populating those fixtures into the architectural control system, dimming rack control module and lighting control console, dimmer module curve settings, providing/swapping out indicated modules for modules that will control the associated fixtures better (i.e. ELV's for D20e's, etc. As needed), assisting in visual confirmation of performance acceptability, recording lighting performance visuals for record and any other items as noted in ec houselighting notes or other required coordination. Obtain a written sign-off acceptance by the owner of visual performance of the houselighting system prior to finalizations & programming.
- M. All connector strip, outlet box, gateway, etc. Devices must have the proper grommets and strain relief devices in place from the point where the loose or multicable wiring enters the device and at all connection/transition points into the related device. Devices without grommets and strain relief shall not be allowed.
- N. Verify the actual electrical loading demands of all devices plugged into indicated UPS devices and provide appropriately sized backup UPS devices as needed, even if that means providing upsized devices beyond what is indicated in order to meet the actual electrical demands of the serviced devices. No UPS device shall be allowed to be loaded past 90% of its rated capacity.

### **3.11 INITIAL POST COMPLETION TESTS & SET UP:**

#### **A. FIXTURE FOCUS & GEL:**

- 1. The lighting plot shown on drawings is not necessarily the plot the contractor will hang. Verify with the owner prior to fixture hang that they do not have an alternate plot they want hung.
- 2. Theatrical Focus: The contractor shall be responsible to hang and focus all fixtures indicated on the bid drawings. Theatrical focus shall be directed by the owner or by a designated owner's representative.
- 3. Studio Fixture Focus: The contractor shall be responsible to hang and focus all studio fixtures (and install/set up portable floor lighting kits) indicated on the bid drawings. Studio focus shall be directed by the owner or by a designated owner's representative
- 4. In the event that there were previously removed theatrical style fixtures that are to be reinstalled, the contractor shall be responsible to rehang and focus all previously removed fixtures in a similar fashion as they were prior to the start of this project or as directed by the owner.

#### **B. Focus Hours Required**

- 1. Focus Day Requirements For <100 Theatrical Fixtures: The contractor shall be responsible for (1) one full day of focus (8 hours) and (2) two full days (16 hours) of programming maximum (in addition to any other programming requirements listed elsewhere in this specification). The contractor shall focus all fixtures with the owner or a designated owner's representative present.
- 2. Man-Power Requirements (Dead-Hung System): The contractor shall supply (2) two qualified lighting technicians for the day of focus and (3) three walkie-talkies or intercom belt packs, power supplies and all related required cabling. The contractor shall supply a manlift and either extension or stepladders for the day for focus.

3. Intent of Theatrical Focus: The intent of the theatrical focus is for the contractor to hang the fixtures indicated on the drawings to their related and indicated pipe battens, tormentor, Shakespeare or truss locations and then to focus or aim those fixtures in a logical fashion toward the stage or pit areas (depending on fixture location intents) in order to establish a base-line lighting plot for typical events. If a focus plot has been included, then this is what the contractor shall use as a basis for his rough focus. If the owner has a specific focus plot; however, that they wish executed, then the contractor shall focus all fixtures as directed by the owner (the owner's wishes shall supercede all directives here or on the drawings). This includes, but is not limited to, general area washes for the pit and stage areas, even borderlight style colored washes, lectern focus lighting, seamless cyclorama illumination, basic backlighting setups and general area lighting for choral events, orchestral events, lectures, worklight setups and basic stage usage events. The intent for this initial focus and hang is not for the contractor to generate and/or execute a detailed lighting plot for specific theatrical shows and performances. The intent is also not for the contractor to act as a lighting designer or technical lighting advisor. The focus day(s) may also require the contractor to swap barrels, relocate fixtures, swap color changing devices, etc. as directed by the owner.
  4. Specific ladder style to provide depends upon accessibility and physical restrictions present in the auditorium. Typically if a man-lift cannot access FOH rigid cove or motorized FOH truss areas, then a stepladder is used in order to obtain a good "ground-focus" height from which fixtures are then hung and focused (motorized truss fixtures are hung with truss at low trim and then rough focused from an intermediate height. Final focus tweaks are then accomplished by minor adjustments at low trim height until fixtures focus properly at the truss operating height.). Stage fixtures are typically focused from a man-lift, scaffolding or stepladder. Tormentor or Shakespeare position fixtures are typically focused with a stepladder on flat floor areas or with an extension ladder for sloped floor areas. All accessible areas reachable with a man-lift shall utilize a man-lift for both hang and focus as this presents the safest method of installation. Neither the contractor nor any related personnel shall be allowed to "ride" counterweight sets or motorized truss/stage electric sets or climb tormentor or Shakespeare assemblies in order to hang and focus lights in lieu of utilizing ladders or a man-lift to access lighting support positions.
- C. ARCHITECTURAL CONTROL STATIONS:
1. All architectural control stations (pushbutton, etc.) shall be named in the Light Designer and Control Designer software so that they reflect the actual room and geographic locations within the room (i.e. Auditorium South Entrance, etc.).
  2. Room, entry or other names and designations TBD by owner. The contractor shall obtain these descriptions from the owner in writing prior to ordering these faceplates or programming the architectural control system. All stations shall be labeled with the owner indicated names and with specific nomenclature as indicated on the bid drawings. No device model number names shall be allowed. Names shall be engraved on device plates with a high contrasting color in a legible, large enough font size so that they are easily seen and read. No black on black or self-adhesive tape labels shall be allowed.
- D. ARCHITECTURAL SYSTEM PRESETS:
1. Architectural lighting will be included in the preset configurations.
  - a. The presets to be programmed by the lighting contractor will consist of no more than 10 presets for architectural lighting. The presets will be determined by the owner and consultant.

- b. The contractor shall program the houselighting presets to minimize hotspotting, dark rows and large footcandle variations from row to row. Contractor shall coordinate preset setup with the owner and consultant. Preset looks shall be finalized only after most room treatments, etc. have been completed and with the consultant present.
- c. All pushbutton stations shall be programmed so that, when no presets are selected and no lights are on, there is an led or button on each station that is lit at all times so that the stations are readily visible in the dark.
- d. All faders shall be programmed per owner's instructions (typically faders control groups of similar fixtures and/or fixtures in similar locations as a group).
- e. All pushbutton stations shall be programmed so that engaging any particular pushbutton toggles the associated preset on and off with subsequent pushes of that button. All preset pushbuttons shall trigger mutually exclusive presets (turning the previous preset off as it engages the selected preset) and shall not operate in a pile-on style hierarchy. In other words, if a user engages preset #1 by pressing the associated button, this should trigger all previous light levels or presets to "off" and turn "on" or trigger the lights and light levels associated only with that particular button and preset.
- f. Architectural Station Presets:
  - 1) All preset stations MUST be set up and loaded with the "looks" as directed by the owner. The contractor shall not decide for himself nor preload any temporary preset looks into the architectural control system that the owner hasn't desired. The contractor should obtain all of these programming directives in writing prior to system turn-on so that they can be easily programmed during commissioning, etc.
  - 2) All preset buttons located on pushbutton stations shall have the capability to respond to whichever preset the owner wishes, including conventional theatrical, houselighting and LED color mixing fixtures. In other words, the pushbutton stations shall not be restricted as to which system preset each button or class of stations can trigger.
  - 3) UH10001 (1 Button Stations): If station(s) on stage, it should be programmed to turn on/off the stage worklights ONLY. If station(s) located in catwalk or at catwalk entrances, they should be programmed to turn on/off the catwalk worklights ONLY. If station(s) in the auditorium area, then they should be programmed to trigger one preset as directed by the owner.
  - 4) UH10005 (5 Button Stations): These stations are typically programmed to recall the first four system presets from the architectural controller and off. Contractor shall program each station to control presets as directed by the owner.
  - 5) UH10010 (10 Button Stations): These stations are typically programmed to recall the first nine system presets from the architectural controller and off. Contractor shall program each station to control presets as directed by the owner.
- g. Ipad & Iphone Programming:
  - 1) The contractor shall fully program and set up the iPad tablet to control both the lighting system console as well as the architectural control system. This includes fader pages, preset button programming, etc. This also includes purchasing the apps, setting up an Apple/Android ID/user account for the owner (if one does not already exist - or interfacing with owner personnel in order to obtain existing account login info), downloading the various control software apps (both architectural system and lighting control console interface apps) and setting up/training the owner on the apps and their use in the aud as a portable lighting system controller (both for the lighting console and the architectural control system).



- 2) The contractor shall be responsible to setup and program up to (10) additional wireless devices by owner designated personnel that can control various aspects of the architectural control system or lighting control console. App purchases shall be the responsibility of the device owner for personal devices. The contractor shall simply assist in setting up presets, fader pages, etc.

E. DMX & UNIVERSE SETUP GUIDE:

1. The goal in setting up the DMX addresses for this project is to make things simple for the end user both in operation of the system and in finding fixtures, dimmers, relays, etc. This type of approach will embrace a compact setup/layout. It is our intention to outline a conceptual path forward without actually assigning universes and/or actual addresses. That will still be left up to the contractor to figure out and perform based upon the final fixture count, selections, owner input, etc.
2. The initial objective is as follows:
3. DMX Assignment Order (addressing given/shown on an ascending order priority basis) –
  - 1) Dimmer rack and dimmed modules (incandescent fixture control)
  - 2) Beginning with DMX address #1 and continuing in ascending order without gaps in assignments until all dimmer rack/dimmed modules have been addressed.
  - 3) Relay rack and non-dimmed and/or constant/relay modules (LED & moving head fixture control)
  - 4) Beginning with the next free address after the last dimmer rack/dimmed module address and continuing in ascending order without gaps in assignments until all non-dimmed, constant and relay modules have been addressed.
  - 5) Addressing for theatrical fixture lighting devices
  - 6) Beginning with the next free address after the last non-dimmed, constant and relay module address and continuing in ascending order without gaps in assignments until all theatrical fixtures have been addressed.
  - 7) Fixtures should be addressed in the following ascending order: front of house (first cove, second cove, etc.), stage (1st electric, 2nd electric, 3rd electric, etc.), side house lighting (side galleries, Shakespeares, tormentors, balcony pipes, etc.) \*.
  - 8) Fixtures should be grouped by type and assigned DMX addresses as such at each location for ease of use (i.e. wash fixtures then ellipsoidal fixtures, then zoomable fixtures, etc.). The exception to this is stage LED strip borderlight style fixtures, which would typically be grouped into a range of DMX addresses so that they can be quickly and easily selected as an entire stage wash.
  - 9) \*As an alternative, the owner might select to have the side house lighting (galleries, toms, etc.) occur before the stage assignments.
  - 10) House and work lighting fixtures (incandescent, LED or 0-10V fixture control)
  - 11) All houselighting fixtures (at the top of the address order beyond all other utilized DMX addresses – and within the control system's capabilities).
  - 12) All worklighting fixtures (at the top of the address order beyond all other utilized DMX addresses, including houselighting assignments – and within the control system's capabilities).
4. The intent is that all DMX addressing should occupy as few universes of DMX control as is possible and without the facility's DMX addressing being spread over multiplied universes of control. What should be avoided is assigning each physical location to a different DMX universe (i.e. first electric DMX universe #1, second electric DMX universe #2, ... houselighting to DMX universe #7, etc.).
5. A typical layout would look like the following:

DMX Assignment Schedule
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<i>Description</i>	<i>Fixture/Dimmer #</i>	<i>DMX Channel Assignments</i>		
Dimmer Rack (DR1)	Dimmer Channels #1 - 35	1	-	35
	Relay/Non-Dimmed Channel #1 - 61	36	-	96
Cove/Catwalk - ETC ColorSource Spot LED	RGBL Front of House Cove Spot Fixtures #1 - 10	97	-	146
Cove/Catwalk - ETC ColorSource Par	RGBL Front of House Cove Wash Fixtures #1 - 6	147	-	176
Rear Torm - House Left - ETC ColorSource Spot LED	RGBL Rear Torm Spot Fixtures #1 - 3	177	-	191
Rear Torm - House Left - Philips Showline SL Punchlite 220	RGBL Rear Torm Remote Zoom Fixtures #1 - 3	192	-	245
Rear Torm - House Right - ETC ColorSource Spot LED	RGBL Rear Torm Spot Fixtures #1 - 3	246	-	260
Rear Torm - House Right - Philips Showline SL Punchlite 220	RGBL Rear Torm Remote Zoom Fixtures #1 - 3	261	-	314
Front Torm - House Left - ETC ColorSource Spot LED	RGBL Front Torm Spot Fixtures #1 - 3	315	-	329
Front Torm - House Right - ETC ColorSource Spot LED	RGBL Front Torm Spot Fixtures #1 - 3	330	-	344
Stage - First Electric - Philips Showline SL BAR640 Wash Borderlight Fixtures	RGBW Wash Fixtures #1 - 4	345	-	404
Stage - Second Electric - Philips Showline SL BAR640 Wash Borderlight Fixtures	RGBW Wash Fixtures #5 - 8	405	-	464
Stage - Third Electric - Philips Showline SL BAR640 Wash Borderlight Fixtures	RGBW Wash Fixtures #9 - 12	465	-	524
Stage - First Electric - ETC ColorSource Par	RGBL Stage Wash Fixtures #1 - 4 (Stage Electric #1)	525	-	544
Stage - Second Electric - ETC ColorSource Par	RGBL Stage Wash Fixtures #1 - 4 (Stage Electric #2)	545	-	564
Stage - Third Electric - ETC ColorSource Par	RGBL Stage Wash Fixtures #1 - 4 (Stage Electric #3)	565	-	584
Houselighting Fixtures	Rows #1 – 6	585	-	590
Worklighting Fixtures	Stage Hi-Bays	591	-	592
Worklighting Fixtures	Catwalk	593	-	593
N/A	Any required DMX addresses necessary in order to address and control the DMX or 0-10V misc. fixtures, outlets, etc.	As required		

This DMX Assignments Chart Is Intended To Be A Starting Point Or Failsafe In Case The Owner Has No Particular Addressing Preferences; However, The TC Shall Consult The Owner Prior To Addressing Any Fixtures With A Printed Copy Of This List And Work Out All Specific Assignments With The Owner Prior To Addressing Any Fixtures As The Owner's Wishes May Differ From What Is Shown Here. Get Owner Approved DMX Assignments In Writing Prior To Assigning Any Fixtures, Dimmers, Misc. Portable Devices, Houselighting Fixtures, Etc.	
DMX Assignments Approval:	Duly Authorized Owner Or Owner's Representative Signature:
Approved As Indicated:	_____
Approved With Indicated Changes:	_____
Written Name:	_____
Date:	____ / ____ / ____

**† ALWAYS OBTAIN FINAL OWNER SIGN-OFFS FOR ALL DMX ASSIGNMENTS. FAILURE TO DO SO COULD RESULT IN THE CONTRACTOR HAVING TO REPROGRAM ALL OR LARGE PORTIONS OF THE LIGHTING SYSTEM IN ORDER TO ACCOMMODATE THE OWNER'S WISHES.**

### 3.12 OWNER INSTRUCTION:

- A. The contractor shall provide a training program at the project location and with the project equipment (owner's equipment), consisting of the following hours/periods of instruction specifically and exclusively regarding the lighting system (total training time not to exceed 24 hours. No training block to be less than 4 hours in duration. This time is in addition to training time noted below):
- B. Additional software training for the owner of up to eight (8) hours [in addition to training time mentioned above] in making adjustments to basic settings in presets.
- C. Additional software training for owner of up to four (4) hours [in addition to training time mentioned above] in operating and programming in the Pathport Manager x.x (latest version) software and in operating, configuring, resetting, managing and changing all network and gateway parameters/assignments.
- D. All owner instruction to be provided by the contractor as part of this contract shall be scheduled and performed within 12 months of the final system turnover date to the owner.
  1. The turnover date is defined as the date of completion of all open punch list items
- E. All training hours are exclusive of travel time.

### 3.13 TRAINING:

- A. Training must provide useful information that covers the majority of how a system will be used by the owner. This also applies to documentation and video training.
- B. On a job by job basis this training may vary significantly. The hours allotted may be used by the owner as required for any purpose related to the system.

**3.14 QUALIFICATIONS OF TRAINERS:**

- A. All persons performing system training must be experienced operators of the specific equipment in the project. If no one on the contractor's staff has experience on a specific device, then they will need to provide outside personnel in order to perform the training sessions.

**3.15 SCHEDULING FOR TRAINING:**

- A. Initial Training must be scheduled by the contractor with at least two weeks advance notice.
- B. If the contractor arrives for a scheduled training session and the owner personnel are not present, then the contractor must notify the owner that a four-hour training segment has been forfeited.
- C. If a scheduled session lasts less than four hour it will still expend four hours of allotted training time.

**3.16 INITIAL TRAINING:**

- A. Walk through the facility and familiarize the owner with where all primary system equipment is and what it does. This should include any primary and secondary power panels feeding the systems, system disconnects and the identification of individual system breakers.
- B. Train on primary control surfaces (consoles, touchscreens, etc.) for the most commonly used functions.
- C. Train on how to put together scenes, presets, shows, etc.
- D. Train on how to RDM access fixtures, patch dimmers, etc.
- E. Train on specialty lighting fixtures such as LED, moving heads, remote zoom fixtures, etc.
- F. Train on saving and restoring consoles and other software programmed devices.
- G. It is recommended that most training be hands on with the owner's personnel operating the equipment.

**3.17 FOLLOW-UP TRAINING SESSIONS:**

- A. Often these sessions will be used for in rehearsal or show sessions where the contractor is an assistant to the operators during actual system use.
- B. Some operators may want to schedule session on higher level functions. In these instances, the contractor shall provide that advanced training.
- C. Training sessions may also be used to change configurations for the owner. Often once a system has been in use for a period of time, configuration changes are requested by the owner for default system presets and controls.
- D. Provide training only at the request of the owner's authorized representative (s). Track all training hours and provide copies to the owner of who attended and what general topics were covered.

**3.18 VIDEO RECORDING OF TRAINING WITH OWNER – INITIAL TRAINING:**

- A. The camera should be placed on a tripod in a location that offers a good view of the console and screens. Lighting must be adequate for the video camera; provide portable lighting as needed.
- B. Provide simple explanations of what each piece of equipment does, what would occur if the lighting system were to be shut down, etc.
- C. Console initial training shall also be video recorded. During this training an operator from the owner can operate equipment.

- D. A live training session by default will be interrupted with questions. The camera should record through the entire session.

### 3.19 VIDEO RECORDING OF DEVICE TRAINING – SECONDARY TRAINING:

- A. Device specific training shall be recorded by the contractor independent of the initial training session. This recording can be done in the contractor's shop, at the site without the owner or at other locations as appropriate.
- B. This second video training is to provide multiple levels of information:
1. A walk around of the site should be video recorded that shows the owner where all primary lighting system equipment is located and what all related screens and indicator lights look like when everything is working properly.
  2. A walk to the power panels & disconnects feeding the system and what breakers operate various power feeds and what their normal state looks like.
  3. A quick start video guide for someone who has to use the system who has no idea how to do anything.
  4. Example:
    - a. How to boot up the console.
    - b. How to access a show file.
    - c. How to run a cue.
    - d. How to navigate screen pages and find magic sheets, etc. and how to operate them.
    - e. Basics on lighting priority – why lights might still be on from the architectural control system and how to manage these conflicts, etc.
    - f. How to shut down the console and the lighting system.
  5. Additional information for anyone who needs to do the following:
    - a. Patch lights, including RDM functions. This should include what to do when a fixture won't RDM properly.
    - b. How to create a lighting cue and edit timing, etc.
    - c. How to load faders and sub masters.
    - d. How to save a show to USB.
    - e. How to load a show from USB.
    - f. Patching and grouping – how and why to use groups.
    - g. Color and focus functions – how and why to use.
    - h. Different in color gamut between manufacturers of LED's.
- C. Video recording general requirements (applies to all):
1. Convert each recording to standard formats for playback on Mac/PC based platforms and write to the devices as described below.
  2. Edit and title the final video training sessions into logical chapters so that an end user is quickly able to find what they need. The basis for titles, sections, etc. shall be the general content of all video training.
  3. Provide an electronic file to the owner and owner's personnel that contains all relevant links to the manufacturer's video training series for basic, intermediate and advanced topics/functions.
  4. Provide all training videos in DVD and USB stick formats.
  5. On the USB stick, include a PDF document that contains the active links to the manufacturer's video training sessions and relevant sites.
  6. In subsequent training sessions with the owner's personnel, higher level functions may be covered. Some owners will not require this, but others will. The contractor is not required to video record subsequent sessions. The owner can record any session they want for future reference using their own equipment.
  7. Provide (1) one copy (brand new and not previously used) of Stage Lighting: The Technicians' Guide: An On-the-job Reference Tool with Online Video Resources (provide the latest edition) by Skip Mort. This shall be turned over to the owner.

**3.20 WARRANTY AND SERVICE:**

- A. The contractor guarantees all equipment, materials (excepting incandescent lamps) and workmanship to be free from defects for a period of one year from owner acceptance. This warranty supersedes all manufacturers warranties for the one-year period. Any manufacturer's warranty that exceeds the one-year will continue to be applicable. The contractor will replace any defective materials at no charge to owner. Any equipment replaced during the one-year warranty will have a new one-year warranty to the owner.
- B. The contractor guarantees all labeling to be free from defects for a period of two years from the date of owner acceptance. In cases where the label's adhesive fails or the label suffers from degradation causing it to become unreadable, the label will be considered defective and will be replaced at no cost to the owner.
- C. LED Fixtures and lamps that fail in the first 90 days will be replaced at no cost unless an electrical fault can be shown to have caused a major lamp outage or fixture failures.
- D. The contractor will respond by phone to requests for service within 2 business hours and respond with a technician being sent (if needed) within 1 business day.
- E. Any equipment that tends to "drift" or whose performance deteriorates during the warranty period will be considered defective, even if such drifting is normal during break in. This equipment will be readjusted by the contractor at no additional charge to the owner.
- F. Provide all service at the owner's location regardless of any manufacturer warranty terms regarding carry in service.
- G. During the warranty period if any equipment failed will take more than 24 hours to repair, the contractor will make available and interconnect at no cost to the owner suitable temporary equipment to maintain a fully operational system until repairs are complete.

**3.21 DEMONSTRATION AND ACCEPTANCE:**

- A. CONDITIONS FOR SCHEDULING FINAL ACCEPTANCE:
  - 1. The system is required to be complete and fully tested. Any failure that may have occurred between the contractor's final tests and the date of acceptance will be noted and can be corrected after that date
  - a. Final setup for the houselighting system must be scheduled so that the owner or owner's representative, consultant, contractor and factory technician are all present. This will also constitute the final acceptance meeting for the houselighting system and all related preset setups. A factory technician must be present at this time or no final setup or final acceptance will be performed. If the factory technician has to return for this meeting, it will be at no additional charge to the owner.
- B. PROCEDURE FOR SCHEDULING FINAL ACCEPTANCE:
  - 1. The contractor shall notify the owner and consultant of a proposed date and time for the final acceptance tests. The contractor shall include two alternate dates and times. The dates proposed will be a minimum of fourteen (14) calendar days from the date of the proposal.
  - 2. If none of the dates and times are acceptable, the owner and/or consultant will submit two alternate dates and/or times to the contractor.
- C. DATE OF TESTS:
  - 1. Sufficient personnel will be on hand so that final focus/adjustments can be made to the lighting fixtures.
  - 2. The contractor will have the appropriate equipment available to focus/adjust the lights (for example, ladder, manlift, etc.).
  - 3. Tools must be on hand to remove connector plates and provide for other possible inspections.
  - 4. All racks must be able to be opened for inspection.

5. The contractor will demonstrate operation of all major components of the systems including, but not limited to, the following:
  - a. Demonstrate all system functions and presets.
  - b. Demonstrate programming input.
  - c. Demonstrate operations of all devices with the lighting console.

### 3.22 CONDITIONS OF ACCEPTANCE:

- A. It is understood that the consultant cannot inspect every aspect of the installation. The contractor is responsible for installation quality and methods, fabrication quality and methods, and performance of their work. Acceptance of the project will constitute an acceptance of the following:
- B. All specified equipment is installed, and the system is operating in an acceptable manner from a functional standpoint (See checklist below for specific functional requirements).
- C. Upon completion and acceptance of the project the contractor will provide to the owner a letter stating that all of the equipment and installation methods meet or exceed the specification requirements in all respects, and that the system as installed meets all of the applicable standards and codes required under the specification and meets applicable federal, state and local codes and laws.
- D. ACCEPTANCE TESTS CHECKLIST:
  1. Prior to acceptance testing there are a number of conditions that need to be verified. There are also site conditions required for the consultant to perform tests as indicated. The contractor shall ensure that every item on this checklist has been performed and verified prior to the consultant's acceptance tests can begin. Scheduling of the consultant to perform final acceptance tests must be coordinated with the owner, the project's construction manager (or clerk of the works), the contractor and the consultant (See paragraphs above for detailed requirements).
  2. GENERAL
    - a. No other contractors may be working within the rooms to be tested during tests.
    - b. The contractor must verify these conditions can be maintained during testing.
  3. THEATRICAL LIGHTING – TYPICALLY TAKES 3 – 4 HOURS:
    - a. Required attendance – A technician fully capable of programming and operation on all software including the console, architectural controls and any other software must be on site. Personnel and equipment needed for focus also need to be on site.
    - b. Any remote programming software that requires an external computer to address the lighting system must be on site, on line and loaded into a laptop provided by the contractor and ready for use if system programming changes are required.
    - c. All lighting circuits tested and verified functional.
    - d. Lighting control console set up, monitors in place and on mounts and all cabling and interconnections complete and neatly dressed.
    - e. All lighting console patching including color and any moving lights must be complete.
    - f. Architectural presets and control patching complete.
    - g. All lighting system labeling complete, including wire management, yoke and fixture labeling, portable cabling, etc.
    - h. All nodes and DMX distribution completely programmed and patched.
    - i. Remote focusing device (RFU, RFR, iPad or other wireless console control devices) verified and operational.
    - j. Fixture focus as required within specifications will be done at this time unless the owner chooses to take charge of and responsibility for this at another date.
    - k. Verification, in the form of signed documents, that all portable equipment has been delivered to the owner per specs and drawings and stored as per the owner's instructions. Portable equipment must be available for visual inspection as well.
    - l. Network configuration software set up and fully programmed.

**3.23 CLOSEOUT DOCUMENTATION:**

- A. All closeout documentation, including training videos, must provide the owner with usable content. The determination of acceptability will be determined by the Consultant. Poor quality training videos and documents will be rejected.
- B. Closeout Documentation is to be submitted within two weeks of system completion.
- C. Contractor must submit the following items. All items should be part of the O&M Manual. Provide the quantity and form (paper and/or electronic) of these closeout documents as is indicated in the contract front-end documentation. Physical copies shall only be required if front-end documentation requires them.
- D. System testing documentation as required by final testing and acceptance procedures outlined in this document.
  - 1. ALL paper copy O&M Manual submissions shall be in heavy-duty, D-Ring style, 3-Ring binders All electronic copies shall be "bound" in an Adobe Acrobat style portfolio (see below for more complete information).
  - 2. Complete technical manuals for all equipment installed.
  - 3. List of serial numbers of all equipment installed
  - 4. Warranty cards for all equipment.
  - 5. Manufacturer MSDS sheets for all applicable equipment.
  - 6. Operations & Maintenance Manuals shall include English and Spanish only.
  - 7. Operations & Maintenance Manual: An operations and maintenance manual (or "Systems Manual") written in English on the safe use of a that particular site's lighting, dimming and controls system(s) shall be provided by the contractor to the owner. (provide separate manual sections for different spaces included in this project – each to be a separate, complete and distinct section in the manual for each differing or multiple system and location). This manual should include the following:
    - a. Table of contents.
    - b. A contractor written simplified guide to operating the system Include at minimum:
      - 1) A contractor written simplified troubleshooting guide or what to check and where to check if no lights will come on. Provide this in a 2-column style format.
      - 2) How to power up and power down the console, lighting system, etc.
      - 3) Console touch screen set up and general info on how to access various screens.
      - 4) A key stroke guide on how to quickly get to menus to patch dimmers, RDM fixtures, address/patch LED's or other moving/specialty lights and accessories to the console.
      - 5) Constructing and editing cues.
      - 6) Programming sub masters.
      - 7) Loading Faders.
      - 8) How to perform file saves, file loads, etc.
      - 9) A short list of the required software reset procedures for all lighting system related subsystems.
    - c. A simplified guide to operating the architectural control system, an understanding of pile on system architecture and where the button stations get their content. If editing has been made available on LCD screens, provide a guide on how to save over presets that affect button stations.
    - d. Microsoft Excel spreadsheets of all initial lighting system patch data, DMX assignments and fixture types at final set up.
    - e. Emergency contact number(s) and procedures to follow in the event of a catastrophic system failure.
    - f. One copy of the "Workbook" version of each of the following training guides used (only provide for levels trained on):



- 1) ETC Level 1 console training – Essentials.
  - 2) ETC Level 2 console training – Enhanced Skills.
  - 3) ETC Level 3 – Advanced Programming.
  - g. Maintenance procedures and recommended schedules required for equipment installed that requires regular scheduled maintenance.
  - h. A DVD (or set of DVDS, depending on requirements listed Under Training Sections above) and a USB thumb drive with all content included on it.
- E. O&M Manual pdf requirements: The contractor shall provide a pdf copy (with appropriate titles) for each piece of documentation listed above and bound together in a pdf portfolio/binder, labeled with the owner's name and with the submitting contractor's information. All electronic manuals shall contain only equipment and information that pertains to the project. Where factory manuals are available the contractor shall provide these. Where factory manuals are not available, the contractor shall provide high resolution (150 dpi minimum and fully optimized in Acrobat or equal), full page, properly and consistently oriented pages in a consecutive ascending order. All pdf portfolio and binders produced and submitted shall be professionally put together and presented well. All manuals shall be saved as standard Adobe Portable Document Format (PDF).

**END OF SECTION**



<b>NEWBURGH ECSD</b>	<b>Phase 5: 2019 Capital Improvements Project</b>
13740.20	Theatrical Stage Rigging & Curtains 193000 - 1

## SECTION 193000 THEATRICAL STAGE RIGGING & CURTAINS

### PART 1 GENERAL

#### 1.1 PROJECT INFORMATION:

- A. Owner: Newburgh Enlarged City School District  
400 Old Forge Hill Road  
New Windsor, NY 12553
- B. Architect: CPL  
Architecture Engineering Planning  
50 Front Street, Suite 102  
Newburgh, NY 12250
- C. Consultant: AVL Designs, Incorporated  
1788 Penfield Road, Suite 1  
Penfield, New York 14526  
Phone (585) 586-1100
- D. Contractor: The successful bidder for the work described herein. Also referred to as the contractor, the lighting contractor, the lighting installer or the bidder.
- E. Others: Various companies doing construction work under the general contract.

#### 1.2 PROFESSIONAL STANDARDS:

- A. The contractor is expected to install all work to the appropriate industry professional standards, manufacturer recommendations, and current applicable codes. If any work required exceeds the skills of the contractor, he will employ appropriate subcontractors for the scope required.
- B. The acceptability of materials and workmanship will be determined by the Architect, Consultant, and CM.
- C. Any work that might be damaged, be inadvertently painted, or become dirty during construction will be protected by the contractor. All responsibility for protection shall be by the contractor. The contractor will provide final cleaning and or repair of all equipment in their scope to like new condition.
- D. The contractor will attend and/or arrange meetings as required to make sure their scope is coordinated with all other trades. The contractor is responsible to make known to all other trades critically dimensioned items and locations to avoid conflicts. Where conflicts occur follow required procedures in the project manual to seek resolution.
- E. Where any substandard work is provided by related trades that impedes the work of the contractor, they will notify the CM, Consultant, Architect, or Engineer in writing as called for one the project manila to rectify the issue.
- F. Where work is provided by others, the contractor is responsible to verify installation conditions that relate to their work. If installation of related work is substandard the contractor shall generate a written RFI through proper channels based upon the project manual. The contractor shall not install their work to any substandard devices, etc. provided by others until such work has been resolved or until the contractor has received written authorization from the construction manager to proceed. If the contractor ignores substandard installation work by others and proceeds to install his devices to these items, then he accepts and bears sole responsibility to repair, reinstall and correct any found deficiencies to the satisfaction of the owner upon final inspections.
- G. The contractor will comply with the AHJ (Authority Having Jurisdiction) as it relates to programming any and all emergency interfaces.
- H. The contractor is expected to possess knowledge of the equipment of their industry and to provide all small items required to install the specified equipment. Provide small items such as rack rails,

DIN rails, rack panels, power cords, connectors, wall-wart power supplies, crimps, Nicopress and other items that may not be called out on drawings or in specs but are required to support primary equipment.

- I. When in doubt about any aspect of the work the contractor should not proceed until they obtain clarification from the appropriate entity following procedures detailed in the project manual.

### 1.3 DEFINITIONS:

Code Requirements	Minimum requirements as specified by all applicable and published codes.
Concealed	Work installed in pipe and duct shafts, chases or recesses, inside walls, above ceilings, in slabs or below grade.
Equal or Equivalent	Equally acceptable as determined by Owner's Representative.
Extend	To increase the length(s) of any indicated conduit/wiring so as to reach a particular specified or implied point – including the provision of any misc. additional equipment as required for proper extension and to maintain full system functionality.
Final Acceptance	Owner acceptance of the project from Contractor upon certification by Owner's Representative.
Furnish	Supply and deliver to installation location to the appropriate trade responsible for installation.
Furnished by Others	Receive delivery at job site or where called for and install.
Inspection	Visual observations by Owner's site Representative
Install	Mount and connect equipment and associated items and make ready for use.
Labeled	Refers to classification by a standards agency.
Or Approved Equal	Approved equal or equivalent as determined by Owner's Representative.

Owner's Representative	The Prime Professional, Construction Management or Clerk of the Works.
Patching	Repair of holes, marks, and damage left from removals. Consult project manual for requirements.
Provide	Furnish, install and connect ready for use.
Relocate	Disassemble, disconnect, and transport equipment to new locations, then clean, test, and install ready for use.
Replace	Remove and provide new item.
Remove	Safely Disconnect including any and all wiring, hardware, conduit (except concealed), anchors, suspension hardware etc....Legally dispose of items not called out to be offered to or returned to owner.
Review	A general contractual conformance check of specified products.
Satisfactory	As specified in contract documents.

#### 1.4 INTENT OF DRAWINGS:

- A. Throughout the contract documents there are various manufacturers and products referenced. It is understood that these products establish a basis of design that all other "or equal" substitutions must meet or exceed. All submitted devices must be the referenced product or approved equal.
- B. The drawings in this package are diagrammatic in nature, unless detailed dimensioned drawings are included. The drawings show the approximate locations of equipment and devices. The final and exact locations of all non-dimensioned devices are subject to the approval of the Owner or the Owner's Representative. Devices with detailed installation dimensions; however, are critically located and must be installed to those indicated dimensions unless alternate instructions have been given to the contractor in writing by the consultant.
- C. The contractor(s) shall inspect the entire building(s) with the Owner's representative prior to beginning any work and shall identify the exact locations and installation methods for all devices, conduit and wiring prior to beginning work.
- D. Typical details are shown for the installation of various devices. The details do not apply to all situations. Installation methods for all work shall be subject to the Owner's and construction manager's approval. Provide all work and equipment required for a professional, workman-like installation.

#### 1.5 SECTION INCLUDES BUT IS NOT LIMITED TO:

- A. Removals – May include storage and reinstallation of some items.

- B. Provision of stage and house rigging systems and related work scope as indicted on drawings.
- C. Provision of custom saddle brackets.
- D. Set up and commissioning.
- E. Training and closeout documents.

#### **1.6 RELATED SECTIONS & DOCUMENTS:**

- A. The contractors shall examine the full set of construction drawings and specifications and ascertain all aspects of the scope of work described within this specification. The contractor will be responsible for cooperation with and adherence to the overall scope and intent of the project relative to the work being done by the contractor.
- B. Drawings and general provisions of the Contract including General and Supplementary Conditions and Division 0, 1, 11 and 26 specification sections apply to work of this section (related specification sections may vary depending upon the particular CSI format being adhered to). All related drawings, contract conditions and general requirements found in the project manual that apply to the general contract will apply to the work described in this specification. Examine all referenced documents for general project requirements relating to the work in this specification. Contact the architects, engineers and/or construction manager for any clarification required to properly bid this project. It is the contractor's responsibility to obtain necessary clarification before bidding.

#### **1.7 RELATED WORK NOT INCLUDED:**

- A. The contractor is responsible for all work on the TR series drawings and written specifications.

#### **1.8 GENERAL REQUIREMENTS:**

- A. ITEMS TO BE PROVIDED BY OTHERS:
  - 1. Structural steel, glulam beams, stage wooden rafters, etc. (existing and to remain).
  - 2. Projection screen (existing and to remain).
- B. Removals - Offer all existing portable and removed equipment to the owner prior to legally disposing of these items (counterweights, cheeseboroughs, booms, etc.). Obtain written permission from the owner for all existing removed items that they do not desire to retain prior to disposal.
- C. Provide all equipment outlined and described within this specification and assemble it into a complete, properly functioning system for use by the owner as described within this specification.
- D. It is the contractor's responsibility to clarify any misunderstandings or drawing-to-drawing/drawing-to-spec discrepancies prior to bid. In cases of a difference between stated quantities in drawings, specs or electrical drawings, the higher quantity will prevail.
- E. Check each component before installation as well as each portion of the project during installation to ensure that the intent of this specification is achieved.

#### **1.9 BIDDER QUALIFICATIONS – SUBMITTALS:**

- A. The bidder shall provide references of at least three (3) installations of comparable scope performed by the bidder, including location, system description, and name, address, and telephone number of the architects, consultants, and owners and the names of contract persons for each.
- B. The bidder must maintain service facilities and have service available on site within 24 hours. The bidder must be a factory authorized dealer for all products submitted and may be required to submit such proof of factory authorization in writing, or in the form of copies of authorized agreements with the various vendors.
- C. The bidder and all persons performing theatrical rigging system related work on this job must be ETCP certified (Entertainment Technician Certification Program) as a theater or arena rigger or under the direct supervision of an ETCP certified foreman. This applies to all theatrical rigging

equipment installation and any other assemblies indicated as being provided or installed by the bidder. Proof of current certification MUST be provided in the submittals package (this is typically in the form of a pdf copy of the current and active certification certificates from PLASA). Out of date or expired certifications shall not be recognized as meeting the requirements of ETCF certification.

- D. The bidder must be the installing contractor or shall provide written documentation of any intended qualified subcontractors up front for approval. All subcontractors must be identified.

#### **1.10 INQUIRIES AND COMMUNICATIONS:**

- A. All questions shall be generated as called for in the project manual.
- B. Direct communications to the consultant via phone are recommended for initial discussion about intent or site issues. (unless prohibited in the project manual). No action may be taken based on verbal communications, they must be followed up in writing as called for in the project manual.
- C. Where discrepancies occur, and pre-bid instructions have not been obtained by written request, the contractor will abide by the owner's decision at no additional cost to the owner.

#### **1.11 COORDINATION:**

- A. Cooperate with other trades to achieve well-coordinated progress at all times. Notify the owner and consultant as often as necessary with regards to job progress or changes in the installation schedule. All conflicts will be reported to the architect, construction manager, owner, and consultant in writing. All reasonable attempts will be made to correct any difficulties.
- B. Staff the job site adequately at all times to maintain a progress in keeping with the total project progress.
- C. Provide all materials to be installed by others in a timely fashion based upon the related trades' schedules.
- D. The job site will be left in a clean safe condition at the end of any workday. All cleanup and debris removal to a site designated by the owner will be the responsibility of the bidder on a daily basis.
- E. All storage of tools and materials will be done by the contractor. No on-site storage security will be provided by the owner.
- F. The contractor will attend regular meetings with the architect, owner, general contractor, and the consultant when requested by any of the above, in order to achieve project coordination and progress.
- G. The contractor shall be required to share all approved rigging system electrical shop drawings with the EC prior to rough-in. He shall work closely with the electrician in determining final control wiring types, quantities and requirements, related device locations, backbox sizes, conduit routings, etc. before the EC has purchased his supplies and in order to meet the construction schedule. He shall share all approved rigging system shop drawings and work closely with all contractors prior to any rough-ins in coordinating the stringent requirements and clearances required for the rigging systems equipment.

#### **1.12 DELIVERIES:**

- A. It is each contractor's responsibility to receive all device shipments, equipment, deliveries, etc. for their own equipment on/at the job site personally. Each contractor shall be responsible to arrange for storage of all received materials on site until the appropriate time when they shall either turn them over to installing contractor or install them.
- B. If the contractor chooses to allow a third party to receive shipments on his behalf the contractor bears sole responsibility for any missing and/or damaged parts.
- C. Any equipment that is furnished by the contractor for installation by others shall be turned over to the installing contractor at a time that fits into their production schedule and the project's overall construction schedule.

**1.13 STANDARDS REFERENCES:**

- A. The contractor is responsible for the provision of material and methods installation of equipment conforming to the currently applicable standards of:
1. ADA - Americans with Disabilities Act
  2. AISC - American Institute of Steel Construction
  3. AISI - American Iron and Steel Institute
  4. ANSI - American National Standards Institute
  5. ASME - American Society of Mechanical Engineers
  6. ASTM - American Society for Testing Materials
  7. AWS - American Welding Society
  8. EIA - Electronic Industries Association
  9. ESTA - Entertainment Services and Technology Association
  10. FCC - Federal Communications Commission
  11. IEC - International Electronics Commission
  12. IEEE - Institute of Electrical and Electronics Engineers
  13. IFI - Industrial Fasteners Institute
  14. ISO - International Organization for Standardization
  15. NACM - National Association of Chain Manufacturers
  16. NEC - The National Electric Code
  17. NEMA - National Electrical Manufacturers Association
  18. NFPA - National Fire Protection Association
  19. OSHA - Occupational Safety and Health Association
  20. SAE - Society of Automotive Engineers
  21. SMPTE - Society of Motion Picture and Television Engineers
  22. TIA - Telecommunications Industry Association
  23. UL - Underwriters Laboratories (Electrical components, devices and accessories shall bear a UL label where applicable. UL listed and labeled as defined by NFPA70, article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.)
  24. USITT - United States Institute for Theater Technology "Recommended Guidelines for stage rigging and stage machinery-specifications and practices".
  25. Wire Rope User's Manual
  26. Manual of Steel Construction 15<sup>th</sup> Edition or later (aka the AISC Steel Construction Manual)
- B. Provide certification and labels where applicable. Comply with federal, state, and local regulations and applicable union regulations where required. All equipment will have the proper labels for New York State.
- C. Provide only equipment that is standard, new, previously unused equipment of the latest design or of the latest model of regular stock product and is supplied with all parts regularly used with the equipment offered for the purpose intended. No re-furnished or obsolete materials shall be permitted. The contractor guarantees that no modification of the equipment has been made contrary to the manufacturer's regular practice.
- D. Review all materials and equipment prior to installation and notify owner as to any changes or discrepancies between published specifications and the actual material and equipment to be installed.

**1.14 EQUIVALENTS:**

- A. The successful bidder shall submit any product equivalents prior to award of the contract detailing the kind, type, brand, manufacturer or equipment included in the base bid. Equivalent products must be highlighted on this list. When requested, the successful bidder shall also submit information, describing in specific detail, how the equivalent bid material differs from the



appearance, quality and performance required by the base specification. Submittal of the manufacturer's advertising cut sheets alone is not acceptable for proof of equivalency.

- B. Proof of equivalency may require the bidder to provide physical samples, a full-sized mockup or specific manufacturer information detailing technical equivalency. Proof of equivalency shall be the burden of the submitting contractor/bidder and not that of the consultant. Proof of equivalency relates to all pertinent functions of the specified equipment, regardless of if that information is reflected on any manufacturer's issued cut sheets.
- C. If proposing equivalents that affect the system design as shown on the drawings, the bidder must submit flow charts, and any other drawings necessary to show differences in the system operation from the primary referenced system.
- D. The bidder will pay for any and all changes to related work scope required by the equivalent products.
  - 1. This includes electrical, architectural, structural and other changes that might be needed to implement an equivalent product.
    - a. Some products with virtually identical functions have varying power requirements, physical dimensions, etc.
- E. The risk of whether bid equivalents will be accepted is borne by the contractor. See section 2.1 "Performance Requirements" for more information.
- F. No equivalents will be considered after the Contract award unless specifically provided for in the Contract Documents.
- G. Final judgment as to equality will be solely that of the consultant, architect, construction manager and owner.
- H. The costs for any changes by other trades required to implement the equivalents proposed will be borne by the contractor.

#### **1.15 SUBMITTALS:**

- A. Equipment: After bid award but before ordering any equipment or starting any work submit to the owner for approval a list of all equipment to be furnished showing types, models, quantities and manufacturer. Attach catalog sheets for all items submitted.
- B. The quantity and form (paper and/or electronic copies) of all submittal material required shall be provided by the contractor to the appropriate parties as is indicated in the contract front end documents (in addition to any requirements listed below). If there are no indications in the contract front-end documents, then the contractor shall submit (1) electronic copy of each area, category, etc. of items as listed below. All submissions are understood to be intended for approval by the construction manager, the architect, owner, general contractor and the consultant prior to any fabrication or installation of any devices.
- C. Submit a schedule for submission of drawings for fabrication and site work.
- D. Submit a complete submission package with all required paperwork.
- E. Submit curtain material samples (two for each different type of curtain indicated on contract documents), shell material samples and standard color selection charts (charts must be in color and manufacturer's actual cut sheet – no color selection charts in black & white or photocopies of original color selection charts shall be acceptable) for approval by the architect & owner prior to any fabrication or installation. These copies are to be submitted to the architect ONLY. The intent of these is for the charts and samples to be used for the selection of the curtain and shell colors. Submit documentation in the submittal package to the consultant that these have been delivered to the architect & owner.
- F. Submit proposed embroidered shield(s) for approval by the architect & owner prior to any fabrication or installation. Submit documentation that this design has been carefully worked out with and approved by the owner (in writing) and forward this to the consultant. Shield layout, size,

material color and embroidery thread colors TBD by the owner. Prior to finished submittals of these items to the architect and consultant, the contractor should provide samples of shield size, layout and intended material/thread colors to the owner for selection and approval. This portion of the submittal package may need to be delayed and be submitted at a later date due to the selection and decision-making processes of the owner regarding the shield size, layout, design, configuration and colors.

- G. Submit a copy of the motorized winch manufacturer's written verification ("certificate of compliance") that all motorized hoists and related controls are fully compliant with the latest version of the ANSI motorized rigging standard.
- H. Submit each of the following as each pertains to this project. Provide a copy for each related person performing indicated work who holds these certifications:
  - 1. Current welding certifications
  - 2. Current training certifications.
  - 3. Current ETCP certification.
  - 4. Current manufacturer certifications.
- I. Submit material schedules, shop drawings, bill of materials, rigging system data/cut sheets and any applicable fire rating data or MSDS sheets for all rigging system components and curtains.
- J. Submit a complete set of rigging drawings\* (each sheet bearing the signed stamp of and fully reviewed by a current New York State licensed professional engineer – i.e. a "stamped set" or "NYS PE stamped" set of drawings) of the proposed rigging system and related building components (including, but not limited to, the overhead rigging steel, floor construction and loading under locking rail, etc.).
  - 1. Technical Drawings:
    - a. The full set of submitted drawings and data sheets must be presented in a professional manner.
    - b. All shop drawings for submission must be CADD drawn (created with a computer aided drafting program). Hand drawings are not allowed. Illegible drawings shall not be acceptable.
    - c. All cut sheets for submission must be clean electronic (pdf) copies of the manufacturer's actual data sheets. Mark up each sheet with highlights or boxes around submitted products, options, etc.
    - d. Provide a complete drawing package including attachment details, rigging details, suspension details & mounting and other required miscellaneous details.
    - e. Provide complete system drawings including plans, elevations, sections and details.
    - f. Provide complete fabrication and attachment method drawings.
    - g. Provide a separate cut sheet (manufacturer's data sheet) for every piece of equipment being provided.
      - \* The intent of the stamped shop drawings is for the contractor to communicate to the consultant the exact proposed locations, materials and fabrication methods of all standard and custom items for all intended rigging system equipment as well as to have all proposed systems approved by a structural engineer as to loading, breaking strengths, embedment depths, loads imposed on building structure, etc.
- K. Quality Assurance
  - 1. The Basis of design for the dead hung & counterweight rigging system shall be manufactured by H&H Specialties stage equipment. The equipment is described in complete technical data available from the manufacturer.
  - 2. The Basis of design for the motorized rigging and related control system shall be manufactured by Electronic Theater Controls, Inc., 3030 Laura Lane, Middleton, Wisconsin. The equipment is described in complete technical data available from the manufacturer.
  - 3. Fabrication shall begin only after approved drawings and a written notice to proceed have been delivered to the manufacturer at the manufacturer's place of business.

- L. The intent of the submittal package is that it contain one copy of the appropriate cut sheet for each item that the contractor is proposing to use on this project as well as a complete set of stamped shop drawings that shows plan, section and elevation views and details of the entire rigging system. Typical drawings to include are as follows:
1. Plan view drawings detailing set layouts & dimensions, batten and curtain lengths, locking rail and guide systems and all other related device locations.
  2. Individual elevation/section views that show set travel trims, tormentor/Shakespeare/truss locations and all other pertinent details.
  3. Detail drawings that show all typical attachments, trim chains, beam clamps, pipe assembly constructions, etc. as well as all custom fabricated devices, suspension intentions, etc.
  4. Manufacturer drawings of all required mechanical and electrical details that relate to any included motorized units and control systems. This set is to include plan/section/elevation views, flow diagrams, load ratings, ANSI compliance letter, etc.
  5. The PE review shall include an evaluation of all individual system components, the rigging components together as an interrelated system and a review of all related rigging steel, floor loading, system uplift on structure, etc. Submission of this package by the contractor is proof that the contractor has reviewed the entire system design, understands the intents and concurs that the designed system will actually function as laid out in the contract documents.

#### **1.16 GENERAL SYSTEM DESCRIPTION:**

- A. Theatrical Rigging System:
1. Dead hung rigging system
  2. Dead hung FOH (front of house) systems
  3. Curtains
  4. Unistrut support system

### **PART 2 PRODUCTS**

#### **2.1 PERFORMANCE REQUIREMENTS:**

- A. The requirements of the referenced equipment are not generic in nature. Specific performance, control and routing capabilities are necessary for any alternate equipment. The details set forth herein and within the functional description of the system are the critical criteria for the selection of each piece of equipment.
- B. In bidding equivalent equipment from manufacturers other than those referenced on these contract documents, the contractor must be aware that all functional information included in this specification as well as the manufacturer's specifications, physical size, serviceability, warranty terms, product availability and other non-technical issues may be determining factors in product equivalency. Final judgment as to equivalency will be solely that of the owner, architect and consultant. Equivalent products shall be approved only at the contract bid price and shall not allow for additional costs to the owner, except as described in the contract manual.
- C. Substitution Criteria:
1. Curtain & Track substitutions require proof that the substituted product meets all performance requirements including but not limited to:
    - a. Product warranty period
    - b. Flame rating
    - c. Available colors & finishes
    - d. Sheen of fabric face
    - e. Material weight per square yard
    - f. Light blocking capabilities
    - g. Longevity
    - h. UV Resistance
    - i. General workability and finished appearance
    - j. Track construction, pulleys and material finishes available

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- k. Track weights, accessories and attachments
  - l. Rotator & brake operations and functionality
  - m. Load ratings of curtain track equipment
  - n. Curtain track and accessories available finishes
2. Miscellaneous rigging hardware (counterweight or dead hung) substitutions require proof that the substituted product meets all performance requirements including but not limited to:
- a. Product warranty period
  - b. Physical size.
  - c. Physical weight (self-weight of individual piece).
  - d. Stamping or other indications of load rating.
  - e. Custom pieces available if need arises.
  - f. Critical spacing, line handling or physical size characteristics that may impact installation intents.
  - g. Load ratings and WLL capacities.
  - h. Safety factors.
  - i. Attachment methods.
  - j. Welding requirements.
  - k. Physical construction.
  - l. Rated and expected life duty cycles.
  - m. Part traceability.
  - n. Appropriateness or approval for overhead lifting use.
- D. All individual parts and overall assemblies shall additionally conform to the requirements listed below in the "Standards" section of these written specifications.
- E. No contractor-manufactured products shall be acceptable in place of referenced items except for those items enumerated in this specification as "custom."
- F. The current manufacturer's data sheet for each referenced piece of equipment in force at the date of printing of this specification shall be the basis for the specifications of the referenced equipment.
- G. Any necessary product accessories such as additional power outlets, power supplies, rack mount kits, connectors, adapters or other small items are the responsibility of the contractor to provide, whether or not they are called out in detail within these specifications. This may include additional electrical work, (also depending upon the differences between any substituted vs. specified equipment), junction boxes, breakers, disconnects, etc. and shall be the sole responsibility of the contractor to provide at no additional cost to the owner.
- H. Specification details are provided only for the features required for current and intended future uses of the products.
- I. Quantities:
- 1. Where no quantity is indicated in the written specifications, the contractor shall supply quantities as indicated on drawings.
  - 2. Items not indicated on drawings but necessary for project completion shall be provided as required for project execution at no additional cost.

## 2.2 STANDARDS:

- A. Intentions of standards:
- 1. This document establishes the minimum standards required for the specified rigging and related equipment installed in this facility as part of this specification and related drawings; however, the proper installation and operation of this equipment are equally important. Equipment shall be operated and maintained by (or under the supervision of) a competent person (trained and experienced personnel with the proper knowledge and training to understand stage rigging systems and to recognize all of the imposed hazards and

- functional requirements that these devices involve as it relates to this particular installation). Failure to adhere to these minimum standards could result in serious injury to operators or bystanders and/or substantial structural damage.
2. These standards apply to rigging hardware only and not to the building or related structure from which the rigging components are supported/suspended.
  3. These standards DO NOT apply to raising, lowering, suspending or "flying" of people. None of the items listed within this specification or indicated on the contract documents is intended for the aforementioned rigging or attachment of a person to any portion of the stage rigging or related systems. RIGGING A PERSON TO/FROM THIS SYSTEM IS UNSAFE AND IS NEVER RECOMMENDED.
- B. All rigging systems shall be required to be inspected (as a minimum) to the standards set forth in ANSI E1.47 – 2017 (Entertainment Technology – Recommended Guidelines for Entertainment Rigging System Inspections) or the current version of the most recent standard revision.
- C. All dead hung rigging system components shall conform (as a minimum) to the standards set forth in ANSI E1.4-1 – 2016 (Entertainment Technology - Manual Counterweight Rigging Systems) or the current version of the most recent standard revision.
- D. All parts shall be industry standard load rated types. All hardware shall be rated for maximum possible load with an industry standard safety factor as per the codes and practices noted elsewhere within this specification. A list of load factors for all materials utilized shall be provided to the owner in the form of manufacturer data sheets.
- E. The list of major components that follows does not include all required items, only major system components. Field verify dimensions for all items and change as required to fit field conditions for flange sizes, headblock spacing, steel elevations, orientations, etc.
- F. Materials shall conform to the following ASTM and ANSI standard specifications:
1. A-47 Specification for malleable iron casting.
  2. A-48 Specification for gray iron casting.
  3. A-120 Specification for black and hot-dipped zinc-coated (galvanized) steel pipe for ordinary use.
  4. B18.2.1&2 Specification for square and hex bolts and nuts.
- G. In order to establish minimum standards of safety, the following factors shall be used:
1. Cables and fittings - 10:1 Safety Factor.
  2. Cable bending ratio - Sheave tread diameter is 30 times cable diameter or as recommended by wire rope manufacturer, whichever is more restrictive.
  3. Maximum fleet angle - 1-1/2 degrees.
  4. Steel - 1/5 of yield.
  5. Bearings - Two times required load at full speed for 2000 hours.
  6. Bolts - Minimum SAE J429 Grade 5 (ISO R898 Class 8.8), zinc plated.
  7. Motors - 1.0 Service Factor.
  8. Gearboxes - 1.25 Mechanical Strength Service Factor.
- H. COMPONENTS:
1. All system components shall be designed, engineered and manufactured to withstand all design loads without deformation or damage to components and shall meet the requirements of the "Design Factors" section of the current ANSI codes for counterweight rigging systems.
  2. All housings and mounting components shall use materials having ductile properties that will deform plastically without fracturing.
  3. Unless specifically noted otherwise, fasteners shall have a minimum SAE J429 Grade 5 or ISO R898 Class 8.8 rating. Bolts in tension shall have nuts of equivalent rating. Fasteners shall be self-locking or secured by alternate means (moused) to prevent loosening. Fasteners shall be installed in accordance with the manufacturer's instructions.

Attachments made through slotted, elongated or oversized holes (more than 1/16" over the fastener diameter) shall use flat washers.

4. The maximum allowable fleet angle for lift lines and purchase line shall be in accordance with the requirements of the "Design Factors" section of the current ANSI codes for counterweight rigging systems, unless the grooves in the block, and the bearings, are designed to accept a greater side thrust without harming the wire rope.
5. All welding shall be performed in accordance with current AWS standards as well as in compliance with any additional local, state or other standards. All field welds shall be certified and verified as required in the contract documents – at the bidder's expense.
6. No quick links or quick link style sleeved and threaded coupler style links shall be allowed for overhead lifting under any circumstances – even if the parts are load rated.

## 2.3 MISCELLANEOUS RIGGING HARDWARE:

### A. LIFT CABLES (WIRE ROPE):

1. All lift cables shall be 7 x 19 construction, galvanized aircraft cable, sized as required and with ultimate breaking strengths as follows:
  - a. 1/8" diameter – 2,000 pounds
  - b. 3/16" diameter – 4,200 pounds
  - c. 1/4" diameter – 7,000 pounds
  - d. 5/16" diameter – 9,800 pounds
  - e. 3/8" diameter – 14,400 pounds
2. Damaged or deformed cable shall not be used. All wire rope rigging shall be installed so as to prevent abrasion of the wire rope against any part of the building construction or other equipment.
3. Wire rope shall not contact any part of the building structure, adjacent line sets or other equipment not otherwise intended for contact.
4. Lift lines shall be fabricated of continuous un-spliced lengths of material.
5. In applications where reverse bends are incorporated, the wire rope service life shall be decreased as determined by a qualified person.

### B. CABLE & CHAIN FITTINGS & TERMINATIONS:

1. Swaged sleeve fittings shall be copper Nicopress. Swaged fittings shall be installed per the fitting manufacturer's instructions, using the appropriate tools, and checked with the appropriate Nicopress "Go - No - Go" gauge.
2. All wire rope eyes shall be formed over galvanized metal wire rope thimbles that are sized in accordance with the wire rope diameter.
3. All termination hardware shall be load rated and sized for the working load limit of the line it is used on. All hardware shall be installed and used in accordance with the manufacturer's recommendations.
4. No Crosby wire rope clips or similar items shall be allowed.

### C. EYE BOLTS:

1. All eyebolts shall be The Crosby Group or equal.
2. All eyebolts shall be:
  - a. Drop forged steel and hot dipped galvanized steel in construction or machinery type - quenched and tempered.
  - b. Fatigue rated.
  - c. Load rated.
  - d. Recommended for straight and in-line pulls only.
  - e. Where circumstances require angular loading, only shoulder eye or machinery bolts shall be used. For angular lifts, the contractor shall adjust size of eye bolts in order to maintain the proper working load limit and safety factor based upon manufacturer's standard deratings due to imposed angular forces/loads. Direction of pull of 45° will

cause the adjusted working load to be 30% of the rated working load. Direction of pull of 90° will cause the adjusted working load to be 25% of the rated working load.

- f. Regular nut eye bolts are not allowed and are strictly prohibited.
- g. The shoulder shall always be secured flush against the load surface.

D. SHACKLES:

- 1. All shackles shall be The Crosby Group or equal.
- 2. All shackles shall be:
  - a. Drop forged and hot dipped galvanized steel in construction.
  - b. Screw pin or bolt type only.
  - c. Provided with a redundant fixing means (moused), after pin insertion (this is to keep any and all threaded pins from backing out over time or due to vibration or rotation during use). The fixing method shall be performed in accordance with the manufacturer's recommendations. Mouse with galvanized wire or black nylon wire ties after final adjustment to prevent loosening.
  - d. Fatigue rated.
  - e. Load rated.
  - f. Working load limit permanently shown on the body of the shackle.
  - g. Quenched and tempered.
  - h. Meet DNV impact requirements of 42 joules at -20°C.
  - i. Furnished with certification certificates to design standards (ABS, DNV, Lloyds.) and proof tested.
  - j. Meet the performance requirements of Federal Specification RR-C-271D, Type IVA/IVB, Grade A/B, Class 2/3 (except for those provisions required of the contractor).
  - k. Rated for use in applications involving side-loading circumstances (with reduced load limits, depending on angle of loading).
  - l. Where circumstances require angular loading, the contractor shall adjust size of shackles in order to maintain the proper working load limit and safety factor based upon manufacturer's standard deratings due to imposed angular forces/loads. Direction of pull of 45° will cause the adjusted working load to be 70% of the rated working load. Direction of pull of 90° will cause the adjusted working load to be 50% of the rated working load.
  - m. Shackles shall never be used to join two bridled parts together.
  - n. Angular loads that exceed 120° included angle shall never be imposed upon any shackle (and those that are at 120° included angle shall only be symmetrically loaded).
  - o. Round pin shackles are not allowed and are strictly prohibited.

E. TURNBUCKLES:

- 1. All turnbuckles shall be The Crosby Group or equal.
- 2. All turnbuckles shall be:
  - a. Drop forged and hot dipped galvanized steel in construction.
  - b. Fatigue rated.
  - c. End fittings quenched and tempered.
  - d. Bodies heat treated by normalizing.
  - e. Feature UNC threads with modified UNJ threads on end fittings for improved fatigue properties.
  - f. Recommended for straight and in-line pulls only.
  - g. Meet the performance requirements of Federal Specifications FF-T-791b, Type 1, Form 1 – Class 2/4/7/8 (except for those provisions required of the contractor).
  - h. Provided with a redundant fixing means (moused), after pin insertion (this is to keep any and all threaded pins from backing out over time or due to vibration or rotation during use). The fixing method shall be performed in accordance with the manufacturer's recommendations. Mouse with galvanized wire or black nylon wire ties after final adjustment to prevent loosening.

- i. Turnbuckles shall not feature hook end fittings. Hook end fittings are not allowed and are strictly prohibited.

F. GENERAL FITTINGS REQUIREMENTS:

1. Never use fittings that:
  - a. Show signs of wear or damage.
  - b. Where shafts are bent or eyes are elongated (past manufacturing tolerances).
  - c. Are underrated on their loading limits.
  - d. Are not designed to safely handle the loads imposed upon them.
  - e. Have been modified, undercut, shortened or otherwise altered by the contractor.
  - f. Have had a load applied to them suddenly.
2. Always use fittings that:
  - a. Have clean threads, shanks and receiving holes.
  - b. Have been properly tightened and moused.
  - c. Have been properly seated as per the manufacturer's recommendations against the load.
  - d. Are designed to safely handle the loads imposed upon them, including angular lifts with appropriate deratings.
  - e. Have been shimmed with washers in order to change eye alignment to necessary orientation (if needed).
3. All angular loads must be applied in the plane of the fittings' bow.
4. Misc. fittings and parts shall not be allowed that are "consumer grade" non-load rated, purchased at a local box stores, etc. excepting that these parts shall meet or exceed all requirements as set forth in these specifications.
5. No previously used parts or fittings shall be allowed. Only brand new, never before been installed parts shall be provided for this project.

G. TRIM CHAINS:

1. Trim chains shall be 36" long, made of inherently black, 7 mm, hardened alloy chain (meeting OSHA 1910.184(e)(5) requirements. Connection between the end link and the lifting cable (wire rope lift line) shall be made with a thimble and copper Nicopress sleeve where the wire rope eye termination passes through the end link of the chain. Chains shall be wrapped one and one half turns around the batten and attached back to the thimble at the end of the lift line with a 1/4" forged shackle. Adjustment is made by connecting the shackle into a link along the return side of the chain.
2. Provide and install one 3/8" diameter safety bolt, one nylon insert nut and two flat washers per trim chain after batten is leveled.
3. Trim chains shall have a recommended working load of 3,250 lbs. (with a 4:1 safety factor).
4. Trim chain assemblies shall be fabricated of chain approved by the manufacturer for the application.
5. Trim chain links shall feature a date code for traceability (marked on every 10<sup>th</sup> link or similar).
6. Trim chains shall be JR Clancy Alpha chain or equal.

H. FABRICATION:

1. The mechanical fabrication and workmanship shall incorporate best practices for good fit and finish. There shall be no burrs or sharp edges to cause a hazard nor shall there be any sharp corners accessible to personnel.
2. All moving parts shall have specified tolerances. Sheaves shall run plumb and true and shall not scrape housings.
3. All equipment shall be built and installed to facilitate future maintenance and replacement.

I. FINISHES:

1. Paint shall be the manufacturer's standard finish and color except as noted.



2. All turnbuckles, clips, tracks, chains and other items of incidental hardware shall be furnished plated or painted.

J. RECOMMENDED WORKING LOAD (RWL):

1. This specification calls for minimum recommended working loads for many hardware items. This is the maximum load which the manufacturer recommends be applied to properly installed, maintained and operated new equipment. Manufacturer's recommended working loads shall be determined by calculations by a Licensed Professional Engineer and destructive testing by an independent testing laboratory. These calculations and reports shall be available for review.
2. All rigging hardware, rigging assemblies, etc. noted in this specification shall bear a maximum of 1/10<sup>th</sup> of the MBS (minimum breaking strength) for the weakest component. The minimum safety factor for any rigging related devices or assemblies in this project shall be 10:1 (MBS vs. actual imposed load per location), unless otherwise noted and regardless of the manufacturer's safety factor.
3. Any contractor fabricated or erected assemblies must feature a 10:1 safety factor. It shall be the sole responsibility of the fabricating and installing contractor to verify that the entire assembly meets this minimum 10:1 safety factor, regardless of what pieces may be noted on the contract drawings. If the contractor finds that undersized hardware was specified, then it is his responsibility to provide upgraded/larger sized hardware in order to maintain the noted 10:1 safety factor.
4. All misc. hardware, bolts, shackles, pairing rings, turnbuckles, nuts, washers, etc. shall be as manufactured by The Crosby Group, Inc. or equal, shall be load rated, shall be recommended for the usage imposed and shall be a minimum of Grade 5 or equal. All noted RWL's shown in the table below are based upon The Crosby Group, Inc. published data tables.

K. MINIMUM RECOMMENDED WORKING LOADS PER PART:

Description	Shank Diameter (in/mm)	Working Load Limit (WLL) ton
Screw Pin Anchor Shackle (forged)	3/16"	1/3
(referenced product forged, G-209/S-209)	1/4"	1/2
	5/16"	3/4
	3/8"	1
	7/16"	1.5
	1/2"	2
	5/8"	3.25
	3/4"	4.74
Shoulder Nut Eye Bolt (forged)	6.35 mm	.29
(referenced product forged, G-277)	7.94 mm	.54
	9.53 mm	.70
	12.7 mm	1.18
	15.9 mm	2.35
Machinery Eye Bolt (forged)	6.35 mm	.29
(referenced product forged, S-279 UNC)	7.94 mm	.54
	9.53 mm	.70
	12.7 mm	1.18
	15.9 mm	2.35
Jaw & Eye Turnbuckle (forged)	1/4"	.23
(referenced product forged, HG-227)	5/16"	.36
	3/8"	.54

	1/2"	1
	5/8"	1.59
	3/4"	2.36

- The above chart is only for the most commonly used hardware specified and is not an all-inclusive or comprehensive list. For any hardware specified that is not listed here, the contractor shall refer to the ratings shown in the latest Crosby Group hardware catalog.
- Recommended Working Load (RWL) and Working Load Limit (WLL) are understood to be synonymous terms.
- Fatigue load rating on most Crosby hardware is 1.5 times the Working Load Limit.
- Maximum Proof load rating on most Crosby hardware is 2.0 times the Working Load Limit.
- Minimum Ultimate load rating of most Crosby hardware is 5.0 times the Working Load Limit minimum.
- All tonnage is understood to be a standard ton (2,000 lbs.).
- Verify all load limits with the manufacturer's most recent publications.
- All hardware must be hot dipped galvanized.

#### 2.4 BATTEN CLAMP: REFERENCED PRODUCT H&H SPECIALTIES MODEL #680 BATTEN CLAMP

- All batten clamps shall be made from steel or other ductile materials. Clamps shall fully wrap the perimeter of the batten cross-section and shall provide a positive resistance to rotational loads. The clamps shall permit attachment to the lift line using hardware specifically designed for the connection type indicated. Batten clamps shall not have sharp edges or corners. No half clamps shall be allowed.
- Batten clamps shall be constructed of 10-gauge steel and shall be furnished with 3/8" x 1" Grade 5 hex bolts with locknuts and a hole for the attachment of cable, chain, shackle, turnbuckle, thimble or other fittings.
- Beam clamps shall be for use on standard 1 1/2" schedule 40 pipe battens.
- Batten clamps shall have a WLL of 1,400 lbs.

#### 2.5 GRADED TRIM CHAIN: REFERENCED PRODUCT PEERLESS INDUSTRIAL GROUP GRADE 63 ALLOY CHAIN

- The trim chain shall be 7 mm (0.279" or 9/32") black alloy chain suitable for rigging and overhead lifting. Inside link dimensions: 0.827" nominal length; 0.405" nominal minimum width. Chain MUST be inherently black and cannot be silver, gray, yellow or any other color.
- The trim chain shall be Grade 63 low weight special analysis alloy steel chain meeting or exceeding all existing OSHA, government, NACM and ASTM specification requirements.
- The trim chain shall be suitable for use with 1/4" hardware.
- The trim chain shall feature a date code on at least every 10<sup>th</sup> link for traceability.
- Load limits and safety factors for the chain shall be as follows:
  - Working load limit (WLL): 3,250 lbs.
  - Proof tested load: 6,500 lbs. minimum
  - Ultimate breaking strength: 13,000 lbs. minimum
  - Elongation at break: 20% minimum
  - 4:1 minimum safety factor
- Trim chain installation shall be industry standard and as follows: the end link on one end of the trim chain shall be captured directly with the lift line cable thimble. The trim chain shall be wrapped one and a half turns around the associated pipe batten and be terminated into a load rated forged

screw pin anchor shackle. The shackle shall be routed through the same thimble which captures the end link of the chain.

- G. The contractor shall adjust the overall trim chain length as needed. Some sites with limited overhead height may need the trim chains to be "choked" shorter than normal. This will require the contractor to custom cut the overall length of each trim chain (they all must match and render the related pipe batten level with the stage floor).
- H. The contractor shall provide Grade 5 minimum hex head safety bolts with washers, nylock nuts, etc. as is noted on the contract drawings.
- I. No chain link shall exhibit cracks, voids, burrs, grooves or excessive weld flash. All links shall be uniform and symmetrical with no sharp edges, discontinuities or excessive tooling marks.
- J. Ratings: Zinc plating per ASTM B633 Type II CL FE/ZN8; ASTM B30.9; ISO 9001 Quality Assurance Procedures; OSHA 1910.184.
- K. No proof coil or shiny, metal colored trim chains shall be allowed.

## 2.6 PIPE BATTENS:

- A. All battens shall be 1-1/2" nominal diameter, schedule 40 (schedule 80 only as specifically called out on the contract drawings) black iron pipe in lengths as shown on the drawings. Nominal diameter is the ID size of the pipe. Actual OD shall be larger.
- B. Any batten exceeding one standard pipe length (typically approx. 20') shall be joined using internal splicing sleeves. (All joints shall be spliced with 18" long splicing sleeves with 9" extending into each pipe and held by two 3/8" hex bolts and lock nuts on each side of the joint. Splices shall not occur at lift points. See drawings for more information and requirements for batten splices, bolt orientation and interchangeability.) Threaded couplers shall not be permitted. All batten splices shall have at least the same overall capacity, deflection and strength as the component pipe and shall be interchangeable with any other batten splice provided as part of this project. Each batten shall be coated with a rust resistant finish.
- C. A minimum of 100 mm (4 inches) at each end of the batten shall be durably marked with an approved OSHA color (by use of an item such as a safety yellow vinyl end cap "batten cap" that fits snugly over the end of the batten), except in architecturally sensitive areas.
- D. Each batten shall be capable of supporting at minimum 45 kg/m (30 lbs/ft) of uniformly distributed load. Each batten shall be capable of sustaining a point load of 45 kg (100 pounds) at mid-span between any two lift lines with a maximum span deflection of 1/180 of the span (unless specifically noted elsewhere in these written specifications or on the contract documents).
- E. The typical batten shall be fabricated using materials that support the design loads in accordance with the requirements of this standard.
- F. See Section Labeling and Marking for labeling requirements.

## 2.7 METAL FRAMING SYSTEM: REFERENCED PRODUCT UNISTRUT METAL FRAMING

- A. All contractor provided metal framing, metal channel or miscellaneous support systems indicated on the drawings shall be Unistrut Framing Systems 1 5/8" width series channel and related nuts & hardware as manufactured by Unistrut Corporation or equal.
- B. Framing Members:
  - 1. Unistrut channel members and continuous inserts shall be fabricated from cold-formed to size from structural grade, low carbon strip steel.
  - 2. Welding: All spot-welded combination members (except P1001T) shall be welded on 3" (76 mm) maximum centers.
  - 3. Curved channel: All curved Unistrut channel noted on the drawings shall be curved to the radius specified by the manufacturer. No contractor bent or curved channel shall be acceptable.
  - 4. Raw steel shall conform to the following ASTM specifications:

GAGE	FINISH	ASTM NO.
12	GR & HG	A1011 SS GR 33
	PG	A653 GR 33
14	GR & HG	A1011 SS GR 33
	PG	A653 GR 33
16	GR & HG	A1011 SS GR 33
	PG	A653 GR 33
19	GR	A1008

## C. Nuts &amp; Bolts:

- Unistrut nuts shall be made from steel bars. After all machining operations are complete, they shall be thoroughly case hardened. Nuts shall be rectangular with ends shaped to permit a quarter turn clockwise in the framing member after insertion through the slotted opening in the channel. Two toothed grooves in the top of the nut shall engage the in turned edges of the channel and, after bolting operations are completed, will prevent any movement of the bolt and nut within the framing member. All bolts and nuts shall have unified coarse screw threads. The standard framing nuts shall conform to ASTM Specification A1011 SS GR 33 (material only). Screws shall conform to SAE J429 GR.
- Bolt Torque: Bolt torque values are given to ensure the proper connection between Unistrut Metal Framing components. It is important to understand that there is a direct, but not necessarily consistent, relationship between bolt torque and tension in the bolt. Too much tension in the bolt can cause it to break or crush the component parts. Too little tension in the bolt can prevent the connection from developing its full load capacity. The torque values given have been developed over many years of experience and testing.

Bolt Torque						
Bolt Size	1/4" – 20	5/16" – 18	3/8" – 16	1/2" – 13	5/8" – 11	3/4" – 10
Rec. Torque Ft./Lbs. (N*m)	6 (8)	11 (15)	19 (26)	50 (68)	100 (136)	125 (170)
Max Torque Ft./Lbs. (N*m)	7 (9)	15 (20)	25 (34)	70 (95)	125 (170)	135 (183)

- These are based on using a properly calibrated torque wrench with a clean dry (non-lubricated) Unistrut fitting, bolt and nut. A lubricated bolt or nut can cause extremely high tension in the connection and may lead to bolt failure. It must be noted that the accuracy of commercial torque wrenches vary widely and it is the responsibility of the installer to ensure that proper bolt torque has been achieved.

## D. Fittings:

- Unistrut fittings, unless noted otherwise, shall be punch-press made from hot rolled, pickled and oiled steel plates, strip or coil, and shall conform to ASTM specifications A575, A576, A635 or A36. The fitting steel shall also meet the physical requirement of ASTM A1011 SS GR 33. The pickling of the steel shall produce a smooth surface free from scale.

## E. Loading:

- All loading characteristics shall meet or exceed those published in the Unistrut catalog for each associated member including, but not limited to, beam loading, uniform loading, cantilever loading, column loading, deflection, shear, pull-out force, etc.
- Load Data: All beam and column load data pertains to carbon steel and stainless steel channels. Load tables and charts are constructed to be in accordance with the "Specification

For The Design Of Cold-Formed Steel Structural Members 2001 Edition” published by the American Iron And Steel Institute Using ASD Method.

Type of Load	Safety Factor to Yield Strength	Safety Factor to Ultimate Strength
Beam Loads	1.67	2.0
Column Loads	1.80	2.2

F. Finish:

1. The Unistrut channel, nuts, bolts and all fittings shall be finished with a durable, multi-step process that provides resistance to corrosion, chalking, checking, fading, etc. (unless unfinished, stainless steel or aluminum channels are specifically called out elsewhere within these specifications or on the drawings). All portions of the Unistrut that are visible below ceiling surfaces, etc. shall be painted by the contractor as noted on the drawings (typically this is in a flat black finish, smooth and even, with no brush marks, drips, runs or other visible finish marks showing). In instances where the finish must match a specific adjacent surface, the contractor shall obtain the exact finish color from the architect and the finish paint from related contractors (typically the painting contractor). Finished other than dark colors may also require the contractor to lightly sand all surfaces for maximum paint adhesion, provision of primer coats, provision of finish coats, etc. In order to properly finish all metal framing system parts, the contractor may be required to spray all parts individually in a spray booth.
2. Unless otherwise indicated, all metal framing system parts shall be finished in Unistrut Perma-Green III (GR) or equal high-performance coating. No bare metal finishes shall be allowed where Unistrut channel framing system parts have been called out.
3. Any cut ends, drilled holes or any significant scratches in the finish of metal framing members shall be “touch-up” finished by the contractor with appropriate layers of primer (Rustoleum or Krylon clean metal primer) and finish coats (Rustoleum or Krylon flat finish) of the appropriate matching color (or as close as is possible).
4. Perma-Green III (GR) Technical Data:
  - a. Steel Substrate Preparation:
    - 1) Ten stage continuous cleaning, phosphate process.
    - 2) Substrate after “prep”: sealed zinc phosphate conversion coating.
  - b. Coating:
    - 1) Thermoset acrylic
    - 2) Color: Federal highway green; color tolerance chart; PR color No. 4.
    - 3) Hardness: 2H.
    - 4) Coating Process: Cathodic Electrodeposition.
    - 5) Performance:
      - a) Salt Spray: Scribed – exceeds 400 hours per ASTM B117 (1/8” creep).  
Unscribed – exceeds 600 hours per ASTM B117 (6% red rust).
      - b) Chalk: Nominal at 1,000 hours per weatherometer G023 test.
      - c) Checking: None at 1,000 hours per weatherometer G023 test.
      - d) Fade: Lest than 50% compared to standard epoxy E.C. coatings.
    - 6) Environmental Issues:
      - a) Formulated as a “heavy metal” free coating (trace elements only).
      - b) Outgassing in service: Essentially none at 350° for 24 hours.

## 2.8 CURTAIN OPERATING LINE: REFERENCED PRODUCT STAGE-SET-X

- A. Hand lines shall have a parallel filament core constructed of high-tenacity filament polyester. The core shall remain firm and round under all load conditions. The core shall be wrapped in polyester tape to provide the core with protection against external damage and wear. The braided polyester outer jacket shall be constructed of spun polyester for good gripping.

- B. Provide 3/8" diameter rope and with a black jacket.
- C. The rope shall hold knots well, be easily spliced. Rope shall not be subject to rotting, mildew or moisture damage nor shall its length be affected by changes in humidity.

## **2.9 CURTAIN TRACKS: REFERENCED PRODUCT ADC MODEL 280 SILENT STEEL**

- A. Curtain tracks shall be of 14-gauge galvanized steel construction, entirely enclosed except for slot in bottom, each half to be in one continuous piece except where splicing clamps are required. Each curtain carrier shall be spaced on 12" centers and shall be of nylon (Or steel) construction supported from a ball-bearing by two polyethylene wheels held to ball-bearing by rustproof nickel-plated rivet, such wheels rolling on two separate parallel treads. Each curtain carrier shall consist of a free-moving plated swivel and sufficient trim chain to accommodate curtain snap hook. End pulley blocks shall be adjustable and shall be equipped with sleeve-bearing wheels adequately guarded. A rubber bumper shall be attached to each curtain carrier to function as noise reducer. The manufacturer shall furnish two end stops for placement at each track end and a tension floor pulley for increasing or decreasing cord tension. Stretch-resistant operating cord shall have synthetic center and shall be of 3/8 diameter, extra quality yarn. Provide in black.

## **2.10 CUSTOM SADDLE BRACKETS: REFERENCED PRODUCT IS CUSTOM BY SSRC**

- A. The custom U-shaped saddle bracket assembly shall be constructed of 3/8" nominal plate steel with a matte black finish. All portions of the assembly shall be of welded construction and shall be attached to the Glulam beams or stage rafters (unless otherwise noted on the bid drawings, such as the welding of certain ends to the existing structural steel). The entire assembly (where bolted connections occur) shall be attached with load rated anchors appropriate for the substrate they are mounted into (through bolts). See T series drawings details for more information on bracket assembly construction, mounting requirements and exact mounting location. Some brackets shall feature a plate steel tab while others will feature an integrated welded-in-place 1 1/2" black iron pipe batten. Nominal diameter is the ID size of the pipe. Actual OD shall be larger. No contractor or local fab shop brackets shall be allowed or acceptable.

## **2.11 DETACHABLE FLOOR BLOCK AND PLATE: REFERENCED PRODUCT ADC DFB-3 WITH DFB PLATE**

- A. Floor block shall feature an 8" diameter nylatron ball-bearing wheel (entire assembly shall be flat black).
- B. Floor block keyed floor plates shall be constructed of flat stock painted steel (flat black). Requires recess of 1/4" for mounting of plate with 3/8" channel at center to allow for floor block keys.

## **2.12 CURTAIN ROTATOR: REFERENCED PRODUCT ADC ROTODRAPER PIVOT ARMS**

- A. Provide each pivot arm assembly with the optional self-locking brakes and brake operating lines. Provide with all required hardware, pipe clamps, safety end stops and standard 1" pipe batten for attachment of leg curtains.
- B. Each Rotodrapeer shall be capable of being manipulated to any desired angle of operation, including a full 360° turn.
- C. Provide with a No. 401 self-locking brake and model 2800 track where rotators are indicated on drawings (No. 402 self-locking brake for all other track models). Provide each with operating line and brake line, both to hang behind the curtain.
- D. Curtain weight limited to 75 lbs. per moving Rotodrapeer location (100 lbs. per for each non-moving location).
- E. Provide each pivot arm assembly with the following misc. items:
  - 1. (2) N0. 400 C-Clamps for fitting to each end of the curtain pipe and for use with towlines.
  - 2. Tension springs composed of 1 3/32" O.D. heavy duty compression springs for providing the necessary friction to secure the Rotodrapeer in position.
  - 3. Pipe clamps to accommodate 1" curtain pipe.

4. 1" schedule 40 black iron pipe batten (to attach leg curtain to).
  5. Safety end stops for all track type Rotodrapeer assemblies.
  6. All misc. hardware (Grade 5 minimum) needed in order to assemble and attach Rotodrapeer assemblies as indicated.
- F. Provide the appropriate Rotodrapeer for use with the specified tracks as follows:
1. No. 6 Rotodrapeer for use with U-bolt assemblies in a non-moving application.
  2. No. 14 Rotodrapeer for use with 1400 & 4200 series track.
  3. No. 17 Rotodrapeer for use with 1700 series track.
  4. No. 28 Rotodrapeer for use with 2800 series track.
  5. Provide "A" configurations where owner has indicated a preference for the special, optional pivotal indexing feature. This includes an index plate and spring-loaded roller latch, which secures the Rotodrapeer device at 15° intervals. Provide any additional latch operating lines as needed.

### 2.13 MISCELLANEOUS HARDWARE:

- A. It is the responsibility of the contractor to provide all necessary hardware needed in order to complete this project and all related installations, even if it is not specifically called out or called for on the bid drawings. This includes, but is not limited to, any miscellaneous supplementary steel needed to provide appropriate pickup points, beam clamps, threaded rod, angle iron supports, wall anchors or toggles, bolts, nuts, washers, suspension chain, wire rope and related Nicopress thimbles and closures, brackets, pipe clamps, custom fabricated metal hangers and clips, bracing channel, tube or studs back to substantial structure and all related installation labor. Any and all necessary hardware provided that has not been specifically called out or for on the drawings shall be installed by the contractor in a conscientious manner with respect to symmetry, aesthetics, related surfaces, plumbness and levelness. Obtain written approvals from architect, consultant and owner on these types of items prior to installation where appropriate. No haphazard, crooked or otherwise unsightly installation and related hardware shall be acceptable. Any items installed in this manner shall be fixed and/or replaced by the contractor at no additional expense to the owner.

### 2.14 BATTEN MOUNTED CABLE MANAGEMENT CLAMP: REFERENCED PRODUCT SSRC CCP SERIES

- A. There shall be a series of clamps sized to fit multiple cable diameters and/or multiple cables in managing cables as they relate to a typical pipe batten.
- B. The cable clamps shall be manufactured products which hold the related cable in line with (parallel) the batten it is attached to.
- C. The cable clamps shall feature the following construction:
1. 3/16" (7 gauge) thick steel painted eggshell black
  2. 5/16"-18 Grade 5 hex head cap bolts with hex nut, flat washer and lock washer at each bolt through location.
  3. Steel bent into shape on a press brake machine.
  4. Tack welds as needed for back-to-back portions.
  5. Bent to mount to 1 1/2" schedule 40 black iron pipe battens.
  6. All bends neat and clean.
  7. All clamp edges eased with no sharp edges, burrs or protrusions.
- D. Cable clamps shall be available in the following configurations and sizes. The contractor shall provide the type(s) of clamp(s) specified and/or needed per the installation requirements. Provide enough clamps to properly manage all cabling along battens as is noted in the contract documents.
1. CCP Clamp – A clamp with a single bay to mount to a pipe batten and a single bay for the management of one SO style cable (from 3/4" – 2" diameter).

2. CCP2 Clamp – A clamp with a single bay to mount to a pipe batten and (2) stacked single bays for the management of one SO style cable each – total of two (each from  $\frac{3}{4}$ " – 2" diameter).
  3. CCP3 Clamp – A clamp with a single bay to mount to a pipe batten and (2) stacked bays (one single and one double) for the management of three SO style cables – one in bottom bay (from  $\frac{3}{4}$ " – 2" diameter) and two in top bay (from  $\frac{3}{4}$ " – 1  $\frac{1}{4}$ " diameter each).
  4. CCP Mini Clamp – A clamp with a single bay to mount to a pipe batten and a single bay for the management of one small diameter "light" power or control style cable (up to  $\frac{1}{2}$ " diameter).
  5. CCP Flat Clamp – A clamp with a single bay to mount to a pipe batten and a single bay for the management of up to six flat SO style cables (from  $\frac{1}{4}$ " high x 1  $\frac{3}{8}$ " wide each).
- E. All clamps shall be manufacturer furnished. No contractor fabricated devices shall be acceptable in lieu of the specified clamps. No cable management clamps shall be allowed that mount perpendicular to the batten or that support the cable along the side of any associated batten. All cable clamps must support and hold the cable along the top of the related batten. Any sharp edges that exist must be eased by the contractor (if not done by others) and black plastidip applied to all exposed bolt ends. Deburr prior to application.

## 2.15 STAGE CURTAINS:

### A. GENERAL:

1. All draperies shall be supplied in accordance with the specifications. Colors shall be selected by the Owner from fabric samples supplied by the contractor. All draperies shall be flame retardant in conformance with applicable codes.
2. All traveler, cyc, scrim, scenery drop, walk-alongs or similar sets are to be trimmed so that they are approx.  $\frac{1}{2}$ " –  $\frac{3}{4}$ " AFF. This is especially critical in dead-hung situations where curtain set cannot be raised/lowered. The contractor shall be responsible to trim these curtains as indicated and to make one return trip to the jobsite in order to retrim them, if necessary, due to building settling, snow loading, etc. within 6 months of completion of project.

### B. Materials:

1. All materials shall be new. The largest width of the material specified shall be used with continuous materials for the full height of the curtain. No cross seams or horizontal splices shall be acceptable. All fabric used for a particular set of curtains shall be from the same dye lot. No color differences from mixed dye lots will be acceptable.

### C. FABRICATION:

1. All curtains shall be sewn with a single needle lockstitch (a style of stitching that cannot easily be removed by pulling a single thread). All seams shall be inspected after curtain fabrication in order to insure that there are no broken or missing stitches. All thread colors shall match the color of the face fabric. All thread shall be cotton covered polyester or equal for strength and longevity.
2. The top edge of each drape shall be sewn flat to a 3.5" heavy-duty jute webbing. Jute webbing shall be double stitched to the top edge of each curtain with 2" of face fabric turned under the webbing.
3. Contractor shall provide appropriately sized brass grommets for the size and weight of the specified curtains (i.e. #2 grommets for flat sewn, lightweight curtains, #4 grommets for heavy-weight pleated curtains). Brass grommets shall be set through the webbing  $\frac{3}{4}$ " from the top edge on 12" centers (place grommets on 6" centers only as required due to curved track radius issues and as recommended by track manufacturer). All grommets shall be rolled rim style grommets and inserted using an electric/pneumatic machine. No hand inserted or loose grommets shall be acceptable.



4. Curtains to be located on battens shall have a length of tie line attached to each grommet (Tie line shall be 36" long #4 braided cotton). The tie line at the center of a curtain shall be a different color to indicate the curtain's centerline.
  5. Curtains to be located on tracks (i.e. bi-parting valance, travelers or scenery drops) shall have a plated S hook inserted into each grommet and closed at the grommet.
  6. Curtains specified with added fullness shall have box pleats sewn on 12" centers. No lap or pinch pleats shall be acceptable.
  7. All curtain lining shall be provided in the same fullness as the associated curtain and shall finish 2" shorter than the face fabric. The lining shall be attached to the face fabric at seams along the bottom hem line and at intervals on the side hems by 4" sections of ¾" wide heavy-duty woven tape.
  8. All additional fullness as indicated below shall be in addition to any allowances for seams, hems and turnbacks.
  9. All fabric seams shall be concealed as much as is physically possible within the curtain's vertical pleats in order to hide the seams (especially at the curtain's top edge).
- D. Travelers (OR OTHER BI-PARTING STYLE CURTAINS):
1. Traveler curtains shall be sewn from materials as indicated on the curtain schedule and shall be lined with a flame retardant or Inherently Flame retardant material as noted below, unless otherwise specified.
  2. The main traveler curtain shall incorporate a 75% additional fullness. All other traveler curtains shall incorporate a 50% additional fullness.
  3. Travelers shall be sewn in two identical panels and allow a 24" overlap at center stage.
  4. Traveler side hems: Leading edges shall have turnbacks of 1/2 standard width of the face material. Turnbacks shall have no machine stitching other than the bottom hem. All other side hems shall have a 2" hem with the line of stitching close to the selvedge edge of the fabric. All side hems shall maintain a straight and plumb appearance.
  5. All bottom edges shall have a 6" hem with a separate 3" internal chain pocket incorporating a continuous, zinc plated No. 8 jack chain weight with the ends tacked to prevent bunching. Each chain pocket shall be stitched so that the chain rides 2" above the finished bottom edge of the curtain. Lead tape weights shall not be acceptable. Note that all chain must be removed from pocket when curtains are cleaned.
- E. MAIN VALANCE/BORDERS:
1. The main valance and border curtains shall be sewn from materials as indicated on the curtain schedule. Each curtain shall have a minimum 3" turnback on vertical edges.
  2. All bottom edges shall have a 6" hem no internal chain pocket or jack chain unless otherwise specified.
  3. The main valance curtain shall incorporate a 75% additional fullness.
  4. All border curtains shall incorporate a 50% additional fullness.
- F. LEGS:
1. Leg curtains shall be sewn with only full widths of fabric. No partial or multi-panel leg curtains shall be acceptable. Legs shall be sewn from materials as indicated on the curtain schedule. Each leg shall have a minimum turnback of 6" on vertical edges.
  2. All bottom edges shall have a 6" hem with a separate 3" internal chain pocket incorporating a continuous, zinc plated No. 8 jack chain weight with the ends tacked to prevent bunching. Each chain pocket shall be stitched so that the chain rides 2" above the finished bottom edge of the curtain. Lead tape weights shall not be acceptable. Note that all chain must be removed from pocket when curtains are cleaned.
  3. The leg curtains shall incorporate a 50% additional fullness.
  4. SEW-ON VELCRO -
    - a. 1.5" - DuraGrip Brand Sew-On Hook - Black

- b. Made from 100% Nylon 8 mil Monofilament with 280 hooks/sq. inch, binder coat prevents unraveling when cut.
  - c. Cycle Life: 20,000 operations min.
  - d. Shear Strength: 14.15 per square inch (avg.)
  - e. Peel Strength: 0.68 per inch of width (avg.)
  - f. Selvage: 3/32" max.
5. PRESSURE-SENSITIVE VELCRO -
  - a. 2" - Velcro® brand Pressure Sensitive Adhesive Hook: Rubber - Black
  - b. 6 mil Monofilament and are binder coated to protect against fraying when cut. They also offer excellent durability and have a high cycle life. The rubber-based pressure sensitive adhesive is designed for a medium temperature range that performs well on many substrates, especially uneven or rough surfaces.
  - c. Adhesive shall be Industrial Strength extreme, UV resistant and offer superior holding power without the needs of mechanical fasteners or epoxy resins.
  - d. Operating Temperature Range: -40 F to 120 F
  - e. Closure Shear Strength: 14.0 psi
  - f. Closure Peel Strength: 1.2 psi
  - g. Closure Tension Strength: 6.5 psi
- G. MAINTENANCE PROCEDURES:
  1. Contractor shall instruct the owner on all pertinent points of proper care and maintenance of the stage curtains including, but not limited to, routine curtain inspections, proper fabric tear repair techniques (i.e. no tape repairs – all repairs to be made by either machine sewing or good hand stitching by a qualified professional), standard retrimming practices to keep hems off floor, storage parameters, storage bag types & folding techniques, proper wrinkle removal techniques with hanging durations, irons or steamers, the danger of water contact and steam with FR curtains, retreatment schedules (if applicable) and routine dry cleaning intervals.
  2. All FR material types (those materials that have been treated with a flame retardant chemical and are not inherently flame retardant by themselves) are recommended to be tested annually by qualified personnel using the NFPA 705 (1997 or later) field test method for textiles in order to accurately quantify the material's current flame resistance characteristics. These materials must be retreated on a regular basis (maximum of 5 year spans).
- H. MATERIAL TYPES:
  1. CURTAIN LINING DETAILS (UNLESS OTHERWISE NOTED ELSEWHERE)
    - a. MAIN VALANCE UNLINED
    - b. MAIN TRAVELER UNLINED
    - c. ALL OTHER TRAVELERS UNLINED
    - d. BORDER CURTAINS UNLINED
    - e. ALL LEG CURTAINS UNLINED
  2. IFR VELOUR STAGE CURTAINS: REFERENCED PRODUCT KM FABRICS CRESCENT VELOUR
    - a. Unit Weight: 20 oz. (per linear yard)
    - b. Color TBD by architect/owner.
    - c. Inherently Flame Resistant.
      - 1) Meets the minimum requirements of flame resistance established by the following: NFPA 701 (2004 edition, test method #1); NFPA 705, field test; MVS 302; BIFMA F-1-1978; SC-191-53 Class 1 California; UFAC Class 1.
      - 2) This fabric was manufactured and tested under the supervision of a General Applicator registered as #GA-0358.01 by the Fire Marshall of the State of California.

- 3) This fabric is registered with the Fire Department of the City of New York as #5138.
- 4) Woven with non-combustible filament, it is inherently and permanently flame resistant for the life of the fabric. This flame resistance will NOT wash out by water washing.

d. Fiber Content: 100% polyester.

### **PART 3 EXECUTION**

#### **3.1 GENERAL:**

- A. Contractor shall adhere to all requirements of the general contract for this project as called for in the project manual.
- B. All liability for rigging, fastening, and other installation methods shall be borne by the contractor alone. The fact that the specification calls for any equipment to be installed does not constitute an approval by the consultant or owner of any method for accomplishing the mounting or installation of the device or the suitability of the device for mounting in the manner, which the contractor has proposed in shop drawings. If the contractor has a reason to believe safety will be compromised in the installation of any of the specified equipment, they must note this at the time of bid and offer alternatives in writing.
- C. Assess life safety implications of all installation methods and verify there is no compromise of life safety issues.
- D. Any dangerous work areas marked or roped off in a manner, which will inform all persons as to potential danger regardless of sensory handicaps.
- E. Maintain M.S.D.S. for all materials used where applicable and submit same to architect.
- F. Maintain integrity of all fire-walls and doors during construction and upon completion.
- G. The contractor will verify all on site dimensions prior to ordering or installation of critically dimensioned equipment and wiring or any of the rigging system equipment. In a case of discrepancy between these documents and attached drawings, construction documents, and actual on-site dimensions the contractor will notify the owner and consultant before making any changes in intended work. The owner and consultant will determine the correct modification to the work to be done. No additional payments will be made for material or equipment improperly ordered or sized due to site variations.
- H. Any equipment, hardware, wiring harnesses, or other items not specifically included in this specification but required for the system to function as called for within this document will be the responsibility of the contractor at no extra cost to the owner.
- I. Provide all hardware and all other required parts to provide a complete system to the extent that such items are not provided by others.
- J. All methods must be cosmetically acceptable to the owner. All equipment will be installed neatly, with respect to level, sight lines, and finish. All wiring must be neatly run and concealed in an orderly fashion and attached to appropriate support structures.
- K. Moderate changes or moves necessary to accommodate other equipment, coordination with other trades, or for pleasing appearance will be made without claim for additional payment.
- L. Coordinate all work with other on-site trades in order to achieve a coordinated progress at all times.
- M. If specific elevations of dead hung sets are not indicated on the contract documents, it is the responsibility of the contractor to obtain these elevations in writing from the consultant prior to any set installation. Any installation of sets without proper knowledge and written documentation of the actual and exact set trim heights intended will result in the contractor rehanging all such improperly installed sets to the intended trim heights. The contractor shall be solely responsible

for all removal and reinstallation labor, hardware, etc. as is needed in order to rehang all improperly installed sets at the intended trim heights.

### 3.2 WIRING AND RACKS:

- A. The contractor shall field verify all locations where contractor provided wiring shall be run in order to determine each space's "plenum status." If any wiring noted on the drawings must be run through an air plenum space, then the contractor must provide plenum rated wiring for all such locations, even if the wiring noted on the drawings is non-plenum rated or spaces have ducted air. The contractor shall provide plenum rated wiring matching the specified wiring as closely as is possible. This applies to both EC provided wiring and other wiring to be installed by theatrical or A/V specialty prime contractors and subcontractors.
- B. All wiring shall be neatly tie wrap bundled (or as indicated otherwise on contract drawings) with wires parallel and perpendicular to device sides (i.e. no random angle wiring).
- C. All related SO style or other control and power wiring related to the motorized units shall be strain relieved to structure (unless otherwise indicated).
- D. Wiring Standards - Plenum Rated Cable: Unless specifically noted on the drawings, all low voltage wiring is to be CL2/CL3 wiring. Where specific plenum conduits exist, it has been noted to use a plenum rated cable. Where wiring runs occur in concealed spaces – walls, ceilings, etc. - and are not enclosed in conduit the EC must verify the space is not being used as a plenum path. Any areas encountered that are plenums must have plenum cable or the wiring must be contained in conduit rated for the plenum application. Field verify conditions prior to ordering or installing cabling.
- E. All conduits indicated on the drawings shall terminate directly into racks, control panels, motor control junction boxes, wireways, etc. as shown – top, bottom or at any of the provided knockout locations (unless otherwise and specifically indicated on the drawings as otherwise) and so as not to obstruct access to the racks or adjacent walkways or approaches. Route conduits into devices with as few bends as possible – use sweep elbows where necessary. No loose or dangling or drooping wiring/cabling draped, dropped or festooned into the devices from dead-ended conduits or overhead cable tray systems shall be acceptable. All wiring shall be protected in conduit until it has reached the internal space of the indicated device(s).
- F. ELECTRICAL & GROUNDING:
  - 1. Grounding of shields and chassis will adhere to industry standard practice and as required by the rigging and motorized systems manufacturer.
  - 2. Verify that all hot, neutral and ground conductors are tightened at least 5 days after initial installation and landing of line & load conductors.
  - 3. Any AC service shall be installed by the EC to standard Edison U-Ground style outlets at the locations noted on the electrical drawings. Where racks are located the service is to be run to the interior of the rack. This service should be capable of powering all system equipment at 100% of rated power.
  - 4. Internal rack AC distribution is the responsibility of the contractor. Acceptable methods: Rack mount power strips, rack mounted power distribution devices, Wiremold style outlet strip. All shall be provided by the contractor as needed.
  - 5. Install all internal AC rack/device power with all switches and controls carrying hazardous voltage housed in steel enclosures within the rack. Provide positive electrical grounding for all steel enclosures. All AC service will incorporate separate hot, neutral and ground for each device. All grounds and neutrals will be appropriately bonded and connected to earth as required by codes and normal practice.
- G. CONDUITS (OR ASSOCIATED RACEWAY/WIREWAY):
  - 1. Use separate conduits for data/control and power cabling and as per NEC code.
  - 2. All wiring in conduit shall be rated as necessary for full load continuous operation of the wiring within the conduit.

3. All conduits shall be concealed unless the owner has been notified in writing and accepts by written approval the location of all exposed conduits.
4. No conduit shall be allowed that is loaded beyond 50% fill. The contractor responsible for installing the indicated conduits shall upsize as needed any conduit found to be too small at no additional cost to the owner.
5. A pull string shall be left in place by the installing contractor (typically the EC) after pulling all wiring through each conduit. This pull string shall be tied off at both ends and left for future use.
6. All lines, cabling or wiring in any conduit run must be free from any splices or junction points.
7. All lines, cabling or wiring must be free from damage. Any that exhibits stress, damage, intermittent signal problems, data errors or other anomalies due to excessive pull torque shall be replaced by the installing contractor at no additional cost to the owner.

H. JUNCTION/GANG BOXES:

1. Unless otherwise specified all controls, receptacles, user interface stations, plugs and outlets shall be located in an appropriately sized gang box. No multi-gang backboxes with raised, tile ring, extension ring or mud ring style reducers to obtain the specified faceplate gang size shall be acceptable in lieu of the indicated device backbox. Any multi-gang devices with these extension rings used shall be replaced and the specified backbox sizes provided by the EC at no additional cost to the owner.
2. Any junction (i.e. terminal blocks, punch down blocks etc.) shall be housed in metal enclosures with an attached ground. No such connections may be made in ceiling spaces or other areas without the use of a steel enclosure.
3. Any added junction boxes shall be sized and located for ease of troubleshooting access and all connections within shall be connected on terminal strips, which are clearly identified, in a logical, consistent & permanent manner.

**3.3 ASSEMBLY AND PRETEST:**

- A. All rigging equipment shall be assembled per manufacturer's instructions and tested prior to installation.
- B. All controls and motorized elements shall be tested prior to installation.

**3.4 FINISHES & CLEANING:**

- A. All finishes shall be returned to their original finish and condition after any temporary machining or other work.
- B. Cover any walls, furniture, finished floors and carpeted areas to catch all metal particles, grit, etc. that may occur during installation.
- C. Cover and protect all equipment left or installed on site during construction.
- D. Provide thorough cleaning of all work areas including vacuuming, spray cleansers and dust removal as required. Clean all equipment fan filters before final acceptance tests.
- E. Maintain clean work areas, removing all debris daily.
- F. Finishes:
  1. All welds (and the surrounding area) must be touched up by the contractor to match adjacent undisturbed finishes. No bare metal, unfinished welds, weld spatter or other welding debris, weld "heat" or scorch marks, etc. shall be allowed.
  2. All finishes which are disturbed during shipping and installation shall be touched up to match the original.
- G. Provide a thorough cleaning of all rigging system equipment and related devices, including but not limited to, blocks, pulleys, sheaves, battens, arbors, guide system, locking rail, FOH devices, catwalk pipes, rigid coves/positions, motorized devices/remotes/controls, misc. related cabinets, cable trays, pantographs, etc. regardless of status (new or existing to remain/reuse). Cleaning

shall be after all dust/dirt creating work has been completed and just prior to walk-through/punch list and turnover to the owner.

- H. No curtains shall be installed prior to the stage floor being swept and wet mopped by the rigging installer in order to remove all dirt, dust, misc. spilled items, etc. Alternatively, the rigging installer may cover the entire stage floor with a single layer (overlapped 12" as needed) of new, clean, heavy-duty, clear plastic prior to the installation of stage drapery (the rigging installer shall also be responsible for the removal and legal disposal of this covering as well as obtaining written permission by the owner, architect and/or construction manager to install it). Any curtains installed so that portions of the curtain drag across or touch the floor or become dusty, cob-webbed or soiled by any means during construction and prior to turning the room over to the owner shall be completely cleaned, repaired (if damaged) and retrimmed by the rigging contractor at no additional cost to the owner. The rigging contractor shall clean all dirt, dust, etc. from curtains that may have accumulated on them just prior to turning the room over to the owner.
- I. The rigging contractor shall wipe clean (with a clean, damp cloth) all pantograph tracks, motorized truss, tormentor, Shakespeare, gallery, catwalk, rigid cove or any other pipe batten, pipe-style or ladder assemblies, motor control or operator control panels, stage pipe battens, remote control devices, locking rail, arbors, rope locks, index lighting system, floor blocks, tension floor pulleys, etc. just prior to turning the systems over to the owner. Upon cleaning, all items shall appear in as new condition and without scratches, blemishes, dirt, dust, debris, chalking, paint marks, etc. on them.

### 3.5 LABELING:

- A. All labeling and signage shall comply with the requirements of the following recognized national standards, where such requirements can be implemented with rigging components, assemblies and systems:
  - 1. ANSI Z535.1-2006, Safety Color Code
  - 2. ANSI Z535.2-2006, Environmental and Facility Safety Sign
  - 3. ANSI Z535.3-2006, Criteria for Safety Symbols
  - 4. ANSI Z535.4-2006, Product Safety Signs and Labels
- B. All signs or labels shall be in English. If operating personnel are not familiar with English, additional signs or labels in the appropriate language shall be permitted.
- C. The working load limit, manufacturer's name or grade reference mark shall be permanently displayed on each piece of equipment and hardware. Chain, rope and wire rope shall be exempt from this requirement. If the hardware or equipment is size-specific (e.g. wire rope clips), then the size shall be displayed on the product. Where permanent labeling or marking of individual components is impractical, then the load, manufacturer, or grade reference information shall be indicated in the system reference documents.
- D. Dead Hung Rigging Systems: Each batten shall be marked and labeled with its set number, maximum batten capacity (see tables below), stage centerline and lift line locations. Batten labels shall be marked on the bottom of the end of each set pipe batten clear of the batten end cap and in 2" high lettering. Lettering shall be Arial Bold Black. Cover labels with clear heat-shrink tubing after application and heat tubing until it firmly adheres to pipe (all of label must be covered after tubing has been heated and shrunk into place). See drawings for more details and intents of batten labeling. This applies to all rigging systems except pipe grid systems. Maximum batten capacities shall be based upon those weight limits set forth in the chart below (unless otherwise indicated in the bid documents). Maximum capacities as marked on each batten shall be reflective of the batten's capacity without safety factors, reductions, etc.
- E. Load Types Defined:
  - 1. Dead loads are those static forces that are relatively constant for an extended period of time. This includes typical structural elements like the pipe batten, trim chains, lift lines,

- turnbuckles and shackles, etc. These are items that are structurally related to the working mechanics of the sets.
2. Live loads are typically unstable loads or loads that are moving. These are also sometimes called dynamic loads and typically include items such as fixtures, clamps, power supplies, curtains, speakers, hanging mics, etc. These are items that are taken off and put on battens on a semi-regular basis as the look, theme or focus of each show is restruck.
  3. Cyclic loads are typically moving loads that are associated with a motor. These loads would include those presented by the use of curtain draw machines, motorized winches, motorized trusses, moving lights, etc.
- F. Any equipment requiring lubrication shall be identified in the maintenance manual stating quantity, type of lubricant and frequency of lubrication. Lubrication points shall be clearly indicated. Lubrication points shall be accessible without major disassembly of the related component.
- G. Each curtain, leg, electric and border light set shall be so designated.
- H. A wall plaque/sign shall be placed on stage indicating standard rigging system operations and methods, as well as load capacities for the sets, basic system operation etc. See paragraphs below for additional and job specific safety signage requirements.
- I. All curtains shall have a label affixed as to the date of flame-retardant treatment (and/or current IFR status) and the life cycle of the treatment. This label shall not be visible from the audience. Label location shall be on the lower rear hem of curtains so that it is readily visible from backstage without lowering a set or climbing a ladder.
- J. SIGNAGE:
1. Provide safety signs for loading areas as indicated on the contract documents. See the TR series drawings for sample safety signage, verbiage, quantities, etc. Obtain owner desired installation location sign-offs, in writing, prior to installing signage. Signage information is to be job specific. Signage should include procedures for loading and unloading sets, curtains, electrics, etc. as well as standard safety and operational procedures. Specific load ratings shall be detailed for the system designed as indicated on the bid documents and may not exactly reflect the information on the signage sample pictured below. Signage sample, text and title below is for illustrative purposes ONLY and does not include all job specific information or weight related data for this system that should appear on each sign. Signage sizes may be longer than noted below if more room for pertinent safety text is required; however, the signage size indicated is the MINIMUM size allowed. Signage to be printed with permanent, non-smudging ink. No smudges or high gloss surface treatments will be allowed. Contractor is to obtain specific weight related information and pertinent operational procedures for this system from bid drawings and manufacturer's recommendations and is to obtain weight stacking information from the architect and the designed load capacities of the stage floor at each weight stacking location. Spare weight stacking locations are TBD by the owner, architect or owner's representative. Contractor is to submit sample signage to the consultant for approval of text and information prior to ANY sign fabrication, ordering or installation. These signs are in addition to standard safety and operational signage that should be included. Contractor is to obtain exact signage locations and mounting heights from the architect, owner and any applicable codes relating to safety signage placement. Signs should be placed in locations where they will not be obstructed and are highly visible and readable. FOAM CORE SIGNAGE IS NOT ACCEPTABLE.
  2. Provide custom "Rigging Inspections" signs that detail the ANSI E1.47-2017 "Entertainment Technology-Recommended Guidelines for Entertainment Rigging Systems" recommendations. Signage shall be similar to other safety signage for this project and per contract document details.

3. A sign shall be posted in an accessible location providing the name, address and phone number of the primary system contractor, manufacturer and supplier (if not already listed) of the system equipment.

### 3.6 RIGGING:

- A. The following minimum standards apply in addition to the standards referenced elsewhere within this specification. These guidelines do not negate the standards referenced elsewhere within this specification. The standards indicated are minimum standards and do not supersede the requirements of the structural engineer to meet appropriate codes and standards.
- B. All equipment not described as portable in this specification will be rigidly held in place.
- C. All equipment will be supported at a minimum of three (3) points plus a backup. The contractor shall be responsible to provide backups as required, even if those backups do not appear in plans or on the detail drawings.
- D. Each point shall be able to carry the entire rated load with a safety margin of at least five (5) times the rated load. All methods shall incorporate an independent safety backup with a safety margin of at least five (5) times the rated maximum load as installed in case of failure of any rigging component.
  1. In the case of counterweight rigging systems, utilize industry standard practices for lift lines gauges and conform to all applicable codes.
- E. All rigging and related fastening methods must be treated as permanent. All threads shall be treated with vibration compounds such as Vibratite or Loctite as per manufacturer's recommendations.
- F. All rigging hardware shall be load rated with the load rating or approval stamped on each piece of hardware.
- G. No chain of any type will be acceptable for the primary hanging or backup support of any equipment, unless specifically noted on the drawings. (Trim chains and fire curtain chains excepted)
- H. No fabric devices, polyester roundslings, ratchet straps, webbing, wire mesh slings, wire rope core windings with fabric jackets, natural or synthetic corded or devices incorporating cam or buckle parts shall be considered as acceptable methods of hanging of any equipment excepting curtains.
- I. No stainless-steel rope shall be secured with threaded compression type fittings alone. Compression type closures such as Nicopress with copper sleeves only must be utilized. All wire rope where connected to turnbuckles, trim chain or eyes will have strain relief/minimum bend radius thimbles installed. A go-no-go calibration tool must be on the job site and closures checked during installation.
- J. All loose ends of the wire rope shall be neatly taped down after Nicopress is installed and crimped. No frayed rope ends shall be allowed under this specification.
- K. The contractor shall be responsible for how installed devices (even those provided by others but intended to be used in conjunction with the related rigging equipment) affect any rigging related system he has provided and installed (i.e. rigid coves, pipe battens, FOH cove positions, balcony pipes, tormentors, catwalk battens, etc.). If devices provided by others causes battens or related structure, strut channel systems, etc. to bend, twist, warp, rotate, etc., then the contractor shall be responsible for all additional or replacement hardware, return visits and labor necessary in order to remedy any unnatural, abnormal or otherwise unacceptable anomalies and in order to bring the related rigging equipment pipes, strut channel, structure, etc. back into a standard, flush/plumb/level and non-rotating condition.
- L. All Nicopress or equal compression connections and wire rope swaging products utilized on this project shall be required to pass field gauge tests as to their proper terminations and compression (typically referred to as go-no-go gauge tests). Due to the sheer quantity of manufacturer's and



the varying types/styles of compression tools in use, this will require the contractor to provide the proper go-no-go gauge during acceptance testing (punch list) for each different compression tool utilized on the project (typically a specific gauge is provided with each tool purchased). This gauge will be turned over to the consultant for use in verifying that the correct compression has been performed on the oval sleeves. It is understood that the consultant cannot test every single oval sleeve but will, instead, check a random percentage of sleeves that will be assumed to be typical of all similar compression fittings on this project. It is the contractor's responsibility to verify, during installation, that every oval sleeve has been compressed properly and that it passes the go-no-go gauge test. Improperly swaged oval sleeves pose a serious risk to stage personnel. Improperly swaged oval sleeves shall be replaced by the contractor as required, even if that means that the associated wire rope and other related hardware must also be replaced.

- M. All Nicopress or equal compression connection thimbles shall be loaded (mounted) only on a round shaft. Thimbles through a punched hole or other where the thimble encounters an edge shall not be allowed.
- N. Nothing shall be allowed into the interior of any Nicopress or equal compression connection oval sleeves except the wire rope itself. Any taping of wire rope ends shall be performed only after all compression connections are properly swaged.

### 3.7 ROUGH-IN:

- A. Due to small scale of Drawings, it is not possible to indicate all offsets, fittings, changes in elevation, etc. Verify final locations for rough-ins with field measurements and with the equipment being connected. Verify exact location and elevations at work site prior to any rough in work. DO NOT SCALE PLANS. If field conditions, details, changes in equipment or shop drawing information require a significant change to the original documents, contact the owners representative for approval before proceeding.
- B. All equipment locations shall be coordinated with other trades to eliminate interference with required clearances for equipment maintenance and inspections.
- C. Coordinate work with other trades and determine exact routing of all duct, pipe, conduit, etc., before fabrication and installation. Coordinate with Architectural Drawings. Verify with Owner's Representative exact location and mounting height of all equipment in finished areas, such as thermostats, fixtures, communication and electrical devices, including panels. Coordinate all work with the architectural reflected ceiling plans and/or existing Architecture. Mechanical and electrical drawings show design arrangement only for Diffusers, grilles, registers, air terminals, lighting fixtures, sprinklers, speakers and other items. Do not rough-in contract work without reflected ceiling location plans.
- D. Before roughing for equipment furnished by Owner or in other contracts, obtain from Architect and other Contractors, approved roughing drawings giving exact location for each piece of equipment. Do not "rough in" services without final layout drawings approved for construction. Cooperate with other trades to insure proper location and size of connections to insure proper functioning of all systems and equipment. Obtain written authorization from the Owners representative or other contractor for any "rough ins" that, due to project schedule, are required before approved coordination drawings are available. Any work installed without written authorization or approved coordination drawings, causing a conflict will be relocated by the electrical contractor at no expense to the Owner.
- E. For equipment and connections provided in this contract, prepare roughing drawings as follows:
  - 1. Existing equipment being relocated: Measure the existing equipment and prepare drawings for installation in new location.
  - 2. New equipment: Obtain equipment roughing drawings and dimensions, then prepare rough-in drawings.
- F. Where more than one trade is involved in an area, space or chase, all shall cooperate and install their own work to utilize the space equally between them in proportion to their individual

requirements. In general, ductwork shall be given preference except where grading of piping becomes a problem, followed by piping then electrical wiring. If, after installation of any equipment, piping, ducts, conduit, and boxes, it is determined that ample maintenance and passage space has not been provided, rearrange work and/or furnish other equipment as required for ample maintenance space. Any changes in the size or location of the material or equipment supplied, which may be necessary in order to meet field conditions or in order to avoid conflicts between trades, shall be brought to the immediate attention of the Owner's Representative and approval received before such alterations are made.

- G. Provide easy, safe, and code mandated clearances at controllers, motor starters, valve access, and other equipment requiring maintenance and operation.

### **3.8 CUTTING AND PATCHING:**

- A. Each trade shall include their required cutting and patching work unless shown as part of the General Construction work on the architectural drawings. Refer to "General Conditions of the Contract for Construction" for additional requirements. Patch all cut or abandoned holes left by removals of equipment or devices. Patch adjacent existing work disturbed by installation of new work including insulation, walls and wall covering, ceiling and floor covering or other finished surfaces. Patch openings and damaged areas equal to existing surface finish (i.e. "patch to match existing"). If no instructions exist in the contract documents addressing these issues, then the contractor shall contact the architect and construction manager in writing prior to proceeding with any work in order to obtain written instructions regarding this type of work.

### **3.9 CONCEALMENT:**

- A. Conceal all contract work visible in architecturally sensitive areas above ceilings and in walls, below slabs and elsewhere throughout building (this does not pertain to stage rigging, pipe assemblies, motorized trusses or other items that are normally visible). If concealment is impossible or impractical, notify Owner's Representative before starting that part of the work and install only after his review and written authorization and instructions on how to proceed. In areas with no ceilings, install only after Owner's Representative reviews and comments on arrangement and appearance. Obtain and maintain written records and approvals for all work exposed work performed or devices installed.

### **3.10 PERFORMANCE:**

- A. All batten ends must line up with each other (for all battens of similar length).
- B. All battens of similar trim (both high and low trims) must be even with each other  $\pm \frac{1}{2}$ ".
- C. All stage battens shall be trimmed in such a way so that trim heights match those shown on contract drawings.
- D. All curtains shall be installed only after all dirt and dust creating work and paintwork has been completed and cleaned up. Curtains must be installed very near the end of the job but before all final acoustic testing, AFC tuning and sound system tuning have been performed. This will require the rigging installer to coordinate with all related trades and their schedules in order to install curtains at the appropriate times.
- E. No battens shall be allowed to have threaded ends or threaded couplings at all.
- F. No battens shall be allowed to have plug welded splices at all.
- G. Any installation errors or variance in installation methods from standard industry practices and standards shall be corrected by the contractor at no additional cost to the owner, even if that means that the contractor must remove and reinstall the entire rigging system (and with the owner's schedule in mind).
- H. If trim chains have been noted on the drawings, but the end result is a batten that rotates when "top loaded" with dimmer strips or fixtures, then the contractor shall simply replace all trim chains

with H&H Specialties #680 full batten clamps in lieu of the specified trim chains at no additional cost.

- I. Do not tighten turnbuckles to the point of deforming/deflecting the Unistrut channels upwards or causing them to "hump up" at the connection point(s).
- J. Final curtain presentation requirements:
  - 1. All curtains must be hung properly and per industry standards and shall not feature excessively long jack chains, tie offs, etc.
  - 2. All traveler curtains shall be secured on the off-stage end so that the curtain cannot track completely onto the stage while leaving an exposed section into the stage wing areas.
  - 3. All curtains must be hung for long enough so that wrinkles/folds/creases from storage & shipment are removed. Final curtain presentation, upon turning the room over to the owner, shall be smooth, flat, non-wrinkled (wrinkle & crease free) curtains. If, after installation of the curtains on stage, the curtains display wrinkles, creases, folds or any other such visual anomalies, then the contractor shall provide additional labor, etc. as needed in order to iron or steam (or other approved and recommended procedures appropriate for the fabric) any such wrinkles, folds, creases, etc. from the curtains prior to turning the room over to the owner. No curtains displaying wrinkles, folds, creases, etc. or other such visual anomalies shall be allowed or accepted.
  - 4. All traveler curtains must be fabricated so that there is a 24" overlap at the center of the stage without any undue stress on the other ends of the curtains, excessive pulling or tensioning of the curtains or connection points or stretching of the additional fullness in order to accomplish this. Any curtains not having the proper center overlap shall be re-fabricated by the contractor at no additional cost to the owner.
  - 5. The bottom edge of all curtains shall be level with the stage floor for its entire length across the stage and shall not deviate from stage level more than 1/8".
  - 6. All curtains shall be trimmed so that the bottom of each clears the floor by 1/2" - 3/4". This is especially critical on dead hung systems where curtains cannot be retrimmed by readjusting the counterweight arbor. Curtain fullness and potential roof snow loading conditions shall be calculated and considered prior to the curtains' final installation. This will require the contractor to provide one additional trip to the site during the winter season and with snow load on the roof in order to re-trim curtains as and if needed in order to account for snow loading deflection of the rigging steel and so that curtains do not drag on the floor.

### 3.11 INITIAL POST COMPLETION TESTS & SET UP:

- A. Verify that all stage sets & FOH supports have been properly installed, safety cabled, etc.

### 3.12 OWNER INSTRUCTION:

- A. The contractor shall provide a training program at the project location and with the project equipment (owner's equipment), consisting of the following hours/periods of instruction specifically and exclusively regarding the stage/house rigging systems and related equipment (total training time not to exceed 4 hours. No training block to be less than 2 hours in duration. This time is in addition to training time noted below):
- B. All owner instruction to be provided by the contractor as part of this contract shall be scheduled and performed within 12 months of the final system turnover date to the owner.
  - 1. The turnover date is defined as the date of completion of all open punch list items
- C. All training hours are exclusive of travel time.

### 3.13 TRAINING:

- A. Training must provide useful information that covers the majority of how a system will be used by the owner. This also applies to documentation and video training.
- B. On a job-by-job basis this training may vary significantly. The hours allotted may be used by the owner as required for any purpose related to the system.

**3.14 QUALIFICATIONS OF TRAINERS:**

- A. All persons performing system training must be experienced operators of the specific equipment in the project. If no one on the contractor's staff has experience on a specific device, then they will need to provide outside personnel in order to perform the training sessions.

**3.15 SCHEDULING FOR TRAINING:**

- A. Initial Training must be scheduled by the contractor with at least two weeks advance notice.
- B. If the contractor arrives for a scheduled training session and the owner personnel are not present, then the contractor must notify the owner that a four-hour training segment has been forfeited.
- C. If a scheduled session lasts less than four hour it will still expend four hours of allotted training.

**3.16 INITIAL TRAINING:**

- A. Walk through the facility and familiarize the owner with where all primary system equipment is and what it does. This should include any related power panels or disconnects feeding the system, all rigging related equipment, controls, etc.
- B. Training on Counterweight Operations:
  - 1. Overall safety instructions.
  - 2. Set loading & unloading procedures for all curtains and electrics.
  - 3. Operational norms – verbal commands on stage.
  - 4. How to deal with large load changes such as curtain removals.

**3.17 FOLLOW-UP SESSIONS:**

- A. Often these sessions will be used for in rehearsal or show sessions where the contractor is an assistant to the operators during actual system use.
- B. Provide training only at the request of the owner's authorized representative (s). Track all training hours and provide copies to the owner of who attended and what general topics were covered.

**3.18 VIDEO RECORDING OF TRAINING WITH OWNER – INITIAL TRAINING:**

- A. The camera should be placed on a tripod in a location that offers a good view of the rigging system, locking rail, arbors and any related equipment or controls. Lighting must be adequate for the video camera; provide portable lighting as needed.
- B. Provide simple explanations of what each piece of equipment does, what would occur if a piece of rigging equipment failed, if the motorized portions (if present) were to be shut down, etc.
- C. A live training session by default will be interrupted with questions. The camera should record through the entire session.

**3.19 VIDEO RECORDING OF DEVICE TRAINING – SECONDARY TRAINING:**

- A. Device specific training shall be recorded by the contractor independent of the initial training session. This recording can be done in the contractor's shop, at the site without the owner or at other locations as appropriate.
- B. This second video training is to provide multiple levels of information:
  - 1. A walk around of the site should be video recorded that shows the owner where all primary lighting system equipment is located and what all related screens and indicator lights look like when everything is working properly.
  - 2. A walk to any power panels & disconnects feeding the system (motorized equipment, index lighting, etc.) and what breakers operate various power feeds and what their normal state looks like.
  - 3. For all motorized elements note the control boxes, their use and how to check for trouble status in controls.

4. This video should include a discussion of the ANSI/ESTA standards for inspections, the frequency of inspections and the necessity to contact the installer if any motorized elements malfunction in any way.
  5. A quick start video guide for someone who must use the system who has no idea how to do anything.
- C. Video recording general requirements (applies to all):
1. Convert each recording to standard formats for playback on Mac/PC based platforms and write to the devices as described below.
  2. Edit and title the final video training sessions into logical chapters so that an end user is quickly able to find what they need. The basis for titles, sections, etc. shall be the general content of all video training.
  3. Provide an electronic file to the owner and owner's personnel that contains all relevant links to the manufacturer's video training series for basic, intermediate and advanced topics/functions.
  4. Provide all training videos in DVD and USB stick formats.
  5. On the USB stick, include a PDF document that contains the active links to the manufacturer's video training sessions and relevant sites.
  6. In subsequent training sessions with the owner's personnel, higher level functions may be covered. Some owners will not require this, but others will. The contractor is not required to video record subsequent sessions. The owner can record any session they want for future reference using their own equipment.
  7. Provide (1) one copy (brand new and not previously used) of the Stage Rigging Handbook (provide the latest edition) by Jay O. Glerum. This shall be turned over to the owner and used as the instructional text for training of the designated operators of the stage rigging equipment. This book shall remain with the owner as a reference manual.

### 3.20 WARRANTY AND SERVICE:

- A. The contractor guarantees all equipment, materials, and workmanship to be free from defects for a period of one (1) year from owner acceptance. This warranty supersedes all manufacturers warranties for the one (1) year period. Any manufacturer's warranty that exceeds the one (1) year will continue to be applicable. The contractor will replace any defective materials at no charge to owner. Any equipment replaced during the one (1) year warranty will have a new one (1) year warranty to the owner.
- B. The contractor guarantees all labeling to be free from defects for a period of two years from the date of owner acceptance. In cases where the label's adhesive fails, or the label suffers from degradation causing it to become unreadable, the label will be considered defective and will be replaced at no cost to the owner.
- C. The contractor will respond by phone to requests for service within two (2) business hours and respond with a technician being sent (if needed) within one (1) business day.
- D. Any equipment that tends to "drift" or whose performance deteriorates during the warranty period will be considered defective, even if such drifting is normal during break in. This equipment will be readjusted by the contractor at no additional charge to the owner.
- E. Provide during the warranty period one (1) service inspection for preventive maintenance, at six (6) months after acceptance. This will include but not be limited to a full system operational and safety check and tightening of manila operating lines as required.
- F. Provide all service at the owner's location regardless of any manufacturer warranty terms regarding carry in service.
- G. INSPECTIONS:
  1. The contractor shall be responsible to inform the owner in person and in writing of the necessity and critical nature of having their stage rigging systems inspected per the latest ANSI E1.47-2017 "Entertainment Technology-Recommended Guidelines for Entertainment

Rigging System Inspections" guidelines. This shall also be reflected in safety signage as specified.

2. The contractor shall be responsible to inform the owner in person and in writing that without annual motorized rigging inspections, the warranty on the motorized equipment ceases to be in effect.
3. General inspections:
  - a. Each system component shall be inspected by a qualified person on a recurring schedule as recommended by the manufacturer and ANSI E1.47-2017.
  - b. All installations and equipment shall be visually inspected and shall be tested for operation in a non-destructive manner.
  - c. All systems and equipment shall be inspected after installation and prior to user operation. Inspections shall meet the requirements of this section, but additional requirements shall be permitted.
  - d. Qualified persons shall either perform or oversee the inspection and testing process and shall certify that all inspection requirements have been met.
  - e. Inspection procedures and results shall be fully documented. The testing supervisor, the installer and the system owner shall retain complete copies of the test documentation.
  - f. Any lineset not meeting the prerequisite requirements detailed above shall be tested by applying a controlled test load at no less than 150% of the design load.

### 3.21 DEMONSTRATION AND ACCEPTANCE:

#### A. CONDITIONS FOR SCHEDULING FINAL ACCEPTANCE:

1. The system is required to be complete and fully tested. Any failure that may have occurred between the contractor's final tests and the date of acceptance will be noted and can be corrected after that date. All the following conditions must be met before scheduling an acceptance test:
  - a. The contractor shall inspect, completely verify and submit signed documentation that all system components meet all applicable current ANSI, ESTA & PLASA rigging standards as well as all the performance criteria set forth within this specification.

#### B. PROCEDURE FOR SCHEDULING FINAL ACCEPTANCE:

1. The contractor shall notify the owner and consultant of a proposed date and time for the final acceptance tests. The contractor shall include two alternate dates and times. The dates proposed will be a minimum of fourteen (14) calendar days from the date of the proposal.
2. The owner and consultant will respond within two (2) business days as to whether the date and time for final acceptance tests has been approved.
3. If none of the dates and times are acceptable, the owner and/or consultant will submit two alternate dates and/or times to the contractor. The contractor will respond within two (2) business days as to whether the dates and times for acceptance tests are acceptable.
4. If the dates and/or times proposed by the owner and/or consultant are not accepted, the contractor, owner, and/or consultant will continue to alternate per these procedures until an acceptable date and time has been found.

#### C. DATE OF TESTS:

1. The contractor will demonstrate operation of all major components of the systems including, but not limited to, the following:
  - a. Demonstrate the operation of the dead hung rigging system.
  - b. Demonstrate the operation of the FOH (front of house) system components.
  - c. Demonstrate operation of all curtains and tracks.
  - d. Provide proof of flame certifications.

### 3.22 CONDITIONS OF ACCEPTANCE:

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- A. It is understood that the consultant cannot inspect every aspect of the installation. The contractor is responsible for installation quality and methods, fabrication quality and methods and performance of their work. Acceptance of the project will constitute an acceptance of the following:
1. All specified equipment has been installed and the system is operating properly.
- B. Upon completion and acceptance of the project the contractor will provide to the owner a letter stating that all of the equipment and installation methods meet or exceed the specification requirements in all respects, and that the system as installed meets all of the applicable standards and codes required under the specification and meets applicable federal, state and local codes and laws.
- C. ACCEPTANCE TESTS CHECKLIST:
1. Prior to acceptance testing there are a number of conditions that need to be verified. There are also site conditions required for the consultant to perform tests as indicated. The contractor shall ensure that every item on this checklist has been performed and verified prior to the consultant's acceptance tests can begin. Scheduling of the consultant to perform final acceptance tests must be coordinated with the owner, the project's construction manager (or clerk of the works), the contractor and the consultant (See paragraphs above for detailed requirements).
  2. GENERAL
    - a. No other contractors may be working within the rooms to be tested during tests.
    - b. No rehearsals or other activities may take place during tests.
  3. RIGGING SYSTEM – TYPICALLY TAKES 2 - 4 HOURS.
    - a. Required attendance – Adequate Personnel from the rigging contractor to operate sets, answer specific system installation questions and verify all installation details.
    - b. Curtains and all required lighting fixtures installed to battens.
    - c. All sets installed level, true and plumb.
    - d. All curtain tracks checked for end stops and binding on tracks.
    - e. All cable drops for stage electrics properly dressed and not tangling during travel.
    - f. Verification that all portable equipment has been delivered to the owner per specs and drawings. Portable equipment must be available for visual inspection as well.
    - g. All Nicopress or equal compression sleeves have been properly swaged and tested by the contractor with a go-no-go gauge and found to comply with recognized standards and specification requirements.
    - h. All curtain track tension floor pulleys (or sandbag pulleys) properly installed and fully functional.
    - i. All curtains hung, clean, wrinkle-free & crease-free and with the proper documentation on site as to their flame-retardant characteristics.
    - j. All shackles and turnbuckles properly moused with all wire ties clipped short and clean (with no protruding ends).
    - k. All batten end caps installed.
    - l. All standard and custom safety signage correct, site specific and properly installed in all locations called for in the written specifications.

### 3.23 CLOSEOUT DOCUMENTATION:

- A. Contractor must submit the following items. All items should be part of the O&M Manual. Provide the quantity and form (paper and/or electronic) of these closeout documents as is indicated in the contract front-end documentation. Physical copies shall only be required if front-end documentation requires them. If the owner requests physical copies, these shall be provided at an additional expense to the owner.
- B. System testing documentation as required by final testing and acceptance procedures outlined in this document.

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- C. ALL paper copy O&M Manual submissions shall be in heavy-duty, D-Ring style, 3-Ring binders (provide size most appropriate for the quantity of paperwork included) with front plastic display pocket and internal side pockets. NO PAPER FOLDERS SHALL BE ALLOWED. All electronic copies shall be "bound" in an Adobe Acrobat style portfolio (see below for more complete information).
- D. Complete technical manuals for all equipment installed.
- E. List of serial numbers of all equipment installed and the specific location of each piece of equipment.
- F. Warranty cards for all equipment or classes of equipment (if warranty cards exist, otherwise provide copies of the manufacturer's warranty policies).
- G. Curtain flame resistance certificates.
- H. Manufacturer MSDS sheets for all applicable equipment.
- I. Operations & Maintenance Manuals shall NOT include any alternate languages or language sections unless specifically requested by the owner (i.e., French, Dutch, German, Spanish, Japanese, etc.).
- J. Operations & Maintenance Manual: An operations and maintenance manual (or "Systems Manual") written in English. This manual should include, but is not limited to, the following (these items shall also be included in the system training and videotaping):
1. A custom compiled simplified guide to standard rigging procedures, including, but not limited to, the following items:
    - a. Industry standard procedures for the handling, loading and unloading of weights, battens, arbors and other pipes
    - b. Make a clear effort to inform the owner (both during formal training and in the O&M Manuals) and to direct ALL operators to abide by the facility's "policy for working at height" and as is OSHA approved.
    - c. The proper procedures for taking curtains down, protecting them from dirt & damage during this process, storing them properly and reinstalling them.
    - d. How to properly load/offload fixtures from electric sets.
    - e. Generally accepted stage practices regarding personnel on stage while sets are in use.
    - f. The operation and intent of legs & rotator operation.
    - g. A complete copy of manufacturer's furnished standard stage & counterweight rigging safety procedures.
    - h. The minimum number of persons required for safely loading/unloading sets along with proper adult supervision requirements during major set changes (four on stage).
    - i. A set of blank rigging equipment inspection, maintenance and service log sheets (include as the first line item on each sheet the initial system installation, date, service performed, etc).
    - j. A sheet providing the name, address and phone number of the primary system installation contractor, manufacturer and supplier (if not already listed) of the system equipment, etc.
    - k. A simple list of any required periodic maintenance procedures that need to be performed on the rigging system (motorized hoists, counterweights or projection screen winch).  
\*See the training section below for the intents of training and any additional requirements.
  2. A sheet showing the ratings, safety factors and load limits of each set and all individual system components (including dead hung, motorized and counterweight sets either on stage or in the main auditorium area).
  3. A reduced size copy of each safety sign and the included verbiage – large enough to be read but still small enough to fit neatly into binder.



4. A complete reduced size set of the final print drawings of the installation ("as built"), including field changes, routings, locations of sets, set numbering, installation details and other pertinent information.
  5. A set of blank rigging equipment inspection, maintenance and service log sheets (include as the first line item on each sheet the initial system installation, date, service performed, etc. Each sheet shall include columns for the listing of date of service, person(s) performing service, service performed, additions or alterations to system or equipment, repairs performed, factory service tech service, etc. Log sheets shall be Microsoft Excel spreadsheet style sheets.
  6. A sheet providing the name, address and phone number of the primary system installation contractor, manufacturer and supplier (if not already listed) of the system equipment, etc.
  7. A sheet outlining the intents and usage of any supplementary auditorium pipe assemblies intended for the suspension of lighting instruments, including but not limited to tormentor, balcony, catwalk, gallery, cove or Shakespeare positions and the dangers involved in climbing or hanging from these assemblies (i.e. these structures should not be climbed – that is not their intent), proper access techniques, etc.
  8. A sheet detailing a "show" operation overview – i.e. how an operator would set up a show, stage procedures on a dark stage, safety precautions and any required programming parameters.  
\*See the training section below for the intents of training and any additional requirements.
- K. The contractor must provide a letter to the owner upon completion of the installation and training work that all fabric/material utilized is flame retardant (or is FR per specifications) and that all system hardware and components have been installed per specifications and industry standard practices (note any approved digressions from contract documents in a short, simple paragraph style format). No digression from industry standard installation practices and/or ANSI standard requirements shall be allowed.
  - L. The contractor must provide a copy of the "Certificate of Flame Resistance" to the owner for each type of curtain fabric used within the job. Each certificate should be complete and signed by the appropriate authority certifying its compliance with applicable fire codes – typically this is a sheet issued by the fabric manufacturer that states compliance with all appropriate NFPA regulations, etc. and is then filled out by the contractor as to the owner of the curtains, pattern and color of the fabric, the order and control numbers, date the order was processed, the contractor's invoice number and the yards processed for the fabrication of the stage curtains (some may even bear the official seal of a particular state and/or authorizing agency). Contractor sworn depositions or even duly witnessed and notarized sheets as to any particular fabric's flame-resistant characteristics is unacceptable as the contractor has no authority to make such statements.
  - M. A sheet detailing any maintenance procedures required for the equipment installed that is custom compiled and written by the contractor as well as a list of the specific tools required, user servicing guidelines, etc. related to serviceable devices.
  - N. The contractor shall provide the owner with complete instructions on maintaining the flame-resistant characteristics of any included fabrics, materials, etc. (e.g., the interval between flame retardant chemical applications) as well as the dangers involved in allowing third party vendors to apply flame retardant chemicals to IFR materials.
  - O. All users of the rigging system shall be instructed to read and thoroughly understand the information contained in the systems manual. Knowledge of the system-specific load capacities, operating instructions and maintenance schedules are important to establishing safe operating practices and should be understood by all users of the rigging systems and related components.
  - P. A DVD (or set of DVDs', depending on requirements listed below) that details the training of users on the owner's installed systems. See owner instruction section below.
  - Q. O&M Manual pdf requirements: The contractor shall provide a pdf copy (with appropriate titles) for each piece of documentation listed above and bound together in a pdf portfolio/binder, labeled

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with the owner's name and with the submitting contractor's information. All electronic manuals shall contain only equipment and information that pertains to the project. Where custom procedural guides and troubleshooting manuals are required, these shall be produced by the contractor in a professional piece of software (Microsoft Office, Adobe Acrobat or cadd software or equal) and shall contain all required information in a neat and logical presentation. Where there are portions of the stock manuals that contain sections that do not pertain, the contractor shall use a program such as Adobe Acrobat Pro, BlueBeam or other similar pdf markup software applications and use the strikethrough function with a heavy red line to strike out any text or sections that do not apply. Where factory manuals are available the contractor shall provide these. Where factory manuals are not available, the contractor shall provide high resolution (150 dpi minimum and fully optimized in Acrobat or equal), full page, properly and consistently oriented pages in a consecutive ascending order. All pdf portfolio and binders produced and submitted shall be professionally put together and presented well. No pdf scan pages that are skewed, illegible, mis-ordered, angled, copied at a low dpi setting or that do not pertain to this project shall be allowed. All manuals shall be saved as standard Adobe Portable Document Format (PDF) files that are capable of being opened & viewed on any modern computer system with a standard pdf reader and shall be without password access protection or other security preventative measures engaged.

**END OF SECTION**

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Sleeves and Sleeve Seals for Plumbing Piping	

## **SECTION 220517 SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Pipe sleeves.
- B. Manufactured sleeve-seal systems.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 220553 - Identification for Plumbing Piping and Equipment: Piping identification.
- C. Section 220719 - Plumbing Piping Insulation.

#### **1.03 REFERENCE STANDARDS**

- A. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) 2016.
- B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems 2013a (Reapproved 2017).

#### **1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.

#### **1.05 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified this section.
- C. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

#### **1.07 WARRANTY**

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a five year period after Date of Substantial Completion.

### **PART 2 PRODUCTS**

#### **2.01 PIPE SLEEVES**

- A. Manufacturers:
  - 1. Flexicraft Industries; Pipe Wall Sleeve: [www.flexicraft.com/#sle](http://www.flexicraft.com/#sle).
  - 2. Substitutions: See Section 016000 - Product Requirements.

### **PART 3 EXECUTION**

#### **3.01 PREPARATION**

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.

#### **3.02 INSTALLATION**

- A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- B. Install piping to conserve building space, to not interfere with use of space and other work.
- C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

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- D. Provide sleeves when penetrating footings, floors, walls, partitions, and [\_\_\_\_\_]. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
1. Underground Piping: Caulk pipe sleeve watertight with lead and oakum or mechanically expandable chloroprene inserts with bitumen sealed metal components.
  2. Aboveground Piping:
    - a. Pack solid using mineral fiber complying with ASTM C592.
    - b. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.
  3. All Rated Openings: Caulk tight with fire stopping material complying with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.
  4. Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed components.
- E. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

### 3.03 CLEANING

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.
- C. See Section 017419 - Construction Waste Management and Disposal, for additional requirements.

**END OF SECTION**

**SECTION 220518  
ESCUTCHEONS FOR PLUMBING PIPING**

**PART 1 GENERAL**

**1.01 RELATED REQUIREMENTS**

- A. Section 013000 - Administrative Requirements: Submittal procedures, project meetings, progress schedules and documentation, reports, coordination.
- B. Section 017000 - Execution and Closeout Requirements: Examination, preparation, and general installation procedures; preinstallation meetings; cutting and patching; cleaning and protection; starting of systems; demonstration and instruction; closeout procedures except payment procedures; requirements for alterations work.
- C. Section 017419 - Construction Waste Management and Disposal.
- D. Section 017800 - Closeout Submittals: Project record documents, operation and maintenance (O&M) data, warranties and bonds.

**1.02 REFERENCE STANDARDS**

- A. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- B. FM (AG) - FM Approval Guide current edition.
- C. UL (DIR) - Online Certifications Directory Current Edition.

**1.03 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

**1.04 QUALITY ASSURANCE**

**1.05 WARRANTY**

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Correct defective Work within a five year period after Date of Substantial Completion.

**PART 2 PRODUCTS**

**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.

**3.02 CLEANING**

- A. See Section 017419 - Construction Waste Management and Disposal for additional requirements.

**3.03 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals for closeout submittals.

**3.04 MAINTENANCE**

- A. See Section 017000 - Execution and Closeout Requirements for additional requirements relating to maintenance service.

**END OF SECTION**

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SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING 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:
1. Bronze ball valves.
  2. Iron, single-flange butterfly valves.
  3. Iron, grooved-end butterfly valves.
  4. Bronze swing check valves.
  5. Iron gate valves.
  6. Lubricated plug valves.

**1.3 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. NRS: Nonrising stem.
- E. OS&Y: Outside screw and yoke.
- F. RS: Rising stem.
- G. SWP: Steam working pressure.

**1.4 ACTION SUBMITTALS**

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

**1.5 QUALITY ASSURANCE**

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
  2. ASME B31.1 for power piping valves.
  3. ASME B31.9 for building services piping valves.
- C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

**1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
  2. Protect threads, flange faces, grooves, and weld ends.
  3. Set angle, gate, and globe valves closed to prevent rattling.
  4. Set ball and plug valves open to minimize exposure of functional surfaces.
  5. Set butterfly valves closed or slightly open.
  6. Block check valves in either closed or open position.
- B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to valve schedule articles for applications of valves.
- B. Per new Federal Lead Free Law, any product designed for dispensing potable water meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
- C. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- D. Valve Sizes: Same as upstream piping unless otherwise indicated.
- E. Valve Actuator Types:
  1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
  2. Handwheel: For valves other than quarter-turn types.
  3. Handlever: For quarter-turn valves NPS 6 and smaller.
  4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
- F. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
  1. Gate Valves: With rising stem.
  2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
  3. Butterfly Valves: With extended neck.
- G. Valve-End Connections:
  1. Flanged: With flanges according to ASME B16.1 for iron valves.
  2. Grooved: With grooves according to AWWA C606.
  3. Solder Joint: With sockets according to ASME B16.18.
  4. Threaded: With threads according to ASME B1.20.1.
- H. Valve Bypass and Drain Connections: MSS SP-45.

### 2.2 BRONZE BALL VALVES

- A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
  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. American Valve, Inc.
    - b. Conbraco Industries, Inc.; Apollo Valves.
    - c. Crane Co.; Crane Valve Group; Crane Valves.
    - d. Hammond Valve.
    - e. Lance Valves; a division of Advanced Thermal Systems, Inc.
    - f. Milwaukee Valve Company.
    - g. NIBCO INC.
    - h. Red-White Valve Corporation.
    - i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
  2. Description:
    - a. Standard: MSS SP-110.
    - b. SWP Rating: 150 psig.
    - c. CWP Rating: 600 psig.
    - d. Body Design: Two piece.



- e. Body Material: Bronze.
- f. Ends: Threaded.
- g. Seats: PTFE or TFE.
- h. Stem: Bronze.
- i. Ball: Chrome-plated brass.
- j. Port: Full.

### 2.3 IRON, SINGLE-FLANGE BUTTERFLY VALVES

- A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
- 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. Conbraco Industries, Inc.; Apollo Valves.
    - b. Cooper Cameron Valves; a division of Cooper Cameron Corporation.
    - c. Crane Co.; Crane Valve Group; Jenkins Valves.
    - d. Crane Co.; Crane Valve Group; Stockham Division.
    - e. DeZurik Water Controls.
    - f. Flo Fab Inc.
    - g. Hammond Valve.
    - h. Kitz Corporation.
    - i. Milwaukee Valve Company.
    - j. NIBCO INC.
    - k. Red-White Valve Corporation.
    - l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
  - 2. Description:
    - a. Standard: MSS SP-67, Type I.
    - b. CWP Rating: 200 psig.
    - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
    - d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
    - e. Seat: EPDM.
    - f. Stem: One- or two-piece stainless steel.
    - g. Disc: Aluminum bronze.

### 2.4 IRON, GROOVED-END BUTTERFLY VALVES

- A. 175 CWP, Iron, Grooved-End Butterfly Valves:
- 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. Kennedy Valve; a division of McWane, Inc.
    - b. Shurjoint Piping Products.
    - c. Tyco Fire Products LP; Grinnell Mechanical Products.
    - d. Victaulic Company.
  - 2. Description:
    - a. Standard: MSS SP-67, Type I.
    - b. CWP Rating: 175 psig.
    - c. Body Material: Coated, ductile iron.
    - d. Stem: Two-piece stainless steel.
    - e. Disc: Coated, ductile iron.
    - f. Seal: EPDM.

### 2.5 BRONZE SWING CHECK VALVES

- A. Class 125, Bronze Swing Check Valves with Bronze Disc:

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. American Valve, Inc.
  - b. Crane Co.; Crane Valve Group; Crane Valves.
  - c. Crane Co.; Crane Valve Group; Jenkins Valves.
  - d. Crane Co.; Crane Valve Group; Stockham Division.
  - e. Hammond Valve.
  - f. Kitz Corporation.
  - g. Milwaukee Valve Company.
  - h. NIBCO INC.
  - i. Red-White Valve Corporation.
  - j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
  - a. Standard: MSS SP-80, Type 3.
  - b. CWP Rating: 200 psig.
  - c. Body Design: Horizontal flow.
  - d. Body Material: ASTM B 62, bronze.
  - e. Ends: Threaded.
  - f. Disc: Bronze.

## 2.6 IRON GATE VALVES

- A. Class 125, OS&Y, Iron Gate Valves:
  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. Crane Co.; Crane Valve Group; Crane Valves.
    - b. Crane Co.; Crane Valve Group; Jenkins Valves.
    - c. Crane Co.; Crane Valve Group; Stockham Division.
    - d. Hammond Valve.
    - e. Kitz Corporation.
    - f. Milwaukee Valve Company.
    - g. NIBCO INC.
    - h. Powell Valves.
    - i. Red-White Valve Corporation.
    - j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
  2. Description:
    - a. Standard: MSS SP-70, Type I.
    - b. CWP Rating: 200 psig.
    - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
    - d. Ends: Flanged.
    - e. Trim: Bronze.
    - f. Disc: Solid wedge.
    - g. Packing and Gasket: Asbestos free.

## 2.7 LUBRICATED PLUG VALVES

- A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
  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. Nordstrom Valves, Inc.
  2. Description:
    - a. Standard: MSS SP-78, Type II.
    - b. CWP Rating: 200 psig.

- c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
  - d. Pattern: Regular or short.
  - e. Plug: Cast iron or bronze with sealant groove.
- B. Class 125, Lubricated Plug Valves with Flanged Ends:
  - 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. Nordstrom Valves, Inc.
  - 2. Description:
    - a. Standard: MSS SP-78, Type II.
    - b. CWP Rating: 200 psig.
    - c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
    - d. Pattern: Regular or short.
    - e. Plug: Cast iron or bronze with sealant groove.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

#### 3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install check valves for proper direction of flow and as follows:
  - 1. Swing Check Valves: In horizontal position with hinge pin level.

#### 3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

#### 3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
  - 1. Shutoff Service: Ball, butterfly valves.
  - 2. Butterfly Valve Dead-End Service: Single-flange (lug) type.

3. Throttling Service: ball, or butterfly valves.
4. Pump-Discharge Check Valves:
  - a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
  - b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or with spring or iron, center-guided, resilient-seat check valves.
  - c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
  1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
  2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
  3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
  4. For Grooved-End Copper Tubing: Valve ends may be grooved.

### **3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE**

- A. Pipe NPS 2 and Smaller:
  1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
  2. Ball Valves: Two piece, full port, bronze with bronze trim.
  3. Bronze Swing Check Valves: Class 125, bronze disc.
- B. Pipe NPS 2-1/2 and Larger:
  1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
  2. Iron Ball Valves: Class 150.
  3. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM seat, aluminum-bronze disc.
  4. Iron, Grooved-End Butterfly Valves: 175 CWP.
  5. Iron Swing Check Valves: Class 125, nonmetallic-to-metal seats.
  6. Iron Gate Valves: Class 125, OS&Y.

### **3.6 SANITARY-WASTE AND STORM-DRAINAGE VALVE SCHEDULE**

- A. Pipe NPS 2 and Smaller:
  1. Bronze Swing Check Valves: Class 125, bronze disc.
- B. Pipe NPS 2-1/2 and Larger:
  1. Iron Swing Check Valves: Class 125, nonmetallic-to-metal seats.

END OF SECTION 220523

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**SECTION 220529  
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT**

**PART 2 PRODUCTS**

**1.01 SUPPORT AND ATTACHMENT COMPONENTS**

- A. General Requirements:
  - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
  - 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
  - 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
  - 4. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
    - a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
    - b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Metal Channel (Strut) Framing Systems:
  - 1. Comply with MFMA-4.
- C. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
- D. Anchors and Fasteners:
  - 1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

**END OF SECTION**

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**SECTION 220553  
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Nameplates.
- B. Tags.
- C. Pipe markers.

**1.02 REFERENCE STANDARDS**

- A. ASME A13.1 - Scheme for the Identification of Piping Systems 2020.

**1.03 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturers catalog literature for each product required.

**PART 2 PRODUCTS**

**2.01 IDENTIFICATION APPLICATIONS**

- A. Piping: Tags.

**2.02 NAMEPLATES**

- A. Description: Laminated three-layer plastic with engraved letters.

**2.03 TAGS**

**2.04 PIPE MARKERS**

- A. Comply with ASME A13.1.
- B. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- C. Color code as follows:
  - 1. Potable, Cooling, Boiler, Feed, Other Water: Green with white letters.

**PART 3 EXECUTION**

**3.01 PREPARATION**

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

**3.02 INSTALLATION**

- A. Install plastic pipe markers in accordance with manufacturer's instructions.
- B. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

**END OF SECTION**

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**SECTION 220719  
PLUMBING PIPING INSULATION**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Piping insulation.

**1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.

**1.03 REFERENCE STANDARDS**

- A. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- B. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.

**1.05 QUALITY ASSURANCE**

**PART 2 PRODUCTS**

**2.01 REGULATORY REQUIREMENTS**

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

**2.02 GLASS FIBER**

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

**3.02 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Glass fiber insulated pipes conveying fluids below ambient temperature:
  - 1. Provide vapor barrier jackets, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
  - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
- C. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- D. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.

**3.03 SCHEDULES**

- A. Plumbing Systems:
  - 1. Domestic Hot Water Supply:
    - a. Glass Fiber Insulation:
  - 2. Domestic Hot Water Recirculation:
    - a. Glass Fiber Insulation:
      - 1) Pipe Size Range: All sizes.
      - 2) Thickness: 1 inch.

**END OF SECTION**

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**SECTION 221006  
PLUMBING PIPING SPECIALTIES**

**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

**1.02 SECTION INCLUDES**

- A. Roof Drains.
- B. Cleanouts.
- C. Floor Drains
- D. Water hammer arrestors.
- E. Hose Bibbs
- F. Escutcheons
- G. Floor Plates

**1.03 RELATED REQUIREMENTS**

- A. Section 221005 - Plumbing Piping.
- B. Section 223000 - Plumbing Equipment.
- C. Section 224000 - Plumbing Fixtures.

**1.04 REFERENCE STANDARDS**

- A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design 2010.
- B. ASME A112.6.3 - Floor and Trench Drains 2019.
- C. ASME A112.6.4 - Roof, Deck, and Balcony Drains 2008 (Reaffirmed 2012).
- D. ASSE 1011 - Performance Requirements for Hose Connection Vacuum Breakers 2017.
- E. ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers 2011.
- F. ASSE 1019 - Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance 2011 (Reaffirmed 2016).
- G. NSF 61 - Drinking Water System Components - Health Effects 2020.
- H. NSF 372 - Drinking Water System Components - Lead Content 2020.
- I. PDI-WH 201 - Water Hammer Arresters 2017.

**1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- C. Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.
- D. Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.
- E. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- F. Project Record Documents: Record actual locations of equipment, cleanouts, backflow preventers, water hammer arrestors.

**1.06 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years documented experience.

**1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Accept specialties on site in original factory packaging. Inspect for damage.

## PART 2 PRODUCTS

### 2.01 GENERAL REQUIREMENTS

- A. Specialties in Potable Water Supply Systems: Provide products that comply with NSF 61 and NSF 372 for maximum lead content.

### 2.02 ESCUTCHEONS

- A. One-piece, Cast-brass Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-piece, Deep-Pattern Type: Deep-drawn, box-shaped with chrome-plated finish and spring-clip fasteners.
- C. One-piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- D. Split-Casting Brass Type: With polished, chrome-plated finish and with the concealed hinge and setscrew.

### 2.03 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
- B. Split-Casting Floor Plates: Castbrass with concealed hinge.

### 2.04 DRAINS

#### 2.05 FLOOR DRAINS (FD-1)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers product offering that may be incorporated into the work include, but are not limited to, the following:
  - 1. Zurn Industries Equal to **Z415-4NH-6B**
  - 2. Josam Company: Josam Div. Equal to 30000-A
  - 3. Jay R. Smith Manufacturing Company: [www.jrsmith.com/#sle](http://www.jrsmith.com/#sle).
  - 4. MIFAB, Inc: [www.mifab.com/#sle](http://www.mifab.com/#sle).
  - 5. Watts Equal to FD-100-A
  - 6. Substitutions: See Section 016000 - Product Requirements.
- B. ASME A112.6.3; lacquered cast iron or stainless steel, two piece body with double drainage flange, weep holes, reversible clamping collar, and round, adjustable nickel-bronze strainer.

#### 2.06 CLEANOUTS (FCO & WCO)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers product offering that maybe incorporated into the work include, but are not limited to, the following:
- B. Cleanouts at Interior Finished Floor Areas (**FCO**):
  - 1. Lacquered cast iron body with anchor flange, reversible clamping collar, threaded top assembly, and round gasketed scored cover in service areas and round gasketed depressed cover to accept floor finish in finished floor areas.
- C. Cleanouts at Interior Finished Wall Areas (**WCO**):
  - 1. Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless steel access cover secured with machine screw.
- D. Cleanouts at Interior Unfinished Accessible Areas (**CO**): Calked or threaded type. Provide bolted stack cleanouts on vertical rainwater leaders.

#### 2.07 HOSE BIBBS (HB)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers product offering that maybe incorporated into the work include, but are not limited to, the following:
  - 1. Jay R. Smith Manufacturing Company: [www.jayrsmith.com/#sle](http://www.jayrsmith.com/#sle).
  - 2. Watts Regulator Company, a part of Watts Water Technologies;[\_\_\_\_]: [www.wattsregulator.com/#sle](http://www.wattsregulator.com/#sle). **Equal to #HY-725**
  - 3. Zurn Industries, LLC: [www.zurn.com/#sle](http://www.zurn.com/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Wall Hydrants:
  - 1. ASSE 1019; freeze resistant, self-draining type with chrome plated wall plate hose thread spout, handwheel, and integral vacuum breaker.

**2.08 WATER HAMMER ARRESTORS (WHA)**

- A. Manufacturers: Subject to compliance with requirements, available manufacturers product offering that maybe incorporated into the work include, but are not limited to, the following:
  - 1. Jay R. Smith Manufacturing Company: [www.jayrsmith.com/#sle](http://www.jayrsmith.com/#sle).
  - 2. Watts Regulator Company, a part of Watts Water Technologies: [www.wattsregulator.com/#sle](http://www.wattsregulator.com/#sle). **Equal to LF15M2-DR**
  - 3. Zurn Industries, LLC: [www.zurn.com/#sle](http://www.zurn.com/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Water Hammer Arrestors:
  - 1. Stainless steel construction, piston type sized in accordance with PDI-WH 201, precharged suitable for operation in temperature range minus 100 to 300 degrees F and maximum 250 psi working pressure.

**2.09 2.03 MISCELLANEOUS STORM DRAIANGE PIPING SPECIALTIES**

- A. TROUGH-PENETRATION FIRE STOP ASSEMBLIES

**PART 3 EXECUTION****3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Install escutcheons for piping penetration of walls, ceilings, and finished floors.
- C. Install escutcheons with ID to closely fit around the pipe, tube, and insulation and with OD that completely covers the opening.
  - 1. Escutcheons for New Piping:
    - a. Piping with Fittings or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    - b. Chrome-Plating Piping: One-piece, cast-brass type with poloshed, chrome-plated finish.
    - c. Insulated Piping: One-piece, stamped-steel type.
    - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
    - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
    - f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass, cast-brass type with polished, chrome-plated finish.
    - g. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.
  - 2. Escutheons for Existing Pipe:
    - a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
    - b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge.
    - c. Bare Piping at Wall or Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
    - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished chrome-plate finish.
    - e. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.
    - f. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated finish.
- D. Install floor plates for piping penetrations of equipment-room floors.
- E. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping with OD that completely covers opening.
  - 1. New Piping: One-piece, floor plate type.
  - 2. Existing Piping: Split-casting, floor-plate type.
- F. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.

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- G. Encase exterior cleanouts in concrete flush with grade.
- H. Install floor cleanouts at elevation to accommodate finished floor.
- I. Install water hammer arrestors complete with accessible isolation valve on hot and cold water supply piping to lavatory sinks or Sinks.

**END OF SECTION**

**SECTION 221116  
DOMESTIC WATER PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

**1.02 RELATED REQUIREMENTS**

- A. Section 011000 - Summary: Contract descriptions, description of alterations work, work by others, future work, occupancy conditions, use of site and premises, work sequence.
- B. Section 013000 - Administrative Requirements: Submittal procedures, project meetings, progress schedules and documentation, reports, coordination.
- C. Section 016000 - Product Requirements: Fundamental product requirements, substitutions and product options, delivery, storage, and handling.
- D. Section 017419 - Construction Waste Management and Disposal.
- E. Section 017800 - Closeout Submittals: Project record documents, operation and maintenance (O&M) data, warranties and bonds.
- F. Section 017900 - Demonstration and Training: Detailed requirements.

**1.03 REFERENCE STANDARDS**

- A. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.

**1.04 ADMINISTRATIVE REQUIREMENTS**

**1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide [\_\_\_\_\_].
- C. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project:
  - 1. See Section 016000 - Product Requirements for additional provisions.

**1.06 QUALITY ASSURANCE**

**1.07 WARRANTY**

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Correct defective Work within a five year period after Date of Substantial Completion.

**PART 2 PRODUCTS**

**PART 3 EXECUTION**

**3.01 INSTALLERS**

- A. Substitution Limitations: Same as specified for products; see Section 016000 - Product Requirements.

**3.02 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.

**3.03 CLEANING**

- A. See Section 017419 - Construction Waste Management and Disposal for additional requirements.

**3.04 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals for closeout submittals.
- B. See Section 017900 - Demonstration and Training for additional requirements.

**3.05 PROTECTION**

**3.06 MAINTENANCE**

**END OF SECTION**

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**SECTION 221316  
SANITARY WASTE AND VENT PIPING**

**PART 1 GENERAL**

**1.01 RELATED REQUIREMENTS**

- A. Section 011000 - Summary: Contract descriptions, description of alterations work, work by others, future work, occupancy conditions, use of site and premises, work sequence.
- B. Section 013000 - Administrative Requirements: Submittal procedures, project meetings, progress schedules and documentation, reports, coordination.
- C. Section 014000 - Quality Requirements: Procedures for testing, inspection, mock-ups, reports, certificates; use of reference standards.
- D. Section 017000 - Execution and Closeout Requirements: Examination, preparation, and general installation procedures; preinstallation meetings; cutting and patching; cleaning and protection; starting of systems; demonstration and instruction; closeout procedures except payment procedures; requirements for alterations work.
- E. Section 017419 - Construction Waste Management and Disposal.
- F. Section 017800 - Closeout Submittals: Project record documents, operation and maintenance (O&M) data, warranties and bonds.

**1.02 REFERENCE STANDARDS**

- A. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.

**1.03 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide [\_\_\_\_].
- C. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

**1.04 QUALITY ASSURANCE**

**1.05 WARRANTY**

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Correct defective Work within a five year period after Date of Substantial Completion.

**PART 2 PRODUCTS**

**PART 3 EXECUTION**

**3.01 INSTALLERS**

- A. Substitution Limitations: Same as specified for products; see Section 016000 - Product Requirements.

**3.02 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.

**3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements for additional requirements.

**3.04 CLEANING**

- A. See Section 017419 - Construction Waste Management and Disposal for additional requirements.

**3.05 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals for closeout submittals.

**3.06 MAINTENANCE**

- A. See Section 017000 - Execution and Closeout Requirements for additional requirements relating to maintenance service.

**END OF SECTION**

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## SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

### 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. Cleanouts.
  - 2. Floor drains.
  - 3. Floor sinks.
  - 4. Area drains.
  - 5. Air-admittance valves.
  - 6. Roof flashing assemblies.
  - 7. Through-penetration firestop assemblies.
  - 8. Miscellaneous sanitary drainage piping specialties.
  - 9. Flashing materials.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

#### 1.4 CLOSEOUT SUBMITTALS

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

#### 1.5 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

#### 1.6 COORDINATION

- A. Coordinate size and location of roof penetrations.

### PART 2 - PRODUCTS

#### 2.1 CLEANOUTS

- A. Exposed Metal Cleanouts CO:
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Josam Company; Josam Div.
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  - 2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.

3. Size: Same as connected drainage piping
  4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
  5. Closure: Countersunk or raised-head, brass plug.
  6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
  7. Closure: Stainless-steel plug with seal.
- B. Metal Floor Cleanouts FCO:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Josam Company; Josam Div.
    - b. Sioux Chief Manufacturing Company, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule threaded, adjustable housing cleanout.
  3. Size: Same as connected branch.
  4. Type: Threaded, adjustable housing.
  5. Body or Ferrule: Cast iron.
  6. Clamping Device: Required.
  7. Outlet Connection: Spigot.
  8. Closure: Brass plug with straight threads and gasket.
  9. Adjustable Housing Material: Cast iron with set-screws or other device.
  10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
  11. Frame and Cover Shape: Round.
  12. Top Loading Classification: Medium Duty.
  13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
  14. Standard: ASME A112.3.1.
  15. Size: Same as connected branch.
- C. Cast-Iron Wall Cleanouts WCO:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Josam Company; Josam Div.
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; d of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  2. Standard: ASME A112.36.2M. Include wall access.
  3. Size: Same as connected drainage piping.
  4. Body: Hub-and-spigot, cast-iron soil pipe T-branch or Hubless, cast-iron soil pipe test tee as required to match connected piping.
  5. Closure: Countersunk, brass plug.
  6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
  7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.

## 2.2 FLOOR DRAINS

- A. Cast-Iron Floor Drains FD-1, general area drain, shower floor, etc.:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Josam Company; Josam Div. Equal to 30000-A
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  2. Standard: ASME A112.6.3.
  3. Pattern: Area Floor drain.
  4. Body Material: Gray iron.
  5. Seepage Flange: Not required.
  6. Clamping Device: Required.
  7. Outlet: Bottom.
  8. Sediment Bucket: Not required.
  9. Top or Strainer Material: Nickel bronze.
  10. Top of Body and Strainer Finish: Nickel bronze.
  11. Top Shape: Round.
  12. Dimensions of Top or Strainer: 8"
  13. Top Loading Classification: Medium Duty.
  14. Funnel: Not required, except if accepting indirect waste discharge (i.e Ice machine) then add funnel.
  15. Trap Material: Cast iron.
  16. Trap Pattern: Deep-seal P-trap.
  17. Trap Features: Trap-seal primer valve drain connection.
- B. Cast-Iron Floor Drains FD-2, mechanical areas:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Josam Company; Josam Div. Equal to 32300-81-1
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  2. Standard: ASME A112.6.3.
  3. Pattern: Mechanical Area Floor drain.
  4. Body Material: Gray iron.
  5. Seepage Flange: Not required.
  6. Clamping Device: Required.
  7. Outlet: Bottom.
  8. Sediment Bucket: Required.
  9. Top or Strainer Material: Nickel bronze.
  10. Top of Body and Strainer Finish: Nickel bronze.
  11. Top Shape: Round.
  12. Dimensions of Top or Strainer: 12" Super-Flo
  13. Top Loading Classification: Medium Duty.
  14. Funnel: Not required, except if accepting indirect waste discharge (i.e Ice machine).
  15. Trap Material: Cast iron.
  16. Trap Pattern: Deep-seal P-trap.
  17. Trap Features: Trap-seal primer valve drain connection.

## 2.3 FLOOR SINKS

- A. Cast-Iron Floor Sinks, Epoxy Coated FS-1, For indirect waste disposal.:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Josam Company; Josam Div. Equal to 49320A-NB-4-33-43
- b. MIFAB, Inc.
- c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
- d. Tyler Pipe; Wade Div.
- e. Watts Drainage Products Inc.
- f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3.
3. Body Material: Gray iron with acid resistant interior and components.
4. Seepage Flange: Not required. (unless it is not slab on grade)
5. Clamping Device: Required.
6. Outlet: Bottom.
7. Sediment Bucket: Required.
8. Top or Strainer Material: Nickel bronze with  $\frac{3}{4}$  grate. Mount flush to floor.
9. Top of Body and Strainer Finish: Nickel bronze.
10. Top Shape: Square.
11. Dimensions of Top or Strainer: 12"
12. Top Loading Classification: Medium Duty.
13. Funnel: Not required.
14. Trap Material: Cast iron.
15. Trap Pattern: Deep-seal P-trap.

## 2.4 AREA DRAINS

- A. Cast-Iron Area Drains AD-1, Exterior Area Drain for Decontamination use.:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Josam Company; Josam Div. Equal to 23500-50
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  2. Standard: ASME A112.6.3.
  3. Body Material: Gray iron.
  4. Seepage Flange: Not required.
  5. Clamping Device: Not required
  6. Outlet: Bottom.
  7. Sediment Bucket: Required.
  8. Top or Strainer Material: Nickel bronze. Provide one top slotted for use during Decontamination events, and one top solid/water tight to seal drain when not in use.
  9. Top of Body and Strainer Finish: Nickel bronze.
  10. Top Shape: Round.
  11. Dimensions of Top or Strainer: 8"
  12. Top Loading Classification: Medium Duty.
  13. Funnel: Not required, except if accepting indirect waste discharge (i.e Ice machine) then add funnel.
  14. Trap Material: Cast iron.
  15. Trap Pattern: Deep-seal P-trap.
  16. Trap Features: Trap-seal primer valve drain connection.

## 2.5 AIR-ADMITTANCE VALVES

- A. Fixture Air-Admittance Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Oatey.
- b. ProSet Systems Inc.
- c. RectorSeal.
- d. Studor, Inc.
2. Standard: ASSE 1051, Type A for single fixture or Type B for branch piping.
3. Housing: Plastic.
4. Operation: Mechanical sealing diaphragm.
5. Size: Same as connected fixture or branch vent piping.

## 2.6 ROOF FLASHING ASSEMBLIES

- A. Roof Flashing Assemblies:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Acorn Engineering Company; Elmdor/Stoneman Div.
    - b. Thaler Metal Industries Ltd.
- B. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch- thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
1. Open-Top Vent Cap: Without cap.
  2. Low-Silhouette Vent Cap: With vandal-proof vent cap.
  3. Extended Vent Cap: With field-installed, vandal-proof vent cap.

## 2.7 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

- A. Through-Penetration Firestop Assemblies:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. ProSet Systems Inc.
  2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
  3. Size: Same as connected soil, waste, or vent stack.
  4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
  5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
  6. Special Coating: Corrosion resistant on interior of fittings.

## 2.8 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

- A. Deep-Seal Traps:
1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
  2. Size: Same as connected waste piping.
    - a. NPS 2: 4-inch- minimum water seal.
    - b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.
- B. Floor-Drain, Trap-Seal Primer Fittings:
1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
  2. Size: Same as floor drain outlet with NPS 1/2 side inlet.
- C. Air-Gap Fittings:
1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
  2. Body: Bronze or cast iron.

3. Inlet: Opening in top of body.
  4. Outlet: Larger than inlet.
  5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.
- D. Sleeve Flashing Device:
1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
  2. Size: As required for close fit to riser or stack piping.
- E. Stack Flashing Fittings:
1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
  2. Size: Same as connected stack vent or vent stack.
- F. Vent Caps:
1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
  2. Size: Same as connected stack vent or vent stack.
- G. Frost-Resistant Vent Terminals:
1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.
  2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.
- H. Expansion Joints:
1. Standard: ASME A112.21.2M.
  2. Body: Cast iron with bronze sleeve, packing, and gland.
  3. End Connections: Matching connected piping.
  4. Size: Same as connected soil, waste, or vent piping.

## **2.9 FLASHING MATERIALS**

- A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
  2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
  3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.
- B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:
1. General Applications: 12 oz./sq. ft..
  2. Vent Pipe Flashing: 8 oz./sq. ft..
- C. Fasteners: Metal compatible with material and substrate being fastened.
- D. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- E. Solder: ASTM B 32, lead-free alloy.
- F. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

## **2.10 SOLIDS INTERCEPTORS**

- A. Solids Interceptors SI-1:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:



- a. Josam Company; Josam Div.
- b. MIFAB, Inc.
- c. Rockford Sanitary Systems, Inc.
- d. Schier Products Company.
- e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
- f. Tyler Pipe; Wade Div.
- g. Watts Drainage Products Inc.
- h. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Type: Factory-fabricated interceptor made for removing and retaining sediment from wastewater.
3. Body Material: Cast iron or steel.
4. Interior Separation Device: Screens.
5. Interior Lining: Corrosion-resistant enamel.
6. Exterior Coating: Corrosion-resistant enamel.
7. Body Dimensions: 8"
8. Flow Rate: 2.5gpm.
9. Inlet and Outlet Size: 1-1/2"
10. End Connections: Threaded.
11. Mounting: Above floor, under sink.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
  1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
  2. Locate at each change in direction of piping greater than 45 degrees.
  3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
  4. Locate at base of each vertical soil and waste stack.
- B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- D. Install floor drains and floor sinks at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
  1. Position floor drains for easy access and maintenance.
  2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
    - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
    - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
    - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
  3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
  4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- E. Install fixture air-admittance valves on fixture drain piping, only where indicated on plans as acceptable.
- F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

- G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.
- H. Install deep-seal traps on floor drains and other waste outlets, if indicated.
- I. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
  - 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
  - 2. Size: Same as floor drain inlet.
- J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- K. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- L. Install vent caps on each vent pipe passing through roof.
- M. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- N. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- O. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- P. Install solids interceptors with cleanout immediately downstream from interceptors that do not have integral cleanout on outlet. Install trap on interceptors that do not have integral trap and are connected to sanitary drainage and vent systems.
- Q. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

### **3.2 CONNECTIONS**

- A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.3 FLASHING INSTALLATION**

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
  - 1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
  - 2. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
  - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
  - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
  - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.

- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 076200 "Sheet Metal Flashing and Trim."
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

### **3.4 FIELD QUALITY CONTROL**

- A. Tests and Inspections:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

### **3.5 PROTECTION**

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

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**SECTION 223000  
PLUMBING EQUIPMENT****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Water Heaters:
  - 1. Residential electric.

**1.02 REFERENCE STANDARDS**

- A. UL 174 - Standard for Household Electric Storage Tank Water Heaters Current Edition, Including All Revisions.

**1.03 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data:
  - 1. Provide dimension drawings of water heaters indicating components and connections to other equipment and piping.
  - 2. Provide electrical characteristics and connection requirements.
- C. Manufacturer's Instructions: Indicate [\_\_\_\_\_].
- D. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
- E. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

**1.04 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Certifications:
  - 1. Water Heaters: NSF approved.
  - 2. Electric Water Heaters: UL listed and labeled to UL 174.
  - 3. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.
- C. Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

**1.06 WARRANTY**

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Provide five year manufacturer warranty for domestic water heaters.

**PART 2 PRODUCTS****2.01 WATER HEATERS (WH-1)**

- A. Manufacturers:
  - 1. Eemax equal to model EMT2.5
  - 2. A.O. Smith Water Products Co: [www.hotwater.com/#sle](http://www.hotwater.com/#sle).
  - 3. Bock Water Heaters, Inc: [www.bockwaterheaters.com/#sle](http://www.bockwaterheaters.com/#sle).
  - 4. Rheem Manufacturing Company: [www.rheem.com/#sle](http://www.rheem.com/#sle).
- B. Residential Electric:
  - 1. Type: Automatic, electric, vertical storage.
  - 2. Performance:
  - 3. Electrical Characteristics:
  - 4. Mini Tank: Glass lined welded steel, thermally insulated with one inch thick glass fiber; encased in corrosion-resistant steel jacket; baked-on enamel finish.

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5. Controls: Automatic water thermostat with externally adjustable temperature range from 120 to 170 degrees F, flanged or screw-in nichrome elements, enclosed controls and electrical junction box and operating light. Wire double element units so elements do not operate simultaneously.
6. Accessories:
  - a. Water Connections: Brass.
  - b. Dip Tube: Brass.
  - c. Drain valve.
  - d. Anode: Magnesium.
  - e. Temperature and Pressure Relief Valve: ASME labeled.

**END OF SECTION**

**SECTION 224000  
PLUMBING FIXTURES****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Water closets.
- B. Urinals.
- C. Lavatories.
- D. Sinks.
- E. Showers.

**1.02 RELATED REQUIREMENTS**

- A. Section 123600 - Countertops: Preparation of counters for sinks and lavatories.
- B. Section 221005 - Plumbing Piping.

**1.03 REFERENCE STANDARDS**

- A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design 2010.
- B. ASME A112.18.1 - Plumbing Supply Fittings 2018, with Errata.
- C. ASME A112.18.9 - Protectors/Insulators for Exposed Waste and Supplies on Accessible Fixtures 2011 (Reaffirmed 2017).
- D. ASME A112.19.2 - Ceramic Plumbing Fixtures 2018.
- E. ASME A112.19.3 - Stainless Steel Plumbing Fixtures 2017.
- F. ASME A112.19.5 - Flush Valves and Spuds for Water Closets, Urinals, and Tanks 2017.
- G. NSF 61 - Drinking Water System Components - Health Effects 2020.
- H. NSF 372 - Drinking Water System Components - Lead Content 2020.

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- C. Manufacturer's Instructions: Indicate installation methods and procedures.
- D. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

**1.05 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Accept fixtures on site in factory packaging. Inspect for damage.
- B. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

**1.07 WARRANTY**

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for electric water cooler.

**PART 2 PRODUCTS****2.01 GENERAL REQUIREMENTS**

- A. Potable Water Systems: Provide plumbing fittings and faucets that comply with NSF 61 and NSF 372 for maximum lead content; label pipe and fittings.

## 2.02 FLUSH VALVE WATER CLOSETS

- A. Water Closets: Vitreous china, ASME A112.19.2, floor mounted, siphon jet flush action, china bolt caps.
  - 1. Flush Valve: Exposed (top spud).
  - 2. Flush Operation: Sensor operated.
  - 3. Handle Height: 44 inches or less.
  - 4. Supply Size: 1-1/2 inches.
  - 5. Manufacturers:
    - a. American Standard, Inc: [www.americanstandard-us.com/#sle](http://www.americanstandard-us.com/#sle).
    - b. Gerber Plumbing Fixtures LLC: [www.gerberonline.com/#sle](http://www.gerberonline.com/#sle).
    - c. Kohler Company: [www.kohler.com/#sle](http://www.kohler.com/#sle).
    - d. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
- B. Flush Valves: ASME A112.18.1, diaphragm type, complete with vacuum breaker stops and accessories.
  - 1. Sensor-Operated Type: Solenoid or motor-driven operator, battery powered, infrared sensor with mechanical over-ride or over-ride push button.
  - 2. Exposed Type: Chrome plated, escutcheon, integral screwdriver stop.
  - 3. Manufacturers:
    - a. American Standard, Inc: [www.americanstandard-us.com/#sle](http://www.americanstandard-us.com/#sle).
    - b. Sloan Valve Company: [www.sloanvalve.com/#sle](http://www.sloanvalve.com/#sle).
    - c. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
- C. Seats:
  - 1. Manufacturers:
    - a. Bemis Manufacturing Company: [www.bemismfg.com/#sle](http://www.bemismfg.com/#sle).
- D. Water Closet Carriers:
  - 1. Manufacturers:
    - a. Jay R. Smith MFG. Co: [www.jrsmith.com/#sle](http://www.jrsmith.com/#sle).
    - b. JOSAM Company: [www.josam.com/#sle](http://www.josam.com/#sle).
    - c. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).

## 2.03 WALL HUNG URINALS

- A. Wall Hung Urinal Manufacturers:
  - 1. American Standard, Inc: [www.americanstandard-us.com/#sle](http://www.americanstandard-us.com/#sle).
  - 2. Kohler Company: [www.kohler.com/#sle](http://www.kohler.com/#sle).
  - 3. Zurn Industries, Inc; EcoVantage Z5798 High-Efficiency Urinal System: [www.zurn.com/#sle](http://www.zurn.com/#sle).
- B. Urinals: Vitreous china, ASME A112.19.2, wall hung with side shields and concealed carrier.
  - 1. Flush Volume: 1.0 gallons, maximum.
  - 2. Flush Valve: Exposed (top spud).
  - 3. Flush Operation: Sensor operated.
  - 4. Trap: Integral.
- C. Flush Valves: ASME A112.18.1, diaphragm type, complete with vacuum breaker stops and accessories.
  - 1. Sensor-Operated Type: Solenoid or motor-driven operator, battery powered, infrared sensor with mechanical over-ride or over-ride push button.
  - 2. Exposed Type: Chrome plated, escutcheon, integral screwdriver stop.
  - 3. Manufacturers:
    - a. Sloan Valve Company: [www.sloanvalve.com/#sle](http://www.sloanvalve.com/#sle).
    - b. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
- D. Carriers:
  - 1. Manufacturers:
    - a. Jay R. Smith MFG. Co: [www.jrsmith.com/#sle](http://www.jrsmith.com/#sle).
    - b. JOSAM Company: [www.josam.com/#sle](http://www.josam.com/#sle).
    - c. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).



**2.04 LAVATORIES**

- A. Lavatory Manufacturers:
  - 1. American Standard, Inc: [www.americanstandard-us.com/#sle](http://www.americanstandard-us.com/#sle).
  - 2. Kohler Company: [www.kohler.com/#sle](http://www.kohler.com/#sle).
  - 3. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
- B. Vitreous China Wall Hung Basin: ASME A112.19.2; vitreous china wall hung lavatory, with 4 inch high back, rectangular basin with splash lip, front overflow, and soap depression.
  - 1. Drilling Centers: 4 inch.

**2.05 SINKS**

- A. Sink Manufacturers:
  - 1. American Standard, Inc: [www.americanstandard-us.com/#sle](http://www.americanstandard-us.com/#sle).
  - 2. Kohler Company: [www.kohler.com/#sle](http://www.kohler.com/#sle).
- B. Single Compartment Bowl: outside dimensions 20 gauge, 0.0359 inch thick, Type 302 stainless steel, self rimming and undercoated, with ledge back drilled for trim.
  - 1. Drain: 1-1/2 inch chromed brass drain.

**PART 3 EXECUTION****3.01 EXAMINATION**

- A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- B. Verify that electric power is available and of the correct characteristics.
- C. Confirm that millwork is constructed with adequate provision for the installation of counter top lavatories and sinks.

**3.02 PREPARATION**

- A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

**3.03 INSTALLATION**

- A. Install each fixture with trap, easily removable for servicing and cleaning.
- B. Provide chrome plated rigid or flexible supplies to fixtures with loose key stops, reducers, and escutcheons.
- C. Install components level and plumb.
- D. Install and secure fixtures in place with wall supports and bolts.
- E. Solidly attach water closets to floor with lag screws. Lead flashing is not intended hold fixture in place.

**3.04 ADJUSTING**

- A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

**3.05 CLEANING**

- A. Clean plumbing fixtures and equipment.
- B. See Section 017419 - Construction Waste Management and Disposal, for additional requirements.

**3.06 PROTECTION**

- A. Protect installed products from damage due to subsequent construction operations.
- B. Repair or replace damaged products before Date of Substantial Completion.

**3.07 SCHEDULES**

- A. Fixture Heights: Install fixtures to heights above finished floor as indicated.
  - 1. Water Closet:
    - a. Standard: 15 inches to top of bowl rim.
    - b. Accessible: 18 inches to top of seat.
  - 2. Water Closet Flush Valves:

- a. Standard: 11 inches min. above bowl rim.
- 3. Urinal:
  - a. Standard: 22 inches to top of bowl rim.
  - b. Accessible: 17 inches to top of bowl rim.
- 4. Lavatory:
  - a. Standard: 31 inches to top of basin rim.
  - b. Accessible: 34 inches to top of basin rim.
- B. Fixture Rough-In
  - 1. Water Closet (Flush Valve Type):
    - a. Cold Water: 1 Inch.
    - b. Waste: 4 Inch.
    - c. Vent: 2 Inch.
  - 2. Water Closet (Tank Type):
    - a. Cold Water: 1/2 Inch.
    - b. Waste: 4 Inch.
    - c. Vent: 2 Inch.
  - 3. Urinal (Flush Valve Type):
    - a. Cold Water: 3/4 Inch.
    - b. Waste: 2 Inch.
    - c. Vent: 1-1/2 Inch.
  - 4. Lavatory:
    - a. Hot Water: 1/2 Inch.
    - b. Cold Water: 1/2 Inch.
    - c. Waste: 1-1/2 Inch.
    - d. Vent: 1-1/4 Inch.
  - 5. Sink:
    - a. Hot Water: 1/2 Inch.
    - b. Cold Water: 1/2 Inch.
    - c. Waste: 1-1/2 Inch.
    - d. Vent: 1-1/4 Inch.

**END OF SECTION**

SECTION 224213 - COMMERCIAL WATER CLOSETS & URINALS

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. Water closets.
  2. Urinals.
  3. Flushometer valves.
  4. Toilet seats.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
  2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

PART 2 - PRODUCTS

**2.1 FLOOR-MOUNTED, BOTTOM-OUTLET WATER CLOSETS**

- A. Water Closets WC-1: Standard height, Floor mounted, bottom outlet, top spud.
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. American Standard America. Equal to Madera 3451.001
    - b. Gerber Plumbing Fixtures LLC.
    - c. Kohler Co.
    - d. Mansfield Plumbing Products LLC.
    - e. TOTO USA, INC.
    - f. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Bowl:
    - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
    - b. Material: Vitreous china.
    - c. Type: Siphon jet.
    - d. Style: Flushometer valve.
    - e. Height: Standard.
    - f. Rim Contour: Elongated.
    - g. Water Consumption: Range 1.1- 1.6 gal. per flush.
    - h. Spud Size and Location: NPS 1-1/2; top.
    - i. Color: White.
  3. Bowl-to-Drain Connecting Fitting: ASTM A 1045 or ASME A112.4.3.
  4. Flushometer Valve: FV-1.
  5. Toilet Seat: Open front - required.

- B. Water Closets WC-2: Accessible height Floor mounted, bottom outlet, top spud.
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. American Standard America. Equal to Madera Right Height 3461.001
    - b. Gerber Plumbing Fixtures LLC.
    - c. Kohler Co.
    - d. Mansfield Plumbing Products LLC.
    - e. TOTO USA, INC.
    - f. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Bowl:
    - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
    - b. Material: Vitreous china.
    - c. Type: Siphon jet.
    - d. Style: Flushometer valve.
    - e. Height: Accessible/"Right height".
    - f. Rim Contour: Elongated.
    - g. Water Consumption: Range 1.1- 1.6 gal. per flush.
    - h. Spud Size and Location: NPS 1-1/2; top.
    - i. Color: White.
  3. Bowl-to-Drain Connecting Fitting: ASTM A 1045 or ASME A112.4.3.
  4. Flushometer Valve: FV-1.
  5. Toilet Seat: Open front - required.

## 2.2 WALL-HUNG URINALS

- A. Urinals UR-1: Wall hung, back outlet, washout, accessible.
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. American Standard America. Equal to WashBrook 6501.010
    - b. Gerber Plumbing Fixtures LLC.
    - c. Kohler Co.
    - d. Mansfield Plumbing Products LLC.
    - e. TOTO USA, INC.
    - f. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Fixture:
    - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
    - b. Material: Vitreous china.
    - c. Type: Washout with extended shields.
    - d. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
    - e. Water Consumption: Water saving 0.5 gpf.
    - f. Spud Size and Location: NPS 3/4, top.
    - g. Outlet Size and Location: NPS 2, back.
    - h. Color: White.
  3. Flushometer Valve: FV-2.
  4. Waste Fitting:
    - a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
    - b. Size: NPS 2.
  5. Support: ASME A112.6.1M, Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.

## 2.3 FLUSHOMETER VALVES

- A. Lever-Handle, Diaphragm Flushometer Valves FV-1:

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. Sloan Valve Company. Equal to 111-1.28
    - b. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Standard: ASSE 1037.
  3. Minimum Pressure Rating: 125 psig.
  4. Features: Include integral check stop and backflow-prevention device.
  5. Material: Brass body with corrosion-resistant components.
  6. Exposed Flushometer-Valve Finish: Chrome plated.
  7. Panel Finish: Chrome plated or stainless steel.
  8. Style: Exposed.
  9. Consumption: 1.28 gal. per flush.
  10. Minimum Inlet: NPS 1.
  11. Minimum Outlet: NPS 1-1/4.
- B. Lever-Handle, Diaphragm Flushometer Valves FV-2:
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. Sloan Valve Company. Equal to 186
    - b. Coyne & Delany Co.
    - c. Gerber Plumbing Fixtures LLC.
    - d. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Standard: ASSE 1037.
  3. Minimum Pressure Rating: 125 psig.
  4. Features: Include integral check stop and backflow-prevention device.
  5. Material: Brass body with corrosion-resistant components.
  6. Exposed Flushometer-Valve Finish: Chrome plated.
  7. Panel Finish: Chrome plated or stainless steel.
  8. Style: Exposed.
  9. Consumption: 0.5 gal. per flush.
  10. Minimum Inlet: NPS 3/4.
  11. Minimum Outlet: NPS 3/4.

## 2.4 TOILET SEATS

- A. Toilet Seats:
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. American Standard America.
    - b. Bemis Manufacturing Company.
    - c. Church Seats.
    - d. Olsonite Seat Co.
    - e. TOTO USA, INC.
    - f. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Standard: IAPMO/ANSI Z124.5.
  3. Material: Plastic.
  4. Type: Commercial (Heavy duty).
  5. Shape: Elongated rim, open front.
  6. Hinge: Self-sustaining.
  7. Hinge Material: Noncorroding metal.
  8. Seat Cover: Not required.
  9. Color: White.

**PART 3 - EXECUTION**

**3.1 EXAMINATION**

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.
- B. Examine walls and floors for suitable conditions where water closets will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

**3.2 INSTALLATION**

- A. Water-Closet Installation:
  - 1. Install level and plumb according to roughing-in drawings.
  - 2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
  - 3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.
- B. Urinal Installation:
  - 1. Install urinals level and plumb according to roughing-in drawings.
  - 2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
  - 3. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.
- C. Support Installation:
  - 1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
  - 2. Use carrier supports with waste-fitting assembly and seal.
  - 3. Install floor-mounted, back-outlet water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
- D. Flushometer-Valve Installation:
  - 1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
  - 2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
  - 3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
  - 4. Install actuators in locations that are easy for people with disabilities to reach.
- E. Install toilet seats on water closets.
- F. Wall Flange and Escutcheon Installation:
  - 1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
  - 2. Install deep-pattern escutcheons if required to conceal protruding fittings.
  - 3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- G. Joint Sealing:
  - 1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
  - 2. Match sealant color to water-closet color.
  - 3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

**3.3 CONNECTIONS**

- A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to water closets, allow space for service and maintenance.

**3.4 ADJUSTING**

- A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.

**3.5 CLEANING AND PROTECTION**

- A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed water closets and fittings.
- C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213

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## SECTION 224213.16 - COMMERCIAL URINALS

### 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. Urinals.
  2. Flushometer valves.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for urinals.
  2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 WALL-HUNG URINALS

- A. Urinals UR-1: Wall hung, back outlet, washout, accessible.
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. American Standard America. Equal to WashBrook 6501.010
    - b. Gerber Plumbing Fixtures LLC.
    - c. Kohler Co.
    - d. Mansfield Plumbing Products LLC.
    - e. TOTO USA, INC.
    - f. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Fixture:
    - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
    - b. Material: Vitreous china.
    - c. Type: Washout with extended shields.
    - d. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
    - e. Water Consumption: Water saving 0.5 gpf.
    - f. Spud Size and Location: NPS 3/4, top.
    - g. Outlet Size and Location: NPS 2, back.
    - h. Color: White.
  3. Flushometer Valve: FV-2.
  4. Waste Fitting:
    - a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
    - b. Size: NPS 2.

5. Support: ASME A112.6.1M, Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.

## 2.2 URINAL FLUSHOMETER VALVES

- A. Lever-Handle, Diaphragm Flushometer Valves FV-2:
  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. Sloan Valve Company. Equal to 186
    - b. Coyne & Delany Co.
    - c. Gerber Plumbing Fixtures LLC.
    - d. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Standard: ASSE 1037.
  3. Minimum Pressure Rating: 125 psig.
  4. Features: Include integral check stop and backflow-prevention device.
  5. Material: Brass body with corrosion-resistant components.
  6. Exposed Flushometer-Valve Finish: Chrome plated.
  7. Panel Finish: Chrome plated or stainless steel.
  8. Style: Exposed.
  9. Consumption: 0.5 gal. per flush.
  10. Minimum Inlet: NPS 3/4.
  11. Minimum Outlet: NPS 3/4.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before urinal installation.
- B. Examine walls and floors for suitable conditions where urinals will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Urinal Installation:
  1. Install urinals level and plumb according to roughing-in drawings.
  2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
  3. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.
- B. Support Installation:
  1. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.
- C. Flushometer-Valve Installation:
  1. Install flushometer-valve water-supply fitting on each supply to each urinal.
  2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
  3. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
- D. Wall Flange and Escutcheon Installation:
  1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
  2. Install deep-pattern escutcheons if required to conceal protruding fittings.
  3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

- E. Joint Sealing:
  - 1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
  - 2. Match sealant color to urinal color.
  - 3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

### **3.3 CONNECTIONS**

- A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to urinals, allow space for service and maintenance.

### **3.4 ADJUSTING**

- A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.

### **3.5 CLEANING AND PROTECTION**

- A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed urinals and fittings.
- C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.16

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## SECTION 224216.14 - COMMERCIAL LAVATORIES

### 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. Lavatories.
  2. Faucets.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
  2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS FOR LAVATORIES

- A. Potable-water piping and components shall comply with NSF 61.
- B. Per new Federal Lead Free Law, any product designed for dispensing potable water meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

#### 2.2 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

- A. Lavatory LAV-1: Accessible height, Vitreous china, wall mounted, with back – for toilet rooms
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. American Standard America. Equal to Lucerne 0355.012
    - b. Gerber Plumbing Fixtures LLC.
    - c. Kohler Co.
    - d. Mansfield Plumbing Products LLC.
    - e. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Fixture:
    - a. Standard: ASME A112.19.2/CSA B45.1.
    - b. Type: For wall hanging.
    - c. Nominal Size: Rectangle, 20 by 18 inches.
    - d. Faucet-Hole Punching: Three holes.
    - e. Faucet-Hole Location: Top.
    - f. Color: White.
    - g. Mounting Material: Chair carrier.
  3. Faucet: LF-1.
  4. Support: ASME A112.6.1M, Type II, concealed-arm lavatory carrier with escutcheons.

5. Protective Insulation Shielding Guards, Per ADA requirements: Required
- B. Lavatory LAV-2: Accessible height, Vitreous china, wall mounted, with back for Hospital/medical area hand wash.
  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. American Standard America. Equal to Lucerne 0355.012
    - b. Gerber Plumbing Fixtures LLC.
    - c. Kohler Co.
    - d. Mansfield Plumbing Products LLC.
    - e. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Fixture:
    - a. Standard: ASME A112.19.2/CSA B45.1.
    - b. Type: For wall hanging.
    - c. Nominal Size: Rectangle, 20 by 18 inches.
    - d. Faucet-Hole Punching: Three holes.
    - e. Faucet-Hole Location: Top.
    - f. Color: White.
    - g. Mounting Material: Chair carrier.
  3. Faucet: LF-2.
  4. Support: ASME A112.6.1M, Type II, concealed-arm lavatory carrier with escutcheons.
  5. Protective Insulation Shielding Guards, Per ADA requirements: Required

### 2.3 SOLID-BRASS, MANUALLY OPERATED FAUCETS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.
- B. Per new Federal Lead Free Law, any product designed for dispensing potable water meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
- C. Lavatory Faucets LF-1 (for LAV-1): Manual-type, single-control mixing, commercial, solid-brass valve.
  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. Chicago Faucets. Equal to 420-CP
    - b. American Standard America.
    - c. Speakman Company.
    - d. T & S Brass and Bronze Works, Inc.
    - e. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Standard: ASME A112.18.1/CSA B125.1.
  3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
  4. Body Type: Two holes.
  5. Body Material: Commercial, solid brass.
  6. Finish: Polished chrome plate.
  7. Maximum Flow Rate: 1.5 gpm non-aerating laminar flow outlet
  8. Mounting Type: Deck, exposed.
  9. Valve Handle(s): Single lever.
  10. Spout: Rigid type.
  11. Spout Outlet: Laminar flow.
  12. Operation: Manual.
- D. Lavatory Faucets LF-2 (for LAV-2-Health Care Facilities): Manual-type, two-handle mixing, commercial, solid-brass valve, no aerator.

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. Chicago Faucets. Equal to 895-317GN2FCAB
  - b. American Standard America.
  - c. Speakman Company.
  - d. T & S Brass and Bronze Works, Inc.
  - e. Zurn Industries, LLC; Commercial Brass and Fixtures.
2. Standard: ASME A112.18.1/CSA B125.1.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
4. Body Type: Centerset.
5. Body Material: Commercial, solid brass.
6. Finish: Polished chrome plate.
7. Maximum Flow Rate: 0.5 gpm, Chicago 50-046KJKNF Laminar Flow Control Device in base of faucet (not at spout)
8. Mounting Type: Deck, exposed.
9. Valve Handle(s): Wrist blade, 4 inches.
10. Spout: Rigid/Swing, gooseneck type.
11. Spout Outlet: Plain end (no aerator)
12. Operation: Manual.

#### 2.4 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout-outlet materials that will be in contact with potable water.
- B. Per new Federal Lead Free Law, any product designed for dispensing potable water meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
- C. 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. AM Conservation Group, Inc.
  2. Chronomite Laboratories, Inc.; a division of Acorn Engineering Company.
  3. NEOPERL, Inc.
- D. Description: Chrome-plated-brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

#### 2.5 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.
- B. Per new Federal Lead Free Law, any product designed for dispensing potable water meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
- C. Standard: ASME A112.18.1/CSA B125.1.
- D. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.
- E. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- F. Operation: Loose key.
- G. Risers:
  1. NPS 1/2.

2. Chrome-plated, rigid-copper-pipe and brass straight or offset tailpieces or ASME A112.18.6, braided- or corrugated-stainless-steel, flexible hose riser.

## **2.6 WASTE FITTINGS**

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.
- C. Trap:
  1. Size: NPS 1-1/2 by NPS 1-1/4.
  2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.
- B. Examine counters and walls for suitable conditions where lavatories will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install lavatories level and plumb according to roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-mounted lavatories.
- C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.
- D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

### **3.3 CONNECTIONS**

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

### **3.4 ADJUSTING**

- A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.



**3.5 CLEANING AND PROTECTION**

- A. After completing installation of lavatories, inspect and repair damaged finishes.
- B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed lavatories and fittings.
- D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.14

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## SECTION 224216.15 - COMMERCIAL SINKS

### 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. Service Basins/Mop Receptor.
  2. Handwash sinks.
  3. Sink faucets.
  4. Laminar-flow, faucet-spout outlets.
  5. Supply fittings.
  6. Waste fittings.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.
  2. Include rated capacities, operating characteristics and furnished specialties and accessories.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For sinks to include in maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS FOR SINKS

- A. Potable-water piping and components shall comply with NSF 61.
- B. Per new Federal Lead Free Law, any product designed for dispensing potable water meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

#### 2.2 SERVICE BASINS

- A. Service Basins/Mop Receptor MR-1: Terrazzo, floor mounted.
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:
  2.
    - a. Crane Plumbing, L.L.C./Fiat – Equal to TSB-100
    - b. Acorn Engineering Company.
    - c. Florestone Products Co., Inc.
    - d. Stern-Williams Co., Inc.
  3. Fixture:
    - a. Standard: IAPMO PS 99.
    - b. Shape: Square.
    - c. Nominal Size: 24 by 24 inches.
    - d. Height: 12 inches.
    - e. Tiling Flange: On two sides.
    - f. Rim Guard: Stainless steel On all top surfaces.

- g. Color: Not applicable.
  - h. Drain: Grid with NPS 3 outlet.
- 4. Mounting: On floor and flush to wall.
- 5. Faucet: Equal to American Standard 8354.112 with integral supply check valves, wall mount with vacuum breaker, 3/4" hose thread, pail hook, adjustable wall brace and 8" center handles.
- 6. Accessories: Equal to Fiat 832-AA hose and hose bracket, 833-AA silicone sealant, 889CC wall mop bracket
- 7. Provide separate 1/2" cold water with isolation valve, RPZ backflow equal to Watts LF009, and threaded hose connection for future/owner provided chemical dispensing system. Valve, backflow and hose connection shall be accessible ~7' above mop sink, with RPZ drain piped to mop sink drain. Chemical dispensing equipment shall not be directly connected to mop sink faucet.

## 2.3 HANDWASH SINKS

- A. Handwash Sinks SK-1: Solid Surface sink integral with counter (by GC). Gooseneck and wrist blade faucet and Components below by PC
  - 1. Faucet: SF-1.
  - 2. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
  - 3. Waste Fittings: Comply with requirements in "Waste Fittings" Article.
- B. Utility Sinks SK-2: Accessible Stainless steel, counter mounted, gooseneck/wrist blade.
  - 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. Just Manufacturing. Equal to SL-ADA-2122-A-GR
    - b. Elkay Manufacturing Co.
  - 2. Fixture:
    - a. Standard: ASME A112.19.3/CSA B45.4.
    - b. Type: Ledge back.
    - c. Number of Compartments: One.
    - d. Overall Dimensions:
    - e. Metal Thickness: 18 gauge
    - f. Compartment:
      - 1) Dimensions: OD 21x22, ID 16x19.
      - 2) Depth: 6-1/2"
      - 3) Drain: Grid with NPS 1-1/2 ADA offset tailpiece and twist drain.
      - 4) Drain Location: Centered in compartment.
  - 3. Faucet(s): SF-1.
    - a. Number Required: One.
    - b. Mounting: On ledge.
  - 4. Supply Fittings:
    - a. Standard: ASME A112.18.1/CSA B125.1.
    - b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
      - 1) Operation: Loose key.
      - 2) Risers: NPS 1/2, chrome-plated, rigid-copper pipe or ASME A112.18.6, braided or corrugated stainless-steel flexible hose.
  - 5. Waste Fittings:
    - a. Standard: ASME A112.18.2/CSA B125.2.
    - b. Trap(s) - ADA offset:
      - 1) Size: NPS 1-1/2.
      - 2) Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall; and chrome-plated brass or steel wall flange.

6. Mounting: On counter with sealant.
- C. Utility Sinks SK-3: Stainless steel, counter mounted, Double Bowl, Deep, gooseneck/wrist blade.
  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. Just Manufacturing. Equal to DLX-1933-A-GR
    - b. Elkay Manufacturing Co.
  2. Fixture:
    - a. Standard: ASME A112.19.3/CSA B45.4.
    - b. Type: Ledge back.
    - c. Number of Compartments: Two.
    - d. Overall Dimensions:
    - e. Metal Thickness: 18 gauge
    - f. Compartment:
      - 1) Dimensions: OD 19x33, ID 14x14 each.
      - 2) Depth: 10-1/2"
      - 3) Drain: Grid with NPS 1-1/2 tailpiece and twist drain.
      - 4) Drain Location: Centered in compartment.
  3. Faucet(s): SF-1.
    - a. Number Required: One.
    - b. Mounting: On ledge.
  4. Supply Fittings:
    - a. Standard: ASME A112.18.1/CSA B125.1.
    - b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
      - 1) Operation: Loose key.
      - 2) Risers: NPS 1/2, chrome-plated, rigid-copper pipe or ASME A112.18.6, braided or corrugated stainless-steel flexible hose.
  5. Waste Fittings:
    - a. Standard: ASME A112.18.2/CSA B125.2.
    - b. Trap(s):
      - 1) Size: NPS 1-1/2.
      - 2) Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall; and chrome-plated brass or steel wall flange.
  6. Mounting: On counter with sealant.
- D. Utility Sinks SK-3: Accessible Stainless steel, counter mounted, gooseneck with foot pedals.
  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. Just Manufacturing. Equal to SL-ADA-2122-A-GR
    - b. Elkay Manufacturing Co.
  2. Fixture:
    - a. Standard: ASME A112.19.3/CSA B45.4.
    - b. Type: Ledge back.
    - c. Number of Compartments: One.
    - d. Overall Dimensions:
    - e. Metal Thickness: 18 gauge
    - f. Compartment:
      - 1) Dimensions: OD 21x22, ID 16x19.
      - 2) Depth: 6-1/2"
      - 3) Drain: Grid with NPS 1-1/2 ADA offset tailpiece and twist drain.
      - 4) Drain Location: Centered in compartment.
  3. Faucet(s): SF-1.
    - a. Number Required: One.

- b. Mounting: On ledge.
  - 4. Supply Fittings:
    - a. Standard: ASME A112.18.1/CSA B125.1.
    - b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
      - 1) Operation: Loose key.
      - 2) Risers: NPS 1/2, chrome-plated, rigid-copper pipe or ASME A112.18.6, braided or corrugated stainless-steel flexible hose.
  - 5. Waste Fittings:
    - a. Standard: ASME A112.18.2/CSA B125.2.
    - b. Trap(s) – ADA offset:
      - 1) Size: NPS 1-1/2.
      - 2) Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall; and chrome-plated brass or steel wall flange.
  - 6. Mounting: On counter with sealant.
- E. Handwash Sinks SK-5: Solid Surface sink integral with counter (by GC). Single lever handle faucet and Components below by PC
  - 1. Faucet: SF-3.
  - 2. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
  - 3. Waste Fittings: Comply with requirements in "Waste Fittings" Article.
- F. Utility Sinks SK-6: Stainless steel, counter mounted, Single Bowl, Deep, gooseneck/wrist blade.
  - 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. Just Manufacturing. Equal to SLXD-2019-A-GR
    - b. Elkay Manufacturing Co.
  - 2. Fixture:
    - a. Standard: ASME A112.19.3/CSA B45.4.
    - b. Type: Ledge back.
    - c. Number of Compartments: One.
    - d. Overall Dimensions:
    - e. Metal Thickness: 18 gauge
    - f. Compartment:
      - 1) Dimensions: OD 21x22, ID 16x19 each.
      - 2) Depth: 12"
      - 3) Drain: Grid with NPS 1-1/2 tailpiece and twist drain.
      - 4) Drain Location: Centered in compartment.
  - 3. Faucet(s): SF-1.
    - a. Number Required: One.
    - b. Mounting: On ledge.
  - 4. Supply Fittings:
    - a. Standard: ASME A112.18.1/CSA B125.1.
    - b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
      - 1) Operation: Loose key.
      - 2) Risers: NPS 1/2, chrome-plated, rigid-copper pipe or ASME A112.18.6, braided or corrugated stainless-steel flexible hose.
  - 5. Waste Fittings:
    - a. Standard: ASME A112.18.2/CSA B125.2.
    - b. Trap(s):
      - 1) Size: NPS 1-1/2.
      - 2) Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall; and chrome-plated brass or steel wall flange.

6. Mounting: On counter with sealant.
- G. Handwash Sinks SK-7: Solid Surface sink integral with counter (by GC). Faucet, Foot Pedals and Components below by PC
  1. Faucet: SF-2.
  2. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
  3. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

## 2.4 SINK FAUCETS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.
- B. Sink Faucets SF-1: Manual type, two-lever-handle mixing valve, Gooseneck with Wrist blade
  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. Chicago Faucets. Equal to 201-AGN2ACP-317
    - b. American Standard America.
    - c. Bradley Corporation.
    - d. Just Manufacturing.
    - e. Speakman Company.
    - f. T & S Brass and Bronze Works, Inc.
    - g. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Standard: ASME A112.18.1/CSA B125.1.
  3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
  4. Body Type: 8" Centerset.
  5. Body Material: Commercial, solid brass.
  6. Finish: Chrome plated.
  7. Maximum Flow Rate: No Aerator
  8. Handle(s): Wrist blade, 4 inches.
  9. Mounting Type: Deck, concealed.
  10. Spout Type: Rigid/Swing gooseneck.
  11. Spout Outlet: Laminar flow or Plain end.
- C. Sink Faucets SF-2: Manual type, Gooseneck with Foot Pedal Control mixing valve.
  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. Chicago Faucets. Equal to 626-E29CP with 834-EP
    - b. American Standard America.
    - c. Bradley Corporation.
    - d. Just Manufacturing.
    - e. Speakman Company.
    - f. T & S Brass and Bronze Works, Inc.
    - g. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Standard: ASME A112.18.1/CSA B125.1.
  3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
  4. Body Type: Single hole.
  5. Body Material: Commercial, solid brass.
  6. Finish: Chrome plated.
  7. Maximum Flow Rate: No Aerator
  8. Handle(s): Foot Pedals.
  9. Mounting Type: Deck, concealed.
  10. Spout Type: Rigid/Swing gooseneck.
  11. Spout Outlet: Laminar flow or Plain end.

- D. Sink Faucets SF-3: Manual-type, single-control mixing, commercial, solid-brass valve.
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. Chicago Faucets. Equal to 420-CP
    - b. American Standard America.
    - c. Speakman Company.
    - d. T & S Brass and Bronze Works, Inc.
    - e. Zurn Industries, LLC; Commercial Brass and Fixtures.
  2. Standard: ASME A112.18.1/CSA B125.1.
  3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
  4. Body Type: Single hole.
  5. Body Material: Commercial, solid brass.
  6. Finish: Polished chrome plate.
  7. Maximum Flow Rate: No aerator
  8. Mounting Type: Deck, exposed.
  9. Valve Handle(s): Single lever.
  10. Spout: Rigid type.
  11. Spout Outlet: Laminar flow.
  12. Operation: Manual.

## **2.5 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS**

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout-outlet materials that will be in contact with potable water.
- B. 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. AM Conservation Group, Inc.
  2. Chronomite Laboratories, Inc.
  3. NEOPERL, Inc.
- C. Description: Chrome-plated brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

## **2.6 SUPPLY FITTINGS**

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.
- C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.
- D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- E. Operation: Loose key.
- F. Risers:
1. NPS 1/2
  2. Chrome-plated, rigid-copper pipe or ASME A112.18.6, braided or corrugated stainless-steel flexible hose.

## **2.7 WASTE FITTINGS**

- A. Standard: ASME A112.18.2/CSA B125.2.



- B. Drain: Grid type with NPS 1-1/2 offset and straight tailpiece.
- C. Trap:
  - 1. Size: NPS 1-1/2.
  - 2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall Insert trap type; and chrome-plated brass or steel wall flange.

## **2.8 GROUT**

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.
- B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install sinks level and plumb according to roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-hung sinks.
- C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.
- D. Set floor-mounted sinks in leveling bed of cement grout.
- E. Install water-supply piping with stop on each supply to each sink faucet.
  - 1. Exception: Use ball, gate, or globe valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523 "General-Duty Valves for Plumbing Piping."
  - 2. Install stops in locations where they can be easily reached for operation.
- F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

### **3.3 CONNECTIONS**

- A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

**3.4 ADJUSTING**

- A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

**3.5 CLEANING AND PROTECTION**

- A. After completing installation of sinks, inspect and repair damaged finishes.
- B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed sinks and fittings.
- D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.15

## SECTION 224716 - PRESSURE WATER COOLERS

### 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 pressure water coolers and related components.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of pressure water cooler.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For pressure water coolers to include in maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 PRESSURE WATER COOLERS

- A. Pressure Water Coolers **EW-1**: Wall mounted, dual height, accessible, with bottle filler.
  - 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. Elkay Manufacturing Co. Equal to LZSTL8WSLK
    - b. Halsey Taylor.
    - c. Haws Corporation.
    - d. Tri Palm International, LLC; Oasis Brand.
  - 2. Cabinet: Bi-level with two attached cabinets, vinyl-covered steel with stainless-steel top, one bottle filler station above one cabinet.
  - 3. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
  - 4. Control: Push bar.
  - 5. Drain: Grid with NPS 1-1/4 tailpiece.
  - 6. Supply: NPS 3/8 with shutoff valve.
  - 7. Filter: Filter NSF 42 & 53 for lead and particulate w/ visual filter monitor.
  - 8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
  - 9. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
    - 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.
  - 10. Capacities and Characteristics:
    - a. Cooled Water: 8 gph.
    - b. Cooled-Water Temperature: 50 deg F.
    - c. Electrical Characteristics:
      - 1) Volts: 120-V ac.
      - 2) Phase: Single.

- 3) Hertz: 60.  
11. Support: ASME A112.6.1M, Type I water-cooler carrier.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
- B. Examine walls and floors for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- B. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
- C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation.
- D. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- E. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings.
- F. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.

#### **3.3 CONNECTIONS**

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Install ball, gate, or globe shutoff valve on water supply to each fixture.
- D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

#### **3.4 ADJUSTING**

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust pressure water-cooler temperature settings.

#### **3.5 CLEANING**

- A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.
- C. Provide protective covering for installed fixtures.
- D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

**END OF SECTION 224716**

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**SECTION 230000**  
**GENERAL PROVISIONS FOR MECHANICAL WORK**

**PART 1 - GENERAL**

**1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Requirements of this Section apply to work in every Section of Division 23 equally as if incorporated therein.

**1.02 WORK INCLUDED**

- A. Work included in Division 23 - Mechanical: Materials, equipment, fabrication, installation, and tests in conformity with applicable codes and authorities having jurisdiction for Mechanical Work covered by all sections within this Division.

**1.03 SCOPE**

- A. Division of the Specification into sections is for the purpose of simplification alone. Responsibility for the work of various trades shall rest with the Contractor. Various sections of this Division are related to each other as well as the mechanical drawings. Examine all drawings and read all applicable parts of the project manual in order to ensure complete execution of all work in this Division, coordinating where required with other trades in order to avoid conflicts.
- B. These specifications and accompanying drawings are intended to cover the furnishing of all labor, materials, equipment and services necessary for the complete installation and acceptable performance of the mechanical systems. Small items of material, equipment and appurtenances not mentioned in detail or shown on the drawings, but necessary for complete and operating systems shall be provided by this contractor without additional charge to the Owner and shall be included under this contract.
- C. In general, specifications establish the quality of material, equipment and workmanship. The contract documents are intended to secure for the Owner, a first-class installation in every respect. Labor shall be performed by skilled mechanics, and the entire facility, when delivered to the Owner, shall be ready for satisfactory and efficient operation.
- D. The Contractor shall carefully examine the drawings and specifications before accepting the contract. He shall call attention to any changes or additions which, in his opinion, are necessary to make possible the fulfillment of any guarantee called for by these specifications; failing which, it shall be deemed that he has accepted full responsibility for all such guarantees.
- E. The contractor shall put his work in place as fast as is reasonably possible. He shall, at all times, keep a competent foreman in charge of the work, to make decisions necessary for the diligent advancement of the work. The Contractor shall facilitate the inspection of the work by the Owner's Representative.
- F. The Contractor shall coordinate all work in the building in order to facilitate intelligent execution of the work. He shall also remove any rubbish as expeditiously as possible.
- G. Materials or products specified herein and/or indicated on the drawings by trade's names, manufacturer's names, model number or catalog numbers establish the quality of materials or products to be furnished. Model numbers are to be confirmed by the manufacturer to provide required capacities and material to meet the specifications and design intent. In no instance shall an obsolete, incomplete or inaccurate trade name, manufacturer name, model number or catalog number indicated on the drawings, result in additional charges to the owner.
- H. Points of connection or continuation of work under this contract are so marked on drawings or herein specified. In case of any doubt as to the required exact location of such points, the Owner's Representative shall decide and direct.
- I. The plumbing contractor shall provide water services to within two (2) feet of HVAC equipment requiring same, and shall terminate service with a shutoff valve. The

mechanical contractor shall make the final connection to the equipment.

#### **1.04 REFERENCE STANDARDS, CODES AND REGULATIONS**

- A. Requirements of Regulatory Agencies:
  - 1. Nothing contained in these specifications or shown on the drawings shall be construed to conflict with any State or local laws, ordinances, rules and regulations, the UL and NFPA regulations. The Contractor shall make all changes required by the enforcing authorities. Where alterations to and / or deviations from the Contract Documents are required by the authorities having jurisdiction, report the requirements to the Engineer and secure acceptance before work is started. All such changes shall be made in a manner acceptable to the Engineer and shall be made without cost to the Owner.
  - 2. When drawings or specifications exceed requirements of applicable laws, ordinances, rules and regulations, comply with documents establishing the more stringent requirement. All work shall be done in full conformity with the requirements of all authorities having jurisdiction. Installation shall be made in compliance with all applicable regulations, and utility company rules, all of which shall be considered a part of this specification and shall take precedence in the order of listing.
  - 3. It is not the intent of drawings or specifications to repeat requirements of codes except where necessary for completeness in individual sections.
- B. Published specifications, standards, tests or recommended method of trade, industry or governmental organizations as listed below apply to all work in this Division, in addition to other standards which may be specified in individual sections:
  - 1. Associated Air Balance Council
  - 2. Air Diffuser Balance Council
  - 3. Air Moving and Conditioning Association
  - 4. American Gas Association
  - 5. American National Standards Institute
  - 6. Air Conditioning and Refrigeration Institute
  - 7. American Society of Heating, Refrigeration and Air Conditioning Engineers
  - 8. American Society of Mechanical Engineers
  - 9. American Society for Testing and Materials
  - 10. Cast Iron Soil Pipe Institute
  - 11. ETL Testing Laboratories
  - 12. Factory Mutual Engineering and Research Corporation
  - 13. National Standard Plumbing Code
  - 14. National Electrical Manufacturer's Association
  - 15. National Fire Protection Association
  - 16. National Board of Fire Underwriters
  - 17. National Electric Code
  - 18. Occupational Safety and Health Administration
  - 19. Plumbing Drainage Institute
  - 20. Sheet Metal & Air Conditioning Contractors National Association
  - 21. Underwriters Laboratories, Inc.
- C. Furnish and file with the proper authorities, all drawings required by them in connection with the work. Contractor shall secure and obtain all approvals, permits, licenses and inspections and pay all legal and proper fees and charges in this connection, before commencing work in order to avoid delays during construction. He shall deliver the official records of the granting of the permits, etc., to the Owner's Representative.

#### **1.05 QUALITY ASSURANCE**

- A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.
- B. Supply all equipment and accessories new and free from defects.
- C. Supply all equipment and accessories in compliance with the applicable standards listed in Article 1.4 of this section with all applicable national, state and local codes.
- D. All items of a given type shall be the product of same manufacturer.

**1.06 DESCRIPTION OF BID DOCUMENTS**

- A. Specifications:
  - 1. Specifications, in general, describe quality and character of materials and equipment.
  - 2. Specifications are of simplified form and include incomplete sentences.
  - 3. Words or phrases such as "The Contractor shall", "shall be", "furnish", "provide", "a", "an", "the", and "all" may have been omitted for brevity.
- B. Drawings: Mechanical drawings under this contract are made a part of these specifications. Deviations from these specifications as noted below must have the approval of the Engineer or Construction Manager without an increase in contract price.
  - 1. The drawings shall be considered as being diagrammatic and for bidding purposes only. Intention is to show size, capacity, approximate location, direction and general relationship of one work phase to another, but not exact detail or arrangement. The attention of the contractor is called to the fact that while these drawings are generally to scale and are made as accurately as the scale will permit, all critical dimensions shall be determined in the field. They are not to be considered as erection drawings.
  - 2. The drawings do not indicate every fitting, elbow, offset, valve, etc. which is required to complete the job. Contractor shall prepare field erection drawings as required for the use of his mechanics to insure proper installation.
  - 3. Scaled and figured dimensions are approximate and are for estimating purposes only. Indicated dimensions are limiting dimensions.
  - 4. Before proceeding with work check and verify all dimensions in field.
  - 5. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
  - 6. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
  - 7. For exact locations of building elements, refer to dimensional Architectural/Structural drawings.
- C. Description of systems: Provide all materials to provide functioning systems in compliance with performance requirements specified, and any modifications resulting from reviewed shop drawings and field coordinated drawings.
  - 1. Installation of all systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination drawings.
- D. Do not use equipment exceeding dimensions indicated or equipment or arrangements that reduce required clearances or exceed specified maximum dimensions.
- E. If any part of Specifications or Drawings appears unclear or contradictory, apply to Architect for his interpretation and decision as early as possible, including during bidding period.
  - 1. Do not proceed with work without Engineer's decision.

**1.07 EQUIPMENT MANUFACTURERS**

- A. The first named manufacturer is used as the basis of design. Other named manufacturers are identified as equivalent manufacturers, not equivalent products. Naming other manufacturers does not necessarily imply conformance of any specific product with the written specifications.
- B. The contractor is required to verify that equipment and material to be used on the project meets the requirements of the specifications and will physically fit the available space, clearance and service requirements of the particular piece of equipment and include all pertinent information when he submits material for acceptance. Contractor shall also be responsible for and bear the cost of any modifications to openings available or anticipated as being available for rigging equipment to its final installation place. This shall include openings in exterior envelope, walls and roofs, interior walls, corridors, passage ways or door openings. Any on site dismantling and any reassembly of equipment made necessary by impediment to the rigging of said equipment shall be the sole responsibility of the contractor.
- C. Contract document indicates power and physical requirements based on the equipment manufacturer's data as first named. If equipment requiring more system capacity is

furnished, the contractor shall be responsible for the cost associated with modifying the design and installation of associated services, including any redesign costs associated with the engineer's review.

#### 1.08 DEFINITIONS

- A. "Provide": To supply, furnish, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.
- B. "Install": To erect, mount and connect complete with related accessories.
- C. "Supply", "Furnish": To purchase, procure, acquire and deliver complete with related accessories.
- D. "Work": Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.
- E. "Piping": Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.
- F. "Wiring": Raceway, fittings, wire, boxes and related items.
- G. "Concealed": Items referred to as hidden from normal sight, embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures.
- H. "Exposed": Not installed underground or "concealed" as defined above.
- I. "Indicated", "Shown", or "Noted": As indicated, shown or noted on drawings or specifications.
- J. "Directed": Directed by Engineer.
- K. "Similar" or "Equal": Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified product.
- L. "Reviewed", "Satisfactory", or "Directed": As reviewed, satisfactory, or directed by or to Engineer.
- M. "Motor Controllers": Manual or magnetic starters (with or without switches), individual pushbuttons or hand-off-automatic (HOA) switches controlling the operation of motors.
- N. "Control or Actuating Devices": Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.
- O. "Remove": Dismantle, demolish and take away from the site and dispose of in accordance with all applicable rules and regulations or, should the Owner so require, deliver to a location as designated by the Owner for the use of the Owner, at no additional cost to the Owner.
- P. "Replace": Remove existing and provide an equivalent product or material as specified.
- Q. "Extract (and Reinstall) ": Carefully disassemble, dismantle existing, save or store where directed by the Owner, in such a manner as to preserve the existing condition and reinstall as indicated on the drawings or as described in the specifications.
- R. Where any device or piece of equipment is referred to in the singular number, such reference shall be deemed to apply to as many devices as are required to complete the installation.

#### 1.09 JOB CONDITIONS

- A. This contractor shall investigate all conditions affecting his work and shall provide such offsets, fittings, valves, sheet metal work, etc., as may be required to meet conditions at the building.
- B. The contractor shall verify all measurements at the building site and shall be responsible for the correctness of same before ordering materials or before starting work of any Section.
  - 1. Report to Architect, in writing, conditions which will prevent proper provision of this work.



2. Beginning work of any Section without reporting unsuitable conditions to Architect constitutes acceptance of conditions by Contractor.
3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.
- C. Piping and ductwork shall be concealed or run behind furring in finished spaces unless otherwise noted to be run exposed.
- D. Horizontal piping and ductwork not run below slabs on grade shall be run as close as possible to underside of roof or floor slab above and parallel to building lines. Maintain maximum headroom in all areas.
- E. Determine possible interference between trades before the work is fabricated or installed. The contractor must coordinate his work to insure that erection will proceed without such interference. Coordination is of paramount importance and no request for additional payment will be considered where such request is based upon interference between trades.
- F. Connections to Existing Work:
  1. Install new work and connect to existing work with minimum of interference to existing facilities.
  2. Temporary shutdowns of existing services:
  3. At no additional charges
    - a. At times not to interfere with normal operation of existing facilities.
    - b. Only with written consent of Owner.
  4. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work.
  5. Restore existing disturbed work to original condition.
- G. Removal, extraction and relocation of existing work.
  1. The work includes demolition or removal of all construction indicated or specified. All materials resulting from demolition work, except as indicated or specified otherwise, shall become the property of the Contractor and shall be removed from the site. Rubbish and debris shall be removed from the site daily unless otherwise directed so as to not allow accumulation inside or outside the building. Materials that cannot be removed daily shall be stored in areas specified by the Owner.
  2. Title to all materials and equipment to be demolished, excepting Owner salvage and historical items, is vested in the Contractor upon receipt of notice to proceed. The Owner will not be responsible for the condition, loss or damage to such property after notice to proceed.
  3. The Owner reserves the "Right of First Refusal" on all material for salvage. Material for salvage shall be stored as approved by the Owner. Salvage materials shall be removed from the site before completion of the Contract. Material for salvage shall not be sold on the site.
  4. Property of the Owner: Salvaged items remaining the property of the Owner shall be removed in a manner to prevent damage and packed or crated to protect the items from damage while in storage or during shipment and relocated by the contractor at no cost, to the Owners designated storage facility on the site. Containers shall be properly identified as to contents.
  5. Damaged Items: Items damaged during removal or storage shall be repaired or replaced to match existing.
  6. Disconnect, remove or relocate material, equipment, plumbing fixtures, piping and other work noted and required by removal or changes in existing conditions.
  7. Where existing pipes, conduits and/or ducts which are to remain prevent installation of new work as indicated, relocate, or arrange for relocation, of existing pipes, conduits, and/or ducts.
  8. Provide new material and equipment required for relocated equipment.
  9. Plug or cap active piping or ductwork behind or below finish.
  10. Do not leave long dead-end branches.
    - a. Cap or plug as close as possible to active line.
  11. Remove unused piping, ductwork and equipment.
  12. Dispose of unusable piping, ductwork and material.

**1.10 CLEARANCE FROM ELECTRICAL EQUIPMENT**

- A. Piping or ductwork:
  - 1. Prohibited, except as noted, in:
    - a. Electric rooms and closets.
    - b. Telephone rooms and closets.
    - c. Elevator machine rooms.
    - d. Electric switchboard room.
  - 2. Prohibited, except as noted, over or within 5 ft. of:
    - a. Transformers.
    - b. Substations.
    - c. Switchboards.
    - d. Motor control centers.
    - e. Standby power plant.
    - f. Bus ducts.
    - g. Electrical panels.
  - 3. Drip pans under piping:
    - a. Only where unavoidable and approved.
    - b. 18 gauge galvanized steel.
      - 1) With bituminous paint coating.
    - c. Reinforced and supported.
    - d. Watertight.
    - e. With 1-1/4 inch drain outlet piped to floor drain or service sink.

**1.11 TEMPORARY FACILITIES**

- A. Temporary facilities are not included within this Section.

**1.12 SPECIAL TOOLS**

- A. Furnish to Owner at completion of work:
  - 1. One set of any special tools required to operate, adjust, dismantle or repair equipment furnished under any section of the Division.
  - 2. "Special tools": those not normally found in possession of mechanics or maintenance personnel.
  - 3. One pressure grease gun for each type of grease required.
    - a. With adapters to fit all lubricating fittings on equipment.
    - b. Include lubricant for lubricated plug valves.

**1.13 PRODUCT DELIVERY, HANDING AND STORAGE**

- A. Provide adequate and secure storage facilities for materials and equipment during the progress of the work.
- B. Contractor shall be responsible for the condition of all materials and equipment employed in the mechanical installation until final acceptance by the Owner. Protect same from any cause whatsoever.
- C. Where necessary, ship in crated sections of size to permit passing through available space.
- D. Ship equipment in original packages, to prevent damaging or entrance of foreign matter.
- E. Handle and ship in accordance with manufacturer's recommendations.
- F. Provide protective coverings during construction.
- G. Replace at no expense to Owner, equipment or material damaged during storage or handling, as directed by Engineer.
- H. Tag all items with weatherproof tag, identifying equipment by name and purchase order number.
- I. Include packing and shipping lists.
- J. Adhere to special requirements as specified in individual sections.

**1.14 PROTECTION OF MATERIALS**

- A. Protect from damage, water, dust, etc., material, equipment and apparatus provided under this Division, both in storage and installed, until Notice of Completion has been filed.
- B. Provide temporary storage facilities for materials and equipment.
- C. Material, equipment or apparatus damaged because of improper storage or protection will be rejected.
  - 1. Remove from site and provide new, duplicate, material, equipment, or apparatus in replacement of that rejected.
- D. Cover motors and other moving machinery to protect from dirt and water during construction. Rotate moving equipment, shafts, bearings, motors etc. to prevent corrosion and to circulate lubricants.
- E. Protect premises and work of other Divisions from damage arising out of installation of work of this Division.
  - 1. Contractor shall be responsible for the replacement of all damaged or defective work, materials or equipment. Do not install sensitive or delicate equipment until major construction work is completed.
  - 2. Remove replaced parts from premises.
- F. Make good any damage to the work caused by floods, storms, accidents, acts of God, acts of negligence, strikes, violence or theft up to time of final acceptance by the Owner.
- G. Do not leave any mechanical work in a hazardous condition, even temporarily.

**1.15 REVIEW OF CONSTRUCTION**

- A. Work may be reviewed at any time by representative of the Engineer.
- B. Advise Architect and Engineer that work is ready for review at following times:
  - 1. Prior to backfilling buried work.
  - 2. Prior to concealment of work in walls and above ceilings.
  - 3. When all requirements of Contract have been completed.
- C. Neither backfill nor conceal work without Engineer's consent.
- D. Maintain on job a set of Specifications and Drawings for use by Engineer's representatives.

**1.16 SCHEDULE OF WORK**

- A. Arrange work to conform to schedule of construction established or required to comply with Contract Documents.
- B. In scheduling, anticipate means of installing equipment through available openings in structure.
- C. Confirm in writing to Architect and Engineer, within 30 days of signing of contract, anticipated number of days required to perform test, balance, and acceptance testing of mechanical systems.
  - 1. This phase must occur after completion of mechanical systems, including all control calibration and adjustment, and requires substantial completion of the building, including closure, ceilings, lighting, partitioning, etc.
  - 2. Submit for approval at this time, names and qualifications of test and balancing agencies to be used.
- D. Arrange with Owner schedule for work in each area.
- E. Unless otherwise directed by Owner, perform work during normal working hours.
- F. Work delays:
  - 1. In case noisy work interferes with Owner's operations, Owner may require work to be stopped and performed at some other time, or after normal working hours.

**1.17 ACCESS TO MECHANICAL WORK**

- A. Access doors in walls and ceilings.

- B. Access Units Fire-Resistance Ratings: Where fire-resistance rating is indicated for construction penetrated by access units, provide UL listed-and-labeled units, except for units which are smaller than minimum size requiring ratings as recognized by governing authority.
- C. Product Data, Access Units: Submit manufacturer's technical data and installation instructions for each type of access door assembly, including setting drawings, templates, instructions and directions for installation of anchorage devices.
- D. Furnish to the general contractor all access doors necessary for access through inaccessible wall or ceiling construction, for installation by the general contractor. Information on the size and location of the subject access doors is to be communicated in writing to the general contractors during the bidding period.

#### **1.18 CONCRETE FOR MECHANICAL WORK**

- A. Concrete for Mechanical Work
  - 1. Basins and curbs for mechanical equipment.
  - 2. Mechanical equipment foundations and housekeeping pads.
  - 3. Inertia bases for isolation of mechanical work.
  - 4. Rough grouting in and around mechanical work.
  - 5. Patching concrete cut to accommodate mechanical work.
- B. Quality control testing for concrete is required as work of this section.
- C. Concrete Work Codes and Standards:
  - 1. Comply with governing regulations and, where not otherwise indicated, comply with the following industry standards; whichever is the most stringent in its application to work in each instance.
    - a. ACI 301: "Specifications for Structural Concrete for Buildings"
    - b. ACI 311: "Recommended Practice for Concrete Inspection"
    - c. ACI 318: "Building Code Requirements for Reinforced Concrete"
    - d. ACI 347R: "Recommended Practice for Concrete Form work"
    - e. ACI 304R: "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete"
    - f. Concrete Reinforcing Steel Institute's, "Manual of Standard Practice"
- D. Submittals: Shop Drawings, Mechanical Concrete Work: Submit shop drawings for structural type concrete work, showing dimensions of formed shapes of concrete; bending, placement, sizes and spacing of reinforcing steel; location of anchors, isolation units, hangers and similar devices to be integrated with concrete work; and piping penetrations, access openings, inlets and other accessories and work to be accommodated by concrete work.
- E. Laboratory Test Reports, Mechanical Concrete Work: Submit laboratory test reports for concrete work materials, and for tested samples of placed concrete (where required as work of this section).

#### **1.19 NOISE REDUCTION**

- A. Cooperate in reducing objectionable noise or vibration caused by mechanical systems.
  - 1. To extent of adjustments to specified and installed equipment and appurtenances.
- B. Correct noise problems caused by failure to install work in accordance with Contract Documents.
  - 1. Include labor and materials required as result of such failure.

#### **1.20 CUTTING AND PATCHING**

- A. Provide all carpentry, cutting and patching required for proper installation of material and equipment specified.
- B. Do not cut or drill structural members without consent of Architect.

#### **1.21 COORDINATION DRAWINGS**

- A. Layout Shop Drawings Required:

1. Prepare layout shop drawings for all areas; minimum 3/8 inch scale.
  2. Individual coordinated trade layout drawings are to be prepared for all areas.
  3. General Contractor is to assure that each trade has coordinated work with other trades, prior to submittal where submittal is required.
    - a. Include stamp on each submittal indicating that layout shop drawing has been coordinated.
  4. No layout shop drawing will be reviewed without stamped and signed coordinated assurance by General Contractor.
  5. All changes shall be clearly marked on each submitted layout drawing.
  6. Drawings shall show work of all trades including but not limited to'
    - a. Ductwork.
    - b. Piping: All Trades.
    - c. Mechanical Equipment.
    - d. Electrical Equipment.
    - e. Main Electrical conduits and bus ducts.
    - f. Equipment supports and suspension devices.
    - g. Structural and architectural constraints.
    - h. Show location of:
      - 1) Valves
      - 2) Piping specialties
      - 3) Dampers
      - 4) Access Doors
      - 5) Control and electrical panels
      - 6) Disconnect switches
  7. Drawings shall indicate coordination with work in other Divisions that must be incorporated in mechanical spaces, including, but not limited to:
    - a. Elevator equipment.
    - b. Cable trays not furnished under Division 16.
    - c. Computer equipment.
  8. Submission of drawings:
    - a. Prepare reproducible drawings.
    - b. Submit to other trades for review of space allocated to all trades.
    - c. Revise drawings to compensate for requirements of existing conditions and conditions created by other trades.
    - d. Review revisions and other trades.
    - e. Submit one reproducible and one blue-line print to Engineer for review.
  9. Final prepared drawings shall show that other trades affected have made reviews and signed, by each trade, at completions of coordination.
    - a. General Contractor
    - b. Include stamp on each submittal indicating that layout shop drawing has been coordinated.
  10. No layout shop drawing will be reviewed without stamped and signed coordination assurance by General Contractor.
- B. Shop Drawings:
1. Layout drawings of mechanical equipment rooms and penthouses showing all related equipment and equipment clearances required by other trades.
  2. Layout drawings of areas in which it may be necessary to deviate substantially from layout shown on the drawings. Minor transitions in ductwork, if required due to job conditions, need not be submitted as long as the duct area is maintained. Show major relocation of ductwork and major changes in size of ducts. Coordinate shop drawings with all trades prior to ductwork fabrication.
  3. Details of intermediate structural steel members required to span main structural steel for the support of ductwork.
  4. Method of attachment of duct hangers to building construction.
  5. Duct material, gage, type of joints and duct reinforcing for each size range, including sketches or SMACNA plate numbers for joints, method of fabrication and reinforcing.

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## **1.22 GUARANTEE**

- A. Furnish guarantee covering all work in accordance with general requirements of the contract for minimum period of one year. This personal guarantee shall exist for a period of one (1) year from the date of final acceptance of the work and shall apply to defects in materials and to defective workmanship of any kind.
- B. For factory-assembled equipment and devices on which the manufacturers furnish standard published guarantees as regular trade practice, obtain such guarantees and replace any such equipment that proves defective during the life of these guarantees.
- C. Guarantee all work for which materials are furnished, fabricated or field erected by the contractor, all factory-assembled equipment for which no specific manufacturer's guarantee is furnished, and all work in connection with installing manufacturer's guarantee is furnished, and all work in connection with installing manufacturer's guaranteed equipment.
- D. In the event of failure of any work, equipment or device during the life of the guarantee, repair or replace the equipment or defective work. Remove, replace or restore, at no cost to the Owner, any part of the structure or building which may be damaged either as the direct result of the defective work or in the course of the contractor's making replacement of the defective work or materials. Work shall be done at a time and in a manner as to cause no undue inconvenience to the Owner. Provide new materials, equipment, apparatus and labor to replace that determined by Engineer to be defective or faulty.
- E. This guarantee also applies to services including Instructions, Adjusting, Testing, Noise, Balancing, etc.
- F. Additional equipment and material guarantees and warranties may be indicated in other sections. In all cases, the more stringent guarantee or warranty shall be provided.

## **PART 2 - PRODUCTS**

### **2.01 MATERIALS AND EQUIPMENT QUALITY**

- A. Material and equipment furnished under this Division of specification shall be new. Defective or inferior materials must be replaced by contractor at no cost to Owner regardless of the stage of construction. Inferior material shall be defined as material or equipment of a quality or performance less than that specified as determined by the Owner's Representative.
- B. Provide each item of equipment with manufacturer's identification tag which is readily accessible and clearly shows model and size.

### **2.02 ACCESS TO MECHANICAL WORK**

- A. Access Doors:
  - 1. General: Where walls and ceilings must be penetrated for access to mechanical work, access doors shall be provided. Furnish adequate size for intended and necessary access. Furnish doors with UL Fire Rating to match wall or ceiling construction. Furnish manufacturer's complete units, of type recommended for application in indicated substrate construction, in each case, complete with anchorages and hardware.
- B. Access Door Construction: Refer to Section 083113 – ACCESS DOORS AND FRAMES

## **PART 3 - EXECUTION**

### **3.01 FIELD QUALITY CONTROL**

- A. Tests:
  - 1. Perform as specified in individual sections, and as required by authorities having jurisdiction.
  - 2. Duration as noted.
- B. Provide required labor, material, equipment, and connections.
- C. Furnish written report and certification those tests have been satisfactorily completed.
- D. Repair or replace defective work, as directed.
- E. Pay for restoring or replacing damaged work due to tests as directed.

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F. Pay for restoring or replacing damaged work of others, due to tests, as directed.

### **3.02 ACCESS TO MECHANICAL WORK**

- A. Coordinate installation and placement of access doors and panels with contractor for general construction.
- B. Remove or replace panels or frames that are warped, bowed, or otherwise damaged.

**END OF SECTION**

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## **SECTION 230002 MECHANICAL AND ELECTRICAL COORDINATION**

### **PART 1 - GENERAL**

#### **1.01 WORK INCLUDED**

- A. Work Included in This Section: Materials, equipment, fabrication, installation, and tests in conformity with applicable codes and authorities having jurisdiction for the following:
  - 1. Motors.
  - 2. Factory-wired equipment (FWE).
  - 3. Factory-wired control panels (FWCP).
  - 4. Motor controllers where provided as part of mechanical equipment.
  - 5. Motor controllers where supplied under Division 23 - Mechanical Work.
  - 6. Disconnects and safety switches for mechanical equipment.
  - 7. Fuses for equipment provided, and starters and disconnect switches.
  - 8. Emergency Pushbutton Operator Station.

#### **1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Division 23 - HVAC Instrumentation and Controls, Motors.
- B. Installation and Power Wiring of Motor Controllers.

#### **1.03 REFERENCE STANDARDS**

- A. Published specifications standards, tests, or recommended methods of trade, industry or governmental organization as apply to work in this section where cited below:
  - 1. ANSI - American National Standards Institute.
  - 2. NEMA - National Electrical Manufacturer's Association.
  - 3. IEEE - Institute of Electrical and Electronic Engineers.

#### **1.04 QUALITY ASSURANCE**

- A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.
- B. Supply all equipment and accessories new and free from defects.
- C. Supply all equipment and accessories in compliance with the applicable standards listed in Article 1.03 of this Section and with all applicable National, State and local codes.
- D. All items of a given-type shall be the products of the same manufacturer.

#### **1.05 DIVISION OF WORK**

- A. This section delineates the work required to be performed by Contractors under Division 23 and Division 26.

#### **1.06 WORK REQUIRED UNDER DIVISION 23**

- A. Furnish motors, manual and combination starters, pushbutton devices, contactors, disconnect switches, electric thermostats, low voltage transformers, Emergency Break Glass Stations and other electrical devices required for equipment furnished.
- B. Install all items in piping and ductwork such as control valves, aquastats, ductstats, etc.
- C. All external wiring of equipment, all temperature control wiring, external wiring of control circuits of magnetic starters, interlocking wiring, boiler wiring, Emergency Break Glass Stations, and mounting of control devices, etc., shall be included under Division 23. All external wiring shall be in conduit. (Unless specifically shown to be provided by the Electrical Contractor)
- D. The Electrical Contractor, under Division 26, shall furnish and install all power wiring and conduit to junction box, to disconnect switch on unit, to motor starters and contactors, and between motor starters and contactors to motor or other load. Electrical Contractor shall be responsible for proper direction of rotation for all three phase equipment. The Electrical Contractor shall mount all starters, disconnects.

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- E. Wiring required under Division 23 shall comply with the specifications as described in Division 26.
- F. The Plumbing Contractor, under Division 22, shall provide water and natural gas services to within two (2) feet of HVAC equipment requiring same and terminating with shut-off valves. The HVAC Contractor, under Division 23, shall make final connections to equipment.
- G. Provide disconnect switches or safety switches for equipment. (Unless specifically shown to be provided by the Electrical Contractor, starters and disconnects shown on the electrical drawings are for installation and do not require the Electrical Contractor to furnish units)
- H. Emergency Generator - Exhaust muffler and flexible exhaust connection shall be furnished by the generator manufacturer under Division 26. Installation of the exhaust system including providing piping, insulation and accessories shall be included under Division 23.

#### **1.07 SUBMITTALS**

- A. Shop Drawings: Complete wiring diagrams of all power and control connections (standard diagrams will not be accepted). Deliver 2 copies of approved wiring diagrams to the Electric Contractor for installation of wiring and connections required under the Electric Contract.
- B. Product Data for Motor Controllers and Disconnect Switches: Manufacturer's catalog sheets, specifications and installation instructions. Submit enclosure type coordinated for service and location. Submit simultaneously with product data required for motors. Identify each controller for use with corresponding motor. Submit shop drawings and product data in accordance with project requirements.
- C. All warranties shall be delivered as part of the close-out submission.
- D. A receipt shall be delivered as part of the close-out submission that states all required spare parts have been delivered to the owner. This receipt must be signed and dated by the owner.

### **PART 2 - PRODUCTS**

#### **2.01 ACCEPTABLE MANUFACTURERS**

- A. Motor Controllers and Disconnects
  - 1. Square D
  - 2. Allen-Bradley
  - 3. General Electric
  - 4. Cutler-Hammer

#### **2.02 MOTOR CONTROLLERS**

- A. General: All starters shall be correctly sized to motor connected thereto. Provide one (1) additional auxiliary contact over and above that normally furnished, at least two (2) required. Provide overload heaters for each phase. Coordinate starters and controllers with the temperature control Contractor and sequence of operations.
- B. Minimum Size: The minimum allowable size of single or three phase magnetic motor controller is NEMA size 0.
- C. Enclosures: Unless otherwise indicated furnish NEMA 1 enclosures, except where installed outdoors furnish NEMA 3R enclosures.
- D. Control Power: Furnish control power transformer (maximum control voltage 120 volts) mounted within each magnetic motor controller enclosure.
- E. Pilot Lights: Furnish pilot lights of the neon lamp type mounted in the controller enclosure, green for running, red for not running.

#### **2.03 MOTOR CONTROLLER TYPES:**

- A. Type A (Full Voltage, Manual, Non-Magnetic):
  - 1. Allen-Bradley Co. Bulletin 609 (or Bulletin 600 - single phase, 1 HP or less only).
  - 2. General Electric Co. CR-1062 (or CR-101 - single phase, 1 HP or less only).
  - 3. Cutler-Hammer. B100 (or MS - single phase, 1 HP or less only).

- B. Type A2 (2 Speed, 2 Winding, Full Voltage, Manual, Non-Magnetic):
  - 1. Allen-Bradley Co. Bulletin 609TS (or Bulletin 600 - single phase, 1 HP or less only).
  - 2. General Electric Co. CR-1062 (or CR-101 - single phase, 1 HP or less only).
  - 3. Square D Co. Class 2512, Type M (or Class 2512, Type F - single phase, 1 HP or less only).
- C. Type B (Full Voltage Magnetic):
  - 1. Allen-Bradley Co. Bulletin 709.
  - 2. General Electric Co. CR-206.
  - 3. Square D Co. Class 8536.
  - 4. Cutler-Hammer. ECN05.
- D. Type B-COM (Combination Full Voltage Magnetic/Safety Switch):
  - 1. Allen-Bradley Co. Bulletin 712.
  - 2. General Electric Co. CR-208.
  - 3. Square D Co. Class 8538.
  - 4. Cutler-Hammer. ECN16.
- E. Type B2 (2 Speed, 2 Winding, Full Voltage, Magnetic):
  - 1. Allen-Bradley Co. Bulletin 715.
  - 2. General Electric Co. CR209.
  - 3. Square D Co. Class 8810.
  - 4. Cutler-Hammer. ECN33.
- F. Type C (Automatic, Reduced Voltage, Magnetic):
  - 1. Allen-Bradley Co. Bulletin 746.
  - 2. General Electric Co. CR-231.
  - 3. Square D Co. Class 8606.
  - 4. Cutler-Hammer. ECA42.
- G. Type C-COM (Combination Automatic, Reduced Voltage, Magnetic/ Safety Switch):
  - 1. Allen-Bradley Co. Bulletin 746C.
  - 2. Square D Co. Class 8606.
  - 3. Cutler-Hammer. ECA43.
- H. Type D (Part Winding, Magnetic):
  - 1. Allen-Bradley Co. Bulletin 736.
  - 2. General Electric Co. CR-230.
  - 3. Square D Co. Class 8640.
  - 4. Cutler-Hammer. ECA45.

## **2.04 REMOTE PUSH BUTTON STATIONS**

- A. Start-Stop with pilot light in NEMA 1 enclosure unless otherwise indicated.
  - 1. Allen-Bradley Co. Bulletin 800S.
  - 2. General Electric Co. CR-2943.
  - 3. Square D Co. Class 9001.
  - 4. Cutler-Hammer. Class 10250.

## **2.05 SAFETY SWITCHES**

- A. General Electric Co. Type TH; Square D Co. Heavy Duty Series; Cutler-Hammer HD Series; with the following:
  - 1. Fused switches equipped with fuseholders to accept only the fuses specified in Section 16181 (U.L. Class RK-1, RK-5, L).
  - 2. NEMA 1 enclosure unless otherwise indicated on drawing or required. 3R for devices installed outdoors.
  - 3. Switch rated 240V for 120V, 208V, 240V, circuits; 600 V for 277V, 480V circuits.
  - 4. Switch rated 600V for 277V, 480V circuits.

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5. Solid neutral bus when neutral or grounding conductor is included with circuit.
6. Current rating and number of poles as indicated on drawings.

## **2.06 NAMEPLATES**

- A. Phenolic Type: Standard phenolic nameplates with 3/8" minimum size lettering engraved thereon.
- B. Embossed Aluminum: Standard stamped or embossed aluminum tags: Tech Products, Inc., Seton Name Plate Corp.

## **2.07 EMERGENCY PUSHBUTTON OPERATOR STATION**

- A. Acceptable Manufacturer: Square D or equal.
- B. Switch Style: Class 9001, NEMA 4 rated emergency mushroom head pushbutton.
- C. Voltage: 120VAC, 60Hz as required.
- D. Contacts: 20A, 2-NO/2-NC contact.
- E. Operation: Manual.
- F. Normal position: Operator out.
- G. Activated position: Operator in.
- H. Reset: Manual, turn to release.
- I. Enclosure: NEMA 4.

## **2.08 CUSTOM LEGEND PLATE**

- A. "EMERGENCY BOILER SHUTOFF"

## **PART 3 - EXECUTION**

### **3.01 GENERAL**

- A. Equipment shall be connected in a neat and skillful manner. Equipment deliver with terminal boxes that are inadequate shall be equipped with special boxes that suit the conditions by the Mechanical Contractor furnishing the equipment.
- B. In general, rigid conduit or tubing shall be used, but equipment that requires movement or that would transmit vibration to conduit shall be wired with flexible (liquid tight) steel conduit not over 18" long.
- C. All equipment shall be grounded with a green-covered ground wire run inside the conduit and connected to equipment frame on one end and to grounding system on the other end.
- D. All electrical work required in the Mechanical Contract shall conform to the applicable requirements of Division 26 of these Specifications.
- E. The Heating, Ventilating, and Air Conditioning Contractor shall assign all Electrical Work required under his contract to the approved Automatic Temperature Control Contractor, who shall perform this work with qualified electricians employed by that Contractor.
- F. The Mechanical Contractors shall cooperate with the Contractor for Electrical Work in making all necessary tests and in receiving, storing, and setting all motor-driven equipment, electrical devices, and controls furnished and/or installed under these contracts.
- G. Install heaters correlated with full load current of motors provided.
- H. Set overload devices to suit motors provided.

### **3.02 INSTALLATION**

- A. Control Wiring:
  1. Provide control wiring and connections.
  2. Where control circuit interlocking is required between individually mounted motor controllers, provide a single pole on-off switch in a threaded type box mounted adjacent to motor safety switches which are remote from the control transformer (to enable interlock circuit to be opened when the motor safety switch is opened).
- B. Nameplates: Rivet or bolt the nameplate on the cover of NEMA 1 enclosures. Rivet or bolt and gasket the nameplate on cover of NEMA 3R or NEMA 12 enclosures. Provide phenolic

or embossed aluminum nameplates as follows:

1. On each remote control station, indicating motor controlled.
  2. On each interlock circuit switch, indicating purpose of switch.
- C. Emergency Pushbutton Operator Station: Wire all switches in series with boiler control branch circuits.

### **3.03 TYPES OF MOTOR CONTROLLERS REQUIRED FOR SINGLE SPEED MOTORS (SYSTEMS UNDER 250 VOLTS)**

- A. Single Phase Motors Less than 5 HP - Manually Operated: Type A.
- B. Single Phase Motors Less than 1/2 HP - Automatically Operated: Type A.
- C. Single Phase Motors 1/2 to 5 HP - Automatically Operated: Type B.
- D. Three Phase Squirrel Cage Motors Less than 7-1/2 HP: Type B (B-COM when indicated on drawings).
- E. Three Phase Squirrel Cage Motors 7-1/2 HP and Larger: Type C (C-COM when indicated on drawings).
- F. Three Phase Hermetically Sealed Compressor Motors Less than 7-1/2 HP: Type B.
- G. Three Phase Hermetically Sealed Compressor Motors 7-1/2 HP and Larger: Type D.

### **3.04 TYPES OF MOTOR CONTROLLERS REQUIRED FOR SINGLE SPEED MOTORS (277/480 VOLT SYSTEM)**

- A. Single Phase Motors Less than 5 HP - Manually Operated: Type A.
- B. Single Phase Motors Less than 1 HP - Automatically Operated: Type A.
- C. Single Phase Motors 1 to 5 HP - Automatically Operated: Type B.
- D. Three Phase Squirrel Cage Motors Less than 15 HP: Type B (B-COM when indicated on drawings).
- E. Three Phase Squirrel Cage Motors 15 HP and Larger: Type C (C-COM when indicated on drawings).
- F. Three Phase Hermetically Sealed Compressor Motors Less than 15 HP: Type B.
- G. Three Phase Hermetically Sealed Compressor Motors 15 HP and Larger: Type D.

### **3.05 TYPES OF MOTOR CONTROLLERS REQUIRED FOR 2 SPEED MOTORS (SYSTEMS UNDER 250 VOLTS)**

- A. Single Phase Motors Less than 5 HP - Manually Operated: Type A2.
- B. Single Phase Motors Less than 1/2 HP - Automatically Operated: Type A2.
- C. Single Phase Motors 1/2 to 5 HP - Automatically Operated: Type B2.
- D. Three Phase Squirrel Cage Motors Less than 7-1/2 HP: Type B2.

### **3.06 TYPES OF MOTOR CONTROLLERS REQUIRED FOR 2 SPEED MOTORS (277/480 VOLT SYSTEM)**

- A. Single Phase Motors Less than 5 HP - Manually Operated: Type A2.
- B. Single Phase Motors Less than 1 HP - Automatically Operated: Type A2.
- C. Single Phase Motors 1 to 5 HP - Automatically Operated: Type B2.
- D. Three Phase Squirrel Cage Motors Less than 15 HP: Type B2.

### **3.07 DISCONNECTS**

- A. Motor Controllers: Provide safety switch for all motor controllers. Provide combination type starter-disconnect unless otherwise noted on drawings.
- B. Motors: Provide a disconnect switch for all motors. Provide a separate safety switch for motors which are not within sight of the starter.

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- C. Provide safety switches for all factory packaged equipment.
- D. Provide NEMA 3R safety switch for all rooftop and outdoor equipment.
- E. Provide unit mounted disconnect switches for all equipment such as unit heaters, fans, unit ventilators, incremental units, etc

### **3.08 EMERGENCY PUSHBUTTON OPERATOR STATION**

- A. Provide Emergency Pushbutton Operator Station at each boiler room exit to de-energize the primary control circuit and to close the main fuel valves to stop the flow of fuel to the burner during an emergency.
- B. Review plans for locations.
- C. Provide all conduit and wiring for interlock of each boiler.

**END OF SECTION**

## SECTION 230210 - VIBRATION ISOLATION

### PART 1 - GENERAL

#### 1.1 WORK INCLUDED, BUT NOT LIMITED TO:

- A. Vibration isolators.
- B. Flexible pipe connectors.
- C. Flexible duct connectors.

#### 1.2 REFERENCE STANDARDS

- A. All mechanical equipment over one horsepower shall be isolated from the structure by means of resilient vibration and noise isolators supplied by a single manufacturer to the Contractor. Where isolator type and required deflection are not shown or tabulated, equipment shall be isolated in accordance with the ASHRAE Systems and Equipment Handbook and the ASHRAE HVAC Applications Handbook.

#### 1.3 DESCRIPTION OF SYSTEM

- A. The work under this Section shall include furnishing all labor, materials, tools, appliances, and equipment, and performing all operations necessary for the complete execution of the installation of noise and vibration isolation devices and systems as shown, detailed, and/or scheduled on the drawings, and/or specified in this Section of the Specification.

This work, in general, shall include, but not necessarily be limited to the following:

1. All mechanical and electrical equipment shall be isolated from the building structure by means of noise and vibration isolators.
2. All piping over 1" outside diameter located in mechanical equipment rooms, and for a minimum of fifty (50) feet or 100 pipe diameters, whichever is greater, from connection to vibration isolated mechanical or electrical equipment, shall be isolated from the building structure by means of noise and vibration isolation hangers. All piping in the building which is connected to vibration isolated equipment shall be noise isolated at connections to the building structure.
3. All ductwork located in mechanical equipment rooms, and for a minimum of fifty (50) feet from connection to vibration isolated air moving equipment shall be isolated from the building structure by means of noise and vibration isolation hangers.
4. All piping and ductwork vertical risers shall be isolated from the building structure by means of noise and vibration isolation guides and supports.
5. All piping and ductwork to be isolated according to this Section of the Specification shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork, and maintain a minimum of 3/4" and maximum of 1-1/4" clearance around the outside surfaces. This clearance space shall be tightly packed with 1.58 P.C.F. fiberglass, and caulked airtight, after installation of piping or ductwork.

## **1.4 SYSTEM DESIGN**

- A. The isolation materials manufacturer shall be responsible for the proper selection of spring rates to accomplish the specified minimum static deflections, for all spring and pad type isolators, based on the weight distribution of equipment to be isolated.
- B. The isolation materials manufacturer shall be responsible for the structural design of steel beam bases, and concrete inertia bases, to support mechanical equipment scheduled to receive a supplementary base.
- C. The Contractor shall furnish a complete set of approved shop drawings, of all mechanical and electrical equipment to receive vibration isolation devices, to the vibration isolation materials manufacturer based upon which the selection of vibration isolators and design of supplementary bases will be completed. The shop drawings to be furnished include operating weight of the equipment to be isolated and the distribution of weight to support points.
- D. The Contractor shall furnish a complete layout of piping and ductwork to be isolated, including vertical risers, showing size or weight and support points of the piping and ductwork system, to the vibration isolation materials manufacturer, for selection and layout of isolation hangers.

## **PART 2 - PRODUCTS**

### **2.1 ACCEPTABLE MANUFACTURERS**

- A. Vibration Isolators: Consolidated Kinetics, Vibration Eliminators, Inc., Mason Industries.
- B. Flexible Pipe Connectors: Metraflex, Flexonics, Flex - Hose Co., Inc.
- C. Flexible Duct Connectors: Ventfabrics.

### **2.2 ISOLATOR TYPES - FLOOR-MOUNTED EQUIPMENT**

- A. Select from the following per Manufacturer's recommendations:
- B. TYPE F fiberglass isolators shall be precompressed molded fiberglass noise and vibration isolation pads, individually coated with a flexible moisture impervious elastomeric membrane. The fiberglass pads shall be molded of glass fibers produced by a multiple flame attenuation process which generates nominal fiber diameters not to exceed 0.00018", and shall have been stabilized by ten (10) compression cycles to three (3) times the maximum published load. Load range and natural frequency shall be as recommended by the isolator manufacturer for each specific application of TYPE F isolators, but in no case shall a natural frequency higher than 12 Hz. be provided for applications intended to isolate sound, nor higher than 15 Hz. for applications intended to isolate impact noise and shock.
  - 1. TYPE F fiberglass isolators shall be MODEL KIP or MODEL AC as manufactured by Consolidated Kinetics Corp.
- C. TYPE N neoprene isolation mounts shall incorporate a cast-in tapped steel load plate, to permit bolting to supported equipment. The neoprene pad shall be molded using 2500 PSI tensile strength, oil resistant, compounds, and shall have no color additives in the compound. The neoprene isolator shall be selected to achieve the minimum operating static deflection tabulated, while not exceeding the published load capacity for the isolator used. Each neoprene isolation mount shall be externally color coded to identify load capacity.
  - 1. Neoprene isolation mounts, used with equipment requiring bolt down to the supporting structure, shall incorporate a cast-in drilled steel anchor/base plate.



2. Neoprene isolation mounts shall be MODEL R or RD as manufactured by Consolidated Kinetics Corporation.
- D. TYPE S spring vibration isolators shall be freestanding unhoused, laterally stabile steel springs, wound, using high strength heat treated spring alloy steel, and shall have a horizontal spring stiffness equal to or greater than 1.3 times the rated vertical spring stiffness. To assure stability the outside spring diameter shall be a minimum of 0.8 times the rated vertical operating height. Springs shall be selected to provide the tabulated minimum operating static deflections and shall provide a 50% overload capacity before exceeding the spring steel fatigue point.
1. TYPE S springs used to isolate floor-mounted equipment shall be MODEL FDS, MODEL FBS, or MODEL SW as manufactured by Consolidated Kinetics Corp.
- E. TYPE L vertically restrained spring mounts shall incorporate a single spring vibration isolator; having all of the characteristics of TYPE S spring isolators as previously specified, into a steel mount assembly designed to limit vertical movement of isolated equipment if equipment loads are reduced or equipment is subjected to external loads, and shall limit vertical movement without degrading the vibration isolation of the spring element during normal equipment operating conditions.
1. TYPE L mounts shall have a flat steel toload plate, for welding to supported equipment, vertically restrained by noise isolated bolts, connected to steel channel and drilled plate assemblies welded to a steel base plate. The base plate shall be bonded to 1/4" thick ribbed neoprene noise stop pad and drilled for bolting to supporting structures. Weld studs on the base plate shall position a spring, tapped steel load plate, and level bolt assembly, which shall carry all equipment loads by lifting the toload plate during normal equipment operating conditions. Load transfer and leveling shall be internal.
  2. TYPE L mounts shall be MODEL FLS as manufactured by Consolidated Kinetics Corp.

### **2.3 BASE TYPES - FLOOR-MOUNTED EQUIPMENT**

- A. TYPE K equipment bases shall consist of structural steel angle or channel sections, with prelocated and drilled isolator and equipment anchor bolt holes, and shall be designed and supplied by the isolation materials manufacturer.
1. The structural steel angles shall have minimum 3", and channels minimum 2", section depths, and shall be a minimum 1/4" thick stock. Each equipment base shall be sized and shaped as required for equipment supported, and shall be rigid enough to prevent bending or distortion of base members between supporting isolators. Bases provided for non-unitary equipment shall be rectangular frames with lateral cross members selected and placed to prevent excessive differential movement of driving and driven members. Isolator and equipment anchor bolt holes shall be prelocated and drilled as required for equipment supported.
  2. TYPE K equipment bases shall be MODEL KFB or KRB as manufactured by Consolidated Kinetics Corp.
- B. TYPE B equipment bases shall consist of structural steel support members, with welded-on isolator support brackets, and prelocated and drilled anchor bolt holes, designed and supplied by the isolation materials manufacturer.
1. The structural steel bases shall have beams of a minimum section depth equal to 8% of the longest span between support isolators, a minimum of 6", or as indicated on the drawings, and shall be of sizes and shapes required for equipment to be supported. Isolator support brackets shall be welded to the structural beam base as required to

- provide the lowest possible mounting height of supported equipment. Anchor bolt holes shall be prelocated and drilled into all equipment bases to bolt down equipment.
2. The structural steel bases shall provide a rigid, distortion-free mounting base for supported equipment, which allows no excessive differential motion between driving and driven equipment components.
  3. TYPE B equipment bases shall be MODEL SFB or SBB as manufactured by Consolidated Kinetics Corp.
- C. Type M motor slide bases shall consist of a single frame steel motor mounting base, and shall have four sliding motor anchor bolts, operated by one or two alignment adjustment bolts, and shall have four anchor bolt holes for attachment to equipment support bases.
1. Motor slide bases, to be supported by concrete or steel frame bases used as part of the noise and vibration isolation of the equipment, shall be furnished by the same manufacturer as the equipment support bases, and shall be sized as required for motors to be mounted.
  2. Motor slide bases shall be MODEL MSB as supplied by Consolidated Kinetics Corp.

## **2.4 ISOLATOR TYPES - SUSPENDED EQUIPMENT - PIPING - DUCTWORK**

- A. TYPE F hangers shall consist of a fiberglass isolator encased in a welded steel bracket.
1. The fiberglass noise stop pad shall meet all specified characteristics of TYPE F fiberglass pads and shall be bonded to the hanger bracket. The pad shall be selected to operate within the published load range for the pad, and shall exhibit a natural frequency of 12 Hz. or less in the load range selected.
  2. The hanger bracket shall be designed to carry a five (5) times overload without failure, and allow up to 15o rod misalignment without metal to metal contact or other short circuit.
  3. TYPE F hangers shall be MODEL FH as manufactured by Consolidated Kinetics Corp.
- B. TYPE S hangers shall consist of a steel spring and a neoprene washer placed in series and encased in a welded steel bracket. The spring element of the hanger shall meet all specified characteristics of a TYPE S spring as previously specified. Springs shall be color coded for ease of load capacity identification and removable for field correction of overloaded hangers.
1. The hanger bracket shall be designed to carry a five 5 times overload without failure, and allow up to 15o rod misalignment without metal to metal contact or other short circuit, and shall be designed to receive either strap or rod suspension members.
  2. TYPE S hangers shall be MODEL SH or MODEL SHM as manufactured by Consolidated Kinetics Corp.
- C. TYPE H hangers shall each consist of a steel spring and a fiberglass isolator placed in series and encased in a welded steel bracket. The spring element of the hanger shall meet all specified characteristics of a TYPE S spring as previously specified. Springs shall be color coded for ease of load capacity identification and removable for field correction of overloaded hangers.
1. The fiberglass noise stop pad shall meet all specified characteristics of TYPE F fiberglass pads, as previously specified, and shall be bonded to the hanger bracket. The pad shall be selected to operate within the published load range for the pad for each spring capacity which can be placed in the bracket used.
  2. The hanger bracket shall be designed to carry a five (5) times overload without failure, and shall allow up to 15o rod misalignment without metal to metal contact or other short circuit.
  3. TYPE H hangers shall be MODEL SFH as manufactured by Consolidated Kinetics Corp.

## **2.5 ISOLATOR TYPES - PIPE RISER SYSTEMS**

- A. TYPE R riser isolation systems shall incorporate supports and anchors having TYPE F fiberglass noise and vibration isolation pads bonded to steel load transfer plates suitable for welding to pipe collar extensions. Riser isolation guides shall incorporate TYPE N neoprene isolation mounts bolted to drilled structural steel mounting angles.
1. Riser isolation mounts used to both support and anchor shall incorporate two TYPE F fiberglass isolation pads with load plates bolt connected on two sides of a structural steel channel. The assembly shall be designed to allow welding to supporting structures without metal to metal connection between risers and the building structure.
  2. Riser supports, anchors and guides shall be selected by the manufacturer, and shall be spaced at locations as indicated on the drawings, or as required for risers to be supported and isolated.
  3. TYPE R riser isolation systems shall incorporate MODEL RSF, riser supports, MODEL RAF riser anchors, and MODEL RGN riser guides, as manufactured by Consolidated Kinetics Corp.

## **2.6 VIBRATION ISOLATOR SELECTION**

- A. Noise and vibration isolator types, minimum operating static deflections, and supplemental bases shall be provided for individual mechanical equipment units according to manufacturer's recommendations unless noted otherwise on the drawings or equipment specification or as tabulated in the equipment schedules of the project drawings.
- B. Vibration isolation rails, TYPE C, shall be used to support all roof curb mounted mechanical equipment. Roof mounted mechanical equipment other than curb mounted shall have isolator types as recommended by manufacturer unless noted otherwise on drawings or equipment specifications for each equipment type with minimum operating static deflections increased 50% for a given span condition.
- C. Noise and vibration isolator types and minimum operating static deflections for suspended or floor mounted piping shall be as follows:
1. TYPE H hangers, or TYPE S floor mounts, with minimum operating static deflections equal to 50% of connected equipment isolator deflections, or one (1) inch, whichever is greater, shall be used to support all piping over one (1) inch outside diameter located within mechanical equipment rooms, traveling between equipment rooms, and for a minimum of 50 feet or 100 pipe diameters, whichever is greater, from connections to vibration isolated mechanical or electrical equipment.
  2. TYPE F hangers of floor mounts, with a maximum natural frequency of 12 Hz. shall be used to support all piping throughout the building which is connected to vibration isolated equipment, and not specified to receive TYPE H or TYPE S isolators.
  3. All piping connected to fire pumps or sprinkler systems is excluded from vibration or noise isolation requirements.
- D. Noise and vibration isolator types and minimum operating static deflections for suspended, or floor mounted, sheetmetal ductwork air plenums, pressure reducing valves, sound traps and similar air distribution elements shall be as follows:
1. TYPE H hangers, or TYPE S floor mounts with minimum operating static deflections equal to 50% of connected equipment isolator deflection, or one (1) inch, whichever is greater, shall be used to support all sheetmetal air distribution elements located within

- mechanical equipment rooms, traveling between equipment rooms, and for a minimum of 50 feet from connections to vibration isolated mechanical equipment.
2. TYPE S hangers, or floor mounts, with minimum operating static deflections of one (1) inch, shall be used to support all sheetmetal ductwork, having air velocities of 1000 feet per minute and higher, which is supported by structures above or below spaces having noise criteria levels of NC 35 or lower.
- E. Isolator types are scheduled to establish minimum standards. At the Contractor's option labor saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages, provided isolators supplied incorporate the specified isolator type, and do not degrade the noise and vibration isolation of equipment mounted.
- F. Supplemental equipment base types tabulated can be deleted for unitary packaged air handling equipment having a rigid frame and casing providing a distortion-free platform for attachment of vibration isolators.
- G. Supplemental equipment bases TYPE K or TYPE B as required shall be provided for all mechanical equipment having non-unitary driving and driven members, or equipment configuration such that mounting on vibration isolators would cause increased strain on connected piping or ductwork if supplemental bases are not provided.
- H. TYPE M motor slide bases shall be provided for non-unitary fan-motor sets to be mounted on supplemental steel frame or concrete inertia bases specified in this section.
- I. Air mount type noise and vibration isolators can be used in lieu of TYPE S spring mount at Contractor's option if the natural frequency of the air mounts supplied is less than or equal to TYPE S spring at tabulated minimum operating static deflections, and manufacturer warrants the air mount for stability in operation.

## **2.7 FLEXIBLE PIPE CONNECTORS**

- A. Flexible pipe connectors shall be Metraflex, Type ML/SL with corrugated inner tubing of tin bronze or Type 321 stainless steel as applicable with stainless steel outer shield for strength and durability. Provide forged steel flanges, ASA 150 lb. standard.

## **2.8 FLEXIBLE DUCT CONNECTIONS**

- A. Provide sound and vibration isolating flexible connections on the inlet and outlet of all fans and units to which duct connections are made. Connections shall be Ventglas neoprene coated glass fabric. At least one inch slack shall be allowed in these connections to insure that no vibration is transmitted from fan to ductwork.

# **PART 3 - EXECUTION**

## **3.1 INSTALLATION**

- A. Installation of all vibration isolation materials and supplemental equipment bases specified in this Section of the Specification shall be accomplished following the manufacturer's written instructions.

- B. Install all pump connectors in a straight line without offset. Piping to be anchored or hung so that the weight of the piping does not rest on the pump connector.
- C. On completion of installation of all isolation materials and before start up of isolated equipment all debris shall be cleared from areas surrounding and from beneath all isolated equipment, leaving equipment free to move on the isolation supports.
- D. No rigid connections between equipment and building structure shall be made that degrades the noise and vibration isolation system herein specified. Electrical conduit connections to isolated equipment shall be looped to allow free motion of isolated equipment.

### **3.2 INSPECTION**

- A. The Contractor shall notify the local representative of the vibration isolation materials manufacturer prior to installing any vibration isolation devices. The Contractor shall seek the representative's guidance in any installation procedures he is unfamiliar with.
- B. The local representative of the vibration isolation materials manufacturer shall conduct periodic inspections of the installation of materials herein specified, and shall report in writing to the Contractor any deviations from good installation practice observed.
- C. On completion of installation of all noise and vibration isolation devices herein specified the local representative of the isolation materials manufacturer shall inspect the completed system and report in writing any installation errors, improperly selected isolation devices, or other fault in the system that could effect the performance of the system.
- D. The Installing Contractor shall submit a report to the Architect, including the manufacturer's representatives final report indicating all isolation reported as properly installed or requiring correction and include a report by the Contractor on steps taken to properly complete the isolation work.

END OF SECTION 230210

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## **SECTION 230513 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT-CPL**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

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

#### **1.02 RELATED REQUIREMENTS**

- A. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.
- B. Section 262913 - Enclosed Controllers.

#### **1.03 REFERENCE STANDARDS**

- A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings 2015.
- B. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators 2017.
- C. NEMA MG 1 - Motors and Generators 2018.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

#### **1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.
- D. Operation Data: Include instructions for safe operating procedures.
- E. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

#### **1.05 QUALITY ASSURANCE**

- A. Comply with NFPA 70.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

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

#### **1.07 WARRANTY**

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Provide five year manufacturer warranty for motors larger than 20 horsepower.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Baldor Electric Company/ABB Group: [www.baldor.com/#sle](http://www.baldor.com/#sle).
- B. Leeson Electric Corporation: [www.leeson.com/#sle](http://www.leeson.com/#sle).
- C. Regal-Beloit Corporation (Century): [www.centuryelectricmotor.com/#sle](http://www.centuryelectricmotor.com/#sle).
- D. Substitutions: See Section 016000 - Product Requirements.

#### **2.02 GENERAL CONSTRUCTION AND REQUIREMENTS**

- A. Electrical Service: Refer to Section 260583 for required electrical characteristics.

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

### 2.03 APPLICATIONS

- A. Exception: Motors less than 250 watts, for intermittent service may be the equipment manufacturer's standard and need not comply with these specifications.
- B. Single phase motors for fans, blowers, and pumps: Capacitor start, capacitor run type.
- C. Motors located in exterior locations, wet air streams downstream of sprayed coil dehumidifiers, draw through cooling towers, air cooled condensers, humidifiers, direct drive axial fans, roll filters, explosion proof environments, and dust collection systems: Totally enclosed type.

### 2.04 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A. Starting Torque: Three times full load torque.
- B. Starting Current: Less than five times full load current.
- C. Pull-up Torque: Up to 350 percent of full load torque.
- D. Breakdown Torque: Approximately 250 percent of full load torque.
- E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings.
- G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

### 2.05 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Starting Torque: Between 1 and 1-1/2 times full load torque.
- B. Starting Current: Six times full load current.
- C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- D. Design, Construction, Testing, and Performance: Comply with NEMA MG 1 for Design B motors.
- E. Insulation System: NEMA Class B or better.
- F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 262913.



- I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- J. Sound Power Levels: To NEMA MG 1.
- K. Part Winding Start Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- L. Nominal Efficiency: As indicated at full load and rated voltage when tested in accordance with IEEE 112.
- M. Nominal Power Factor: As indicated at full load and rated voltage when tested in accordance with IEEE 112.

## **2.06 ELECTRONICALLY COMMUTATED MOTORS (ECM)**

- A. Applications:
  - 1. Commercial:
    - a. Roof Top Unit:
      - 1) Operating Mode: Constant speed.
      - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the roof top unit and/or specified sequence of operation.
      - 3) Shaft Extension: Single.
    - b. Exhaust Fan (EF):
      - 1) Operating Mode: Variable cfm.
      - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the PRV and/or specified sequence of operation.
      - 3) Shaft Extension: Single.
      - 4) Options: Remote mount control.
    - c. Energy Recovery Ventilator:
      - 1) Operating Mode: Constant cfm.
      - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the energy recovery ventilator and/or specified sequence of operation.
      - 3) Shaft Extension: Single.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

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

**END OF SECTION**

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**SECTION 230516  
EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING****PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

**1.02 SUMMARY****1.03 SECTION INCLUDES:**

- A. Slip-joint packed expansion joints.
- B. Flexible-hose packless expansion joints.
- C. Pipe loops and swing connections.
- D. Alignment guides and anchors.

**1.04 PERFORMANCE REQUIREMENTS**

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

**1.05 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Delegated-Design Submittal: For each anchor and alignment guide 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 requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
  - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
  - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
  - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

**1.06 CLOSEOUT SUBMITTALS**

- A. Maintenance Data: For expansion joints to include in maintenance manuals.

**1.07 QUALITY ASSURANCE**

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
  - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
  - 2. ASME Boiler and Pressure Vessel Code: Section IX.

**PART 2 PRODUCTS****2.01 PACKED EXPANSION JOINTS**

- A. Slip-Joint Packed Expansion Joints:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Adscio Manufacturing LLC.
    - b. Advanced Thermal Systems, Inc.
    - c. Hyspan Precision Products, Inc.
  - 2. Standard: ASTM F 1007.
  - 3. Material: Carbon steel with asbestos-free PTFE packing.
  - 4. Design: With internal guide and injection device for repacking under pressure. Include drip connection if used for steam piping.
  - 5. Configuration: Single joint class unless otherwise indicated.
  - 6. End Connections: Flanged or weld ends to match piping system.

**2.02 PACKLESS EXPANSION JOINTS****A. Flexible-Hose Packless Expansion Joints:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Flex-Hose Co., Inc.
  - b. Flexicraft Industries.
  - c. Flex Pression Ltd.
  - d. Metraflex, Inc.
  - e. Unisource Manufacturing, Inc.
2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.
  - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
5. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with flanged or welded end connections.
  - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
6. Expansion Joints for Steel Piping NPS 8 to NPS 12: Carbon-steel fittings with flanged or welded end connections.
  - a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

**2.03 ALIGNMENT GUIDES AND ANCHORS****A. Alignment Guides:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Adscro Manufacturing LLC.
  - b. Advanced Thermal Systems, Inc.
  - c. Flex-Hose Co., Inc.
  - d. Flexicraft Industries.
  - e. Flex-Weld, Inc.
  - f. Hyspan Precision Products, Inc.
  - g. Metraflex, Inc.
  - h. Senior Flexonics Pathway.
  - i. Unisource Manufacturing, Inc.
  - j. S. Bellows, Inc.
2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

**B. Anchor Materials:**

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
  - a. Stud: Threaded, zinc-coated carbon steel.
  - b. Expansion Plug: Zinc-coated steel.
  - c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

- a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
- b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
- c. Washer and Nut: Zinc-coated steel.

### **PART 3 EXECUTION**

#### **3.01 EXPANSION-JOINT INSTALLATION**

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install packed-type expansion joints with packing suitable for fluid service.

#### **3.02 PIPE LOOP AND SWING CONNECTION INSTALLATION**

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

#### **3.03 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION**

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
  1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
  2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
  1. Anchor Attachment to Steel Structural Members: Attach by welding.
  2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

#### **END OF SECTION**

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**SECTION 230517  
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING-CPL**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Pipe sleeves.
- B. Manufactured sleeve-seal systems.

**1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 230719 - HVAC Piping Insulation-CPL.

**1.03 REFERENCE STANDARDS**

- A. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) 2016.
- B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems 2013a (Reapproved 2017).

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.

**1.05 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

**PART 2 PRODUCTS**

**2.01 PIPE SLEEVES**

- A. Vertical Piping:
  - 1. Sleeve Length: 1 inch above finished floor.
  - 2. Provide sealant for watertight joint.
  - 3. Blocked Out Floor Openings: Provide 1-1/2 inch angle set in silicon adhesive around opening.
  - 4. Drilled Penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.
- B. Sheet Metal: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.
- C. Pipe Passing Through Below Grade Exterior Walls:
  - 1. Zinc coated or cast iron pipe.
  - 2. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.
- D. Pipe Passing Through Concrete Beam Flanges, except where Brass Pipe Sleeves are Specified:
  - 1. Galvanized steel pipe or black iron pipe with asphalt coating.
  - 2. Connect sleeve with floor plate except in mechanical rooms.
- E. Pipe Passing Through Mechanical, Laundry, and Animal Room Floors above Basement:
  - 1. Galvanized steel pipe or black iron pipe with asphalt coating.

2. Connect sleeve with floor plate except in mechanical rooms.
- F. Clearances:
  1. Provide allowance for insulated piping.
  2. Wall, Floor, Floor, Partitions, and Beam Flanges: 1 inch greater than external; pipe diameter.
  3. All Rated Openings: Caulked tight with fire stopping material in compliance with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.

## 2.02 MANUFACTURED SLEEVE-SEAL SYSTEMS

- A. Modular/Mechanical Seal:
  1. Synthetic rubber interlocking links continuously fill annular space between pipe and wall/casing opening.
  2. Provide watertight seal between pipe and wall/casing opening.
  3. Elastomer element size and material in accordance with manufacturer's recommendations.
  4. Glass reinforced plastic pressure end plates.

## PART 3 EXECUTION

### 3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.

### 3.02 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- B. Install piping to conserve building space, to not interfere with use of space and other work.
- C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- D. Inserts:
  1. Provide inserts for placement in concrete formwork.
  2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
  3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
  4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
  5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- E. Structural Considerations:
  1. Do not penetrate building structural members unless indicated.
- F. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
  1. Underground Piping: Caulk pipe sleeve watertight with lead and oakum or mechanically expandable chloroprene inserts with bitumen sealed metal components.
  2. Aboveground Piping:
    - a. Pack solid using mineral fiber in compliance with ASTM C592.
    - b. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.
  3. All Rated Openings: Caulk tight with fire stopping material in compliance with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.
  4. Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed components.
- G. Manufactured Sleeve-Seal Systems:
  1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.



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2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
  3. Locate piping in center of sleeve or penetration.
  4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
  5. Tighten bolting for a water-tight seal.
  6. Install in accordance with manufacturer's recommendations.
- H. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

### **3.03 CLEANING**

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

**END OF SECTION**

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**SECTION 230518 - ESCUTCHEONS FOR HVAC 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:
  - 1. Escutcheons.
  - 2. Floor plates.

**1.3 ACTION SUBMITTALS**

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

**PART 2 - PRODUCTS**

**2.1 ESCUTCHEONS**

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

**2.2 FLOOR PLATES**

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

- A. Install escutcheons for exposed piping penetrations of walls, ceilings, finished floors, and millwork, except in mechanical equipment rooms or unoccupied areas.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

**3.2 FIELD QUALITY CONTROL**

- A. Replace broken and damaged escutcheons and floor plates using new materials.

**END OF SECTION 230518**

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## **SECTION 230519 METERS AND GAUGES FOR HVAC PIPING-CPL**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Flow meters.
- B. Pressure gauges and pressure gauge taps.
- C. Thermometers and thermometer wells.
- D. Filter gauges.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 232113 - Hydronic Piping.

#### **1.03 REFERENCE STANDARDS**

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments 2013.
- B. ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi 2004 (Reaffirmed 2017).
- C. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers 2014.
- D. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers 2014 (Reapproved 2021).
- E. UL 393 - Indicating Pressure Gauges for Fire-Protection Service Current Edition, Including All Revisions.

#### **1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components.

#### **1.05 FIELD CONDITIONS**

- A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

### **PART 2 PRODUCTS**

#### **2.01 LIQUID FLOW METERS**

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  - 2. McCrometer: [www.mccrometer.com/#sle](http://www.mccrometer.com/#sle).
  - 3. Venture Measurement, a Danaher Company: [www.venturemeasurement.com/#sle](http://www.venturemeasurement.com/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Calibrated ASME MFC-3M Venturi orifice plate and flanges with valved taps, chart for conversion of differential pressure readings to flow rate, with pressure gauge in case.
- C. Annular element flow stations with meter set.
  - 1. Measuring Station: Type 316 stainless steel pitot type flow element inserted through welded threaded couplet, with safety shut-off valves and quick coupling connections, and permanent metal tag indicating design flow rate, reading for design flow rate, metered fluid, line size, station or location number.
    - a. Pressure rating: 275 psi.
    - b. Maximum temperature: 400 degrees F.
    - c. Accuracy: Plus 0.55 percent to minus 2.30 percent.

#### **2.02 PRESSURE GAUGES**

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  - 2. Moeller Instrument Company, Inc: [www.moellerinstrument.com/#sle](http://www.moellerinstrument.com/#sle).
  - 3. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).

4. Substitutions: See Section 016000 - Product Requirements.
- B. Pressure Gauges: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
  1. Case: Steel with brass bourdon tube.
  2. Size: 4-1/2 inch diameter.
  3. Mid-Scale Accuracy: One percent.
  4. Scale: Psi.

### 2.03 PRESSURE GAUGE TAPPINGS

- A. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections.

### 2.04 STEM TYPE THERMOMETERS

- A. Manufacturers:
  1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  2. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).
  3. Weksler Glass Thermometer Corp: [www.wekslerglass.com/#sle](http://www.wekslerglass.com/#sle).
  4. Substitutions: See Section 016000 - Product Requirements.
- B. Thermometers - Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
  1. Size: 9 inch scale.
  2. Window: Clear Lexan.
  3. Stem: 3/4 inch NPT brass.
  4. Accuracy: 2 percent, per ASTM E77.
  5. Calibration: Degrees F.

### 2.05 THERMOMETER SUPPORTS

- A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- B. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

### 2.06 TEST PLUGS

- A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene core for temperatures up to 200 degrees F.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge with needle valves for isolation suction and discharge pressure.
- C. Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Provide siphon on gauges in steam systems. Extend nipples and siphons to allow clearance from insulation.
- D. Install pressure gauges on the inlet and outlet piping of all hydronic zones, hydronic coils, and heat transfer equipment.
- E. Install pressure gauges upstream and downstream of all pressure reducing valves.
- F. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- G. Install thermometers in air duct systems on flanges.

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- H. Install thermometers in the return duct, outside air duct, inlet duct, and supply duct of all air handling systems and terminal units.
- I. Install thermometers on the inlet and outlet piping of all hydronic zones, hydronic coils, and heat transfer equipment.
- J. Locate duct mounted thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.
- K. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- L. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- M. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- N. Locate test plugs adjacent to pressure gauges and pressure gauge taps.

**END OF SECTION**

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## SECTION 230523 GENERAL-DUTY VALVES FOR HVAC PIPING-CPL

### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Applications.
- B. Globe valves.
- C. Ball valves.
- D. Butterfly valves.
- E. Check valves.
- F. Gate valves.
- G. Chainwheels.

#### 1.02 RELATED REQUIREMENTS

- A. Section 230553 - Identification for HVAC Piping and Equipment-CPL.
- B. Section 230719 - HVAC Piping Insulation-CPL.
- C. Section 232113 - Hydronic Piping.

#### 1.03 ABBREVIATIONS AND ACRONYMS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. NRS: Nonrising stem.
- E. OS&Y: Outside screw and yoke.
- F. PTFE: Polytetrafluoroethylene.
- G. RS: Rising stem.
- H. SWP: Steam working pressure.
- I. TFE: Tetrafluoroethylene.
- J. WOG: Water, oil, and gas.

#### 1.04 REFERENCE STANDARDS

- A. ASME B1.20.1 - Pipe Threads, General Purpose (Inch) 2013 (Reaffirmed 2018).
- B. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250 2020.
- C. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard 2020.
- D. ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves 2017.
- E. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2018.
- F. ASME B16.34 - Valves — Flanged, Threaded, and Welding End 2020.
- G. ASME B31.9 - Building Services Piping 2020.
- H. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings 2004 (Reapproved 2019).
- I. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures 1999 (Reapproved 2018).
- J. ASTM A536 - Standard Specification for Ductile Iron Castings 1984 (Reapproved 2019)e1.
- K. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings 2017.
- L. AWWA C606 - Grooved and Shouldered Joints 2015.
- M. MSS SP-45 - Bypass and Drain Connections 2003 (Reaffirmed 2008).

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- N. MSS SP-67 - Butterfly Valves 2017.
- O. MSS SP-68 - High Pressure Butterfly Valves with Offset Design 2017.
- P. MSS SP-71 - Cast Iron Swing Check Valves, Flanged and Threaded Ends 2018.
- Q. MSS SP-72 - Ball Valves with Flanged or Butt-Welding Ends for General Service 2010a.
- R. MSS SP-80 - Bronze Gate, Globe, Angle and Check Valves 2013.
- S. MSS SP-85 - Cast Iron Globe & Angle Valves, Flanged and Threaded Ends 2011.
- T. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends 2010.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- D. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

#### **1.06 QUALITY ASSURANCE**

- A. Manufacturer:
  - 1. Obtain valves for each valve type from single manufacturer.
  - 2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Prepare valves for shipping as follows:
  - 1. Minimize exposure of operable surfaces by setting plug and ball valves to open position.
  - 2. Protect valve parts exposed to piped medium against rust and corrosion.
  - 3. Protect valve piping connections such as grooves, weld ends, threads, and flange faces.
  - 4. Adjust globe, gate, and angle valves to the closed position to avoid clattering.
  - 5. Secure check valves in either the closed position or open position.
  - 6. Adjust butterfly valves to closed or partially closed position.
- B. Use the following precautions during storage:
  - 1. Maintain valve end protection and protect flanges and specialties from dirt.
    - a. Provide temporary inlet and outlet caps.
    - b. Maintain caps in place until installation.
  - 2. Store valves in shipping containers and maintain in place until installation.
    - a. Store valves indoors in dry environment.
    - b. Store valves off the ground in watertight enclosures when indoor storage is not an option.
- C. Exercise the following precautions for handling:
  - 1. Handle large valves with sling, modified to avoid damage to exposed parts.
  - 2. Avoid the use of operating handles or stems as rigging or lifting points.

### **PART 2 PRODUCTS**

#### **2.01 APPLICATIONS**

- A. Provide the following valves for the applications if not indicated on drawings:
  - 1. Throttling (Hydronic): Butterfly, Ball, and Globe.
  - 2. Throttling (Steam): Gate.
  - 3. Isolation (Shutoff): Butterfly and Ball.
  - 4. Swing Check (Pump Outlet):

- a. 2 NPS and Smaller: Bronze with bronze disc.
  - b. 2-1/2 NPS and Larger: Iron with lever and weight, lever and spring, center-guided metal, or center-guided with resilient seat.
- 5. Dead-End: Butterfly, single-flange (lug) type.
- B. Required Valve End Connections for Non-Wafer Types:
  - 1. Steel Pipe:
    - a. 2 NPS and Smaller: Threaded ends.
    - b. 2-1/2 NPS and Larger: Grooved ends or flanged.
  - 2. Copper Tube:
    - a. 2 NPS and Smaller: Threaded ends (Exception: Solder-joint valve-ends).
  - 3. Steam and Steam Condensate Pipe: Grooved ends not acceptable.
- C. Heating Hot Water Valves:
  - 1. 2 NPS and Smaller, Brass and Bronze Valves:
    - a. Threaded ends.
    - b. Ball: Full port, two piece, stainless steel trim.
    - c. Swing Check: Bronze disc, Class 125.
    - d. Globe: Bronze disc, Class 125.
  - 2. 2-1/2 NPS and Larger, Iron Valves:
    - a. Ball: 2-1/2 NPS to 10 NPS, Class 150.
    - b. Single-Flange Butterfly: 2-1/2 NPS to 12 NPS, aluminum-bronze disc, EPDM seat, 200 CWP.
    - c. Single-Flange Butterfly: 14 NPS to 24 NPS, aluminum-bronze disc, EPDM seat, 150 CWP.
    - d. Grooved-End Butterfly: 2-1/2 NPS to 12 NPS, 175 CWP.
    - e. Swing Check: Nonmetallic-to-metal seats, Class 125.
    - f. Grooved-End Swing Check: 3 NPS to 12 NPS, 300 CWP.

## 2.02 GENERAL REQUIREMENTS

- A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.
- B. Valve Sizes: Match upstream piping unless otherwise indicated.
- C. Valve Actuator Types:
  - 1. Gear Actuator: Quarter-turn valves 8 NPS and larger.
  - 2. Handwheel: Valves other than quarter-turn types.
  - 3. Hand Lever: Quarter-turn valves 6 NPS and smaller.
  - 4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator, of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
- D. Valves in Insulated Piping: Provide 2 NPS stem extensions and the following features:
  - 1. Gate Valves: Rising stem.
  - 2. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
  - 3. Butterfly Valves: Extended neck.
  - 4. Memory Stops: Fully adjustable after insulation is installed.
- E. Memory Stops: Fully adjustable after insulation is installed.
- F. Valve-End Connections:
  - 1. Threaded End Valves: ASME B1.20.1.
  - 2. Flanges on Iron Valves: ASME B16.1 for flanges on iron valves.
  - 3. Pipe Flanges and Flanged Fittings 1/2 NPS through 24 NPS: ASME B16.5.
  - 4. Solder Joint Connections: ASME B16.18.
  - 5. Grooved End Connections: AWWA C606.
- G. General ASME Compliance:
  - 1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
  - 2. Building Services Piping Valves: ASME B31.9.

- H. Bronze Valves:
  - 1. Fabricate from dezincification resistant material.
  - 2. Copper alloys containing more than 15 percent zinc are not permitted.
- I. Valve Bypass and Drain Connections: MSS SP-45.
- J. Source Limitations: Obtain each valve type from a single manufacturer.

### **2.03 BRONZE, GLOBE VALVES**

- A. Class 125: CWP Rating: 200 psig.:
  - 1. Comply with MSS SP-80, Type 1.
  - 2. Body: Bronze; ASTM B62, with integral seat and screw in bonnet.
  - 3. Ends: Threaded or solder joint.
  - 4. Stem and Disc: Bronze or PTFE.
  - 5. Packing: Asbestos free.
    - a. Handwheel: Malleable iron.

### **2.04 IRON, GLOBE VALVES**

- A. Class 125: CWP Rating: 200 psig. and Class 250: CWP Rating: 500 psig.:
  - 1. Comply with MSS SP-85, Type I.
  - 2. Body: Gray iron; ASTM A126, with bolted bonnet.
  - 3. Ends: Flanged.
  - 4. Trim: Bronze.
  - 5. Packing and Gasket: Asbestos free.
  - 6. Operator: Handwheel or chainwheel.

### **2.05 BRONZE, BALL VALVES**

- A. General:
  - 1. Fabricate from dezincification resistant material.
  - 2. Copper alloys containing more than 15 percent zinc are not permitted.
- B. Two Piece, Full Port with Stainless Steel Trim:
  - 1. Comply with MSS SP-110.
  - 2. SWP Rating: 150 psig.
  - 3. CWP Rating: 600 psig.
  - 4. Body: Forged bronze.
  - 5. Ends: Threaded.
  - 6. Seats: PTFE or TFE.
  - 7. Stem: Stainless steel.
  - 8. Ball: Stainless steel, vented.

### **2.06 IRON, BALL VALVES**

- A. Split Body, Full Port:
  - 1. Comply with MSS SP-72.
  - 2. CWP Rating: 200 psig.
  - 3. Body: ASTM A126, gray iron.
  - 4. Ends: Flanged.
  - 5. Seats: PTFE.
  - 6. Stem: Stainless steel.
  - 7. Ball: Stainless steel.

### **2.07 IRON, SINGLE FLANGE BUTTERFLY VALVES**

- A. Lug Style: Bi-directional dead-end service without use of downstream flange.
  - 1. Comply with MSS SP-67, Type I.
  - 2. CWP Rating: 150 psig and 200 psig.
  - 3. Body Material: ASTM A126 cast iron or ASTM A536 ductile iron.
  - 4. Stem: One or two-piece stainless steel.
  - 5. Seat: NBR.
  - 6. Disc: Coated ductile iron.

## **2.08 IRON, GROOVED-END BUTTERFLY VALVES**

- A. CWP Rating: 175 psig (1200 kPa), 300 psig (2070 kPa): 8 NPS (50 DN) or smaller, and 200 psig (1389 kPa): 10 NPS (250 DN) or larger.
  - 1. Comply with MSS SP-67, Type I.
  - 2. Body: Coated ductile iron.
  - 3. Stem: Stainless steel.
  - 4. Disc: Coated ductile iron.
  - 5. Disc Seal: EPDM.

## **2.09 HIGH-PERFORMANCE, SINGLE FLANGE BUTTERFLY VALVES**

- A. Lug type: Bi-directional dead end service without downstream flange.
  - 1. Comply with MSS SP-68.
  - 2. Class 150: CWP Rating: 285 psig and Class 300: CWP Rating: 720 psig at 100 degrees F.
  - 3. Body: Provide carbon steel, cast iron, ductile Iron, or stainless steel.
  - 4. Seat: Metal or reinforced PTFE.
  - 5. Offset stem: Stainless steel.
  - 6. Disc: Carbon steel.

## **2.10 BRONZE, SWING CHECK VALVES**

- A. Class 125: CWP Rating: 200 psig (1380 kPa) and Class 150: CWP Rating: 300 psig (2070 kPa).
  - 1. Comply with MSS SP-80, Type 3.
  - 2. Body Design: Horizontal flow.
  - 3. Body Material: Bronze, ASTM B62.
  - 4. Ends: Threaded.
  - 5. Disc: Bronze.

## **2.11 IRON, FLANGED END SWING CHECK VALVES**

- A. Class 125: CWP Rating: 200 psig (1380 kPa) with Metal Seats.
  - 1. Comply with MSS SP-71, Type I.
  - 2. Design: Clear or full waterway with flanged ends.
  - 3. Body: Gray iron with bolted bonnet in accordance with ASTM A126.
  - 4. Trim: Bronze.
  - 5. Gasket: Asbestos free.

## **2.12 IRON, GROOVED-END SWING CHECK VALVES**

- A. 300 CWP:
  - 1. 2 NPS to 8 NPS.
  - 2. CWP Rating: 300 psig.
  - 3. Body Material: ASTM A536, Grade 65-45-12 ductile iron.
  - 4. Seal: EPDM or Nitrile.
  - 5. Disc: Ductile iron.
  - 6. Coating: Black, non-lead paint.

## **2.13 CHAINWHEELS**

- A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
  - 1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
  - 2. Attachment: For connection to ball, butterfly, and plug valve stems.
  - 3. Sprocket Rim with Chain Guides: Ductile iron include zinc coating.
  - 4. Chain: Hot-dip galvanized steel. Sized to fit sprocket rim.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Discard all packing materials and verify that valve interior, including threads and flanges, are completely clean without signs of damage or degradation that could result in leakage.
- B. Verify valve parts to be fully operational in all positions from closed to fully open.

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- C. Confirm gasket material to be suitable for the service, to be of correct size, and without defects that could compromise effectiveness.
- D. Should valve is determined to be defective, replace with new valve.

### **3.02 INSTALLATION**

- A. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.
- B. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.
- C. Install check valves where necessary to maintain direction of flow as follows:
  - 1. Swing Check: Install horizontal maintaining hinge pin level.
- D. Provide chainwheels on operators for valves 4 NPS and larger where located 96 NPS or more above finished floor, terminating 60 NPS above finished floor.

**END OF SECTION**

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## **SECTION 230529 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT-CPL**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Support and attachment components for equipment, piping, and other HVAC/hydraulic work.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 055000 - Metal Fabrications : Materials and requirements for fabricated metal supports.
- C. Section 230548 - Vibration and Seismic Controls for HVAC.

#### **1.03 REFERENCE STANDARDS**

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware 2016a.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General - Purpose Piping 2014 (Reapproved 2020).
- D. ASTM A36/A36M - Standard Specification for Carbon Structural Steel 2019.
- E. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings 1999, with Editorial Revision (2018).
- F. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel 2019.
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- H. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials 2016.
- I. MFMA-4 - Metal Framing Standards Publication 2004.
- J. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018.
- K. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
  - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
  - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
  - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
  - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.

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- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, nonpenetrating rooftop supports, post-installed concrete and masonry anchors, and thermal insulated pipe supports.
- C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.
  - 1. Application of protective inserts, saddles, and shields at pipe hangers for each type of insulation and hanger.
- D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with applicable building code.
- B. Installer Qualifications for Field-Welding: As specified in Section 055000.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

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

### **PART 2 PRODUCTS**

#### **2.01 SUPPORT AND ATTACHMENT COMPONENTS**

- A. General Requirements:
  - 1. Comply with MSS SP-58.
  - 2. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
  - 3. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
  - 4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 4.0. Include consideration for vibration, equipment operation, and shock loads where applicable.
  - 5. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
  - 6. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
    - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
    - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
    - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
    - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Materials for Metal Fabricated Supports: Comply with Section 055000.
- C. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
  - 1. Manufacturers:
    - a. Cooper B-Line, a division of Eaton Corporation: [www.cooperindustries.com/#sle](http://www.cooperindustries.com/#sle).
    - b. Ferguson Enterprises Inc: [www.fnw.com/#sle](http://www.fnw.com/#sle).
    - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - d. Unistrut, a brand of Atkore International Inc: [www.unistrut.com/#sle](http://www.unistrut.com/#sle).
  - 2. Provide factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.



3. Comply with MFMA-4.
4. Channel Material:
  - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
  - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
5. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch.
6. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.
- D. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
  1. Minimum Size, Unless Otherwise Indicated or Required:
    - a. Equipment Supports: 1/2 inch diameter.
    - b. Piping up to 1 inch (27 mm) nominal: 1/4 inch diameter.
    - c. Piping larger than 1 inch (27 mm) nominal: 3/8 inch diameter.
    - d. Trapeze Support for Multiple Pipes: 3/8 inch diameter.
- E. Pipe Supports:
  1. Liquid Temperatures Up To 122 degrees F:
    - a. Overhead Support: MSS SP-58 Types 1, 3 through 12.
    - b. Support From Below: MSS SP-58 Types 35 through 38.
  2. Operating Temperatures from 122 to 446 degrees F:
    - a. Overhead Support: MSS SP-58 Type 1 or 3 through 12, with appropriate saddle of MSS SP-58 Type 40 for insulated pipe.
    - b. Roller Support: MSS SP-58 Types 41 or 43 through 46, with appropriate saddle of MSS SP-58 Type 39 for insulated pipe.
    - c. Sliding Support: MSS SP-58 Types 35 through 38.
- F. Pipe Stanchions: For pipe runs, use stanchions of same type and material where vertical adjustment is required for stationary pipe.
  1. Manufacturers:
    - a. Anvil International; H-Block: [www.anvilintl.com/#sle](http://www.anvilintl.com/#sle).
  2. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
  3. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.
- G. Beam Clamps: MSS SP-58 Types 19 through 23, 25 or 27 through 30 based on required load.
  1. Manufacturers:
    - a. Ferguson Enterprises Inc: [www.fnw.com/#sle](http://www.fnw.com/#sle).
  2. Material: ASTM A36/A36M carbon steel or ASTM A181/A181M forged steel.
  3. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
- H. Riser Clamps:
  1. Provide copper plated clamps for copper tubing support.
  2. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
- I. Offset Pipe Clamps: Double-leg design two-piece pipe clamp.
- J. Strut Clamps: Two-piece pipe clamp.
- K. Insulation Clamps: Two bolt-type clamps designed for installation under insulation.
- L. Pipe Hangers: For a given pipe run, use hangers of the same type and material.
  1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
  2. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.
- M. Nonpenetrating Rooftop Supports for Low-Slope Roofs:
  1. Manufacturers:
    - a. Anvil International; H-Block: [www.anvilintl.com/#sle](http://www.anvilintl.com/#sle).
    - b. Cooper B-Line, a division of Eaton Corporation: [www.cooperindustries.com/#sle](http://www.cooperindustries.com/#sle).
    - c. Erico International Corporation, a brand of Pentair: [www.erico.com/#sle](http://www.erico.com/#sle).
    - d. Ferguson Enterprises Inc: [www.fnw.com/#sle](http://www.fnw.com/#sle).

- e. PHP Systems/Design: [www.phpsd.com/#sle](http://www.phpsd.com/#sle).
- f. Unistrut, a brand of Atkore International Inc: [www.unistrut.com/#sle](http://www.unistrut.com/#sle).
- 2. Provide steel pedestals with thermoplastic or rubber base that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified.
- 3. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
- 4. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.
- 5. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.
- N. Pipe Shields for Insulated Piping:
  - 1. Manufacturers:
    - a. Anvil International: [www.anvilintl.com/#sle](http://www.anvilintl.com/#sle).
  - 2. General Construction and Requirements:
    - a. Surface Burning Characteristics: Comply with ASTM E84 or UL 723.
    - b. Shields Material: UV-resistant polypropylene with glass fill.
    - c. Maximum Insulated Pipe Outer Diameter: 12-5/8 inch.
    - d. Minimum Service Temperature: Minus 40 degrees F.
    - e. Maximum Service Temperature: 178 degrees F.
    - f. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
- O. Anchors and Fasteners:
  - 1. Manufacturers - Mechanical Anchors:
    - a. Hilti, Inc: [www.us.hilti.com/#sle](http://www.us.hilti.com/#sle).
    - b. ITW Red Head, a division of Illinois Tool Works, Inc: [www.itwredhead.com/#sle](http://www.itwredhead.com/#sle).
    - c. Powers Fasteners, Inc: [www.powers.com/#sle](http://www.powers.com/#sle).
    - d. Simpson Strong-Tie Company Inc: [www.strongtie.com/#sle](http://www.strongtie.com/#sle).
  - 2. Manufacturers - Powder-Actuated Fastening Systems:
    - a. Hilti, Inc: [www.us.hilti.com/#sle](http://www.us.hilti.com/#sle).
    - b. ITW Ramset, a division of Illinois Tool Works, Inc: [www.ramset.com/#sle](http://www.ramset.com/#sle).
    - c. Powers Fasteners, Inc: [www.powers.com/#sle](http://www.powers.com/#sle).
    - d. Simpson Strong-Tie Company Inc: [www.strongtie.com/#sle](http://www.strongtie.com/#sle).
  - 3. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
  - 4. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
  - 5. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
  - 6. Hollow Masonry: Use toggle bolts.
  - 7. Hollow Stud Walls: Use toggle bolts.
  - 8. Steel: Use beam clamps, machine bolts, or welded threaded studs.
  - 9. Sheet Metal: Use sheet metal screws.
  - 10. Wood: Use wood screws.
  - 11. Plastic and lead anchors are not permitted.
  - 12. Hammer-driven anchors and fasteners are not permitted.
  - 13. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
    - a. Comply with MFMA-4.
    - b. Channel Material: Use galvanized steel.
    - c. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch minimum base metal thickness.
    - d. Manufacturer: Same as manufacturer of metal channel (strut) framing system.
  - 14. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) for compliance with applicable building code.
- P. Pipe Installation Accessories:
  - 1. Copper Pipe Supports:

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- a. Manufacturers:
  - 1) HoldRite, a brand of Reliance Worldwide Corporation:  
www.holdrite.com/#sle.
2. Overhead Pipe Supports:
  - a. Manufacturers:
    - 1) HoldRite, a brand of Reliance Worldwide Corporation:  
www.holdrite.com/#sle.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

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

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- D. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Field-Welding (where approved by Architect): Comply with Section 055000.
- H. Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.
- I. Equipment Support and Attachment:
  1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
  2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
  3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
  4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 3 inch high concrete pad constructed in accordance with Section 033000.
  5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- J. Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.
- K. Secure fasteners according to manufacturer's recommended torque settings.
- L. Remove temporary supports.

### **3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

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- D. Correct deficiencies and replace damaged or defective support and attachment components.

**END OF SECTION**

**SECTION 23 05 30 - ROOF CURBS AND VAULTS**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. SECTION 230548 - VIBRATION ISOLATION FOR HVAC EQUIPMENT
- C. SECTION 230550 – WIND RESTRAINT FOR HVAC SYSTEMS

**1.2 DESCRIPTION**

- A. Provide labor, materials, equipment and services as required for the complete installation of roof curbs as shown in Contract Documents.

**1.3 SUBMITTALS**

- A. Typical detail and schedule for equipment. Details shall include cross-sectional view illustrating clearly the type of curb being submitted, i.e. double wall insulated, with or without cant.

**PART 2 - PRODUCTS**

**2.1 ROOF CURBS**

- A. Double wall, 1-1/2 in. minimum thickness, with wood blocking, fully insulated in the interior cavity with rigid insulation. 24 in. high with hinges and service hold-open chain or cable for kitchen exhaust fans. All other fans to have 18 in. high curbs. Curb constructed of galvanized steel, 1-1/2 in. 3# density insulation with continuous welded corner seams and painted at all welds. 20 gauge up to 36 in., 18 gauge 38 to 72 in., 16 gauge over 72 in. in any dimension. Provide curb with gasket on top to make airtight seal between curb and ventilator, fan, or air handling unit. Curb provided with raised cant, flanged or recessed. Curb flange shall suit roof construction and type of insulation being applied.
- B. Design Equipment: Kinetics Noise Control.
- C. Acceptable Make: Pate, Shipman & Son, RPS.

**2.2 EQUIPMENT SUPPORTS**

- A. Double wall, 2 in. x 8 in. wood blocking, minimum 18 in. high. Constructed of 18 gauge galvanized steel with continuous welded corner seams and painted at all welds. Constructed of heavier gauge steel where standard curb cannot support unit weight. Provide with top cap counter flashing. Support provided with raised cant, flanged or recessed. Support flange shall suit roof construction and type of insulation being applied.

**2.3 PIPE SUPPORTS**

- A. Same construction as "Equipment Supports". Provide with full length steel bracket, U bolts and accessories as required to secure piping to the pipe support as detailed on Contract Drawings.
- B. Design Equipment: RPS Model ER-2A.

#### 2.4 **PIPE VAULT**

- A. All aluminum construction, 3rd- Party tested for wind and ICC2015 Air Permeance and Insulated Curb code compliance.
- B. Exit seals to be constructed of aluminum and gasketed. Seals to be provided for all penetrations, including but not limited to, electrical conduits, controls conduits, refrigeration piping.
- C. 18" insulated aluminum curb system.
- D. Vault size to be determined by piping quantity.
- E. Design Make: AWI VAULT Series.

### **PART 3 - EXECUTION**

#### 3.1 **GENERAL**

- A. Height as recommended by equipment manufacturer, not less than described in this specification. This Contractor shall be responsible for exact size, length, and location and shall set and secure each curb to the roof. Shim and level curb as required. Provide curb and supports for all roof-mounted equipment. All roof penetrations shall be made through an appropriate curb. All roof mounted equipment including fans, air handling units, etc, shall be set on an equipment support unless otherwise noted. Refer to Contract Drawings for details on plenums extending from curbs.

END OF SECTION 23 05 30

**SECTION 230548  
VIBRATION AND SEISMIC CONTROLS FOR HVAC****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Vibration isolation requirements.
- B. Vibration-isolated equipment support bases.
- C. Vibration isolators.

**1.02 RELATED REQUIREMENTS**

- A. Section 033000 - Cast-in-Place Concrete.

**1.03 DEFINITIONS**

- A. HVAC Component: Where referenced in this section in regards to seismic controls, applies to any portion of the HVAC system subject to seismic evaluation in accordance with applicable codes, including distributed systems (e.g., ductwork, piping).
- B. Seismic Restraint: Structural members or assemblies of members or manufactured elements specifically designed and applied for transmitting seismic forces between components and the seismic force-resisting system of the structure.

**1.04 REFERENCE STANDARDS**

- A. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications Most Recent Edition Cited by Referring Code or Reference Standard.

**1.05 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate selection and arrangement of vibration isolation and/or seismic control components with the actual equipment to be installed.
  - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
  - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
  - 4. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

**1.06 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
  - 1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification methods for spring element load capacities.
- C. Shop Drawings - Vibration Isolation Systems:
  - 1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators; indicate equipment weights and static deflections.
  - 2. Vibration-Isolated Equipment Support Bases: Include base weights, including concrete fill where applicable; indicate equipment mounting provisions.

**1.07 QUALITY ASSURANCE**

- A. Comply with applicable building code.

**PART 2 PRODUCTS****2.01 VIBRATION ISOLATION REQUIREMENTS**

- A. Design and provide vibration isolation systems to reduce vibration transmission to supporting structure from vibration-producing HVAC equipment and/or HVAC connections

to vibration-isolated equipment.

- B. Comply with applicable general recommendations of ASHRAE (HVACA), where not in conflict with other specified requirements:
- C. General Requirements:
  - 1. Select vibration isolators to provide required static deflection.
  - 2. Select vibration isolators for uniform deflection based on distributed operating weight of actual installed equipment.
- D. Equipment Isolation: As indicated on drawings.

## **2.02 VIBRATION-ISOLATED EQUIPMENT SUPPORT BASES**

- A. Manufacturers:
  - 1. Vibration-Isolated Equipment Support Bases:

## **2.03 VIBRATION ISOLATORS**

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

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that mounting surfaces are ready to receive vibration isolation and/or seismic control components and associated attachments.
- C. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C. Secure fasteners according to manufacturer's recommended torque settings.
- D. Install flexible piping connections to provide sufficient slack for vibration isolation and/or seismic relative displacements as indicated or as required.
- E. Vibration Isolation Systems:
  - 1. Vibration-Isolated Equipment Support Bases:
    - a. Provide specified minimum clearance beneath base.
  - 2. Clean debris from beneath vibration-isolated equipment that could cause short-circuiting of isolation.
  - 3. Use elastomeric grommets for attachments where required to prevent short-circuiting of isolation.
  - 4. Adjust isolators to be free of isolation short circuits during normal operation.
  - 5. Do not overtighten fasteners such that resilient material isolator pads are compressed beyond manufacturer's maximum recommended deflection.

**END OF SECTION**



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## **SECTION 230550 WIND RESTRAINT FOR HVAC SYSTEMS**

### **PART 1 GENERAL**

#### **1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

#### **1.02 SECTION INCLUDES**

- A. Support and brace mechanical and electrical systems, as called for, to resist directional wind forces (lateral, longitudinal and vertical).

#### **1.03 APPLICABLE CODES AND STANDARDS**

- A. Provide work in compliance with the following codes and standards:
- B. 2015 International Building Code (Section 1609).
- C. 2015 International Mechanical Code (Section 301, Item 301.15).
- D. American Society of Civil Engineers (ASCE) Minimum Design Loads for Buildings and Other Structures with Supplement No. 1 - Standard ASCE/SEI 7-10.

#### **1.04 QUALITY ASSURANCE**

- A. General:
  - 1. The contractor shall provide professional engineer stamped and signed calculations, and details of wind restraint systems to meet total design lateral force requirements for support and restraint of mechanical and electrical systems.
  - 2. Systems requiring wind restraint including, but not limited to:
    - a. Exhaust fans.
    - b. Hooded intake or relief ventilators.
    - c. Ductwork.
    - d. Rooftop air handling equipment.
    - e. Condensing units.
    - f. Miscellaneous HVAC equipment.
    - g. Roof curbs and pipe/duct/equipment supports associated with any of the equipment listed above.

#### **1.05 SUBMITTALS**

- A. Submit wind force level (Fp) calculations from applicable building code. Submit pre-approved restraint selections, installation details, and plans indicating locations of restraints.
- B. Calculations, plans, restraint selection, and installation details shall be stamped and signed by a professionally licensed engineer experienced in wind restraint design.
- C. Submit manufacturer's product data.
- D. For each piece of equipment that requires wind restraint as outlined in this section, include the following:
  - 1. Dimensioned Outline Drawings of Equipment Unit: Identify the center of gravity and locate and describe mounting and anchoring provisions.
  - 2. Anchorage: Provide detailed description of equipment anchorage devices on which the calculations are based and their installation requirements. Identify anchor bolts, studs and other mounting devices. Provide information on the size, type and spacing of mounting brackets, holes and other provisions.

### **PART 1 PRODUCTS**

#### **2.01 CODE INFORMATION**

- A. This project is subject to the wind bracing requirements of the 2015 International Building Code (Section 1609) and American Society of Civil Engineers ASCE/SEI 7-10. The following criteria are applicable to this project:
  - 1. Nominal Design Wind Speed (V) (Per ASCE 7-10): 120 mph.
  - 2. Risk Category (Per ASCE 7-10): III

3. Exposure Category (Per ASCE 7-10): C
4. Height and Exposure Adjustment Coefficient (Per ASCE 7-10): 1.21

## **2.02 WIND BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS**

- A. General:
  1. Design analysis shall include calculated dead loads, wind loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
  2. Analysis shall detail anchoring methods, bolt diameter, and embedment depth.
  3. All wind restraint devices shall be designed to accept without failure the forces calculated per the applicable building code and as summarized in Section 2.1.
- B. Friction from gravity loads shall not be considered resistance to wind forces.

## **PART 1 EXECUTION**

### **3.01 INSTALLATION**

- A. Wind Restraint of Ductwork and Equipment:
  1. All restraint systems shall be installed in strict accordance with the manufacturer's restraint guidelines and all certified submittal data.
  2. The interaction between mechanical and electrical equipment and the supporting structures shall be designed into the restraint systems.
  3. Friction clips shall not be used for anchorage attachments.
  4. Expansion anchors shall not be used for non-vibration isolated equipment rated over 10 HP.
  5. Components mounted on vibration isolation systems shall have a bumper restraint or snubber in each horizontal direction and vertical restraints shall be provided to resist overturning.
  6. Installation of restraints shall not cause any change in position of equipment or ductwork, resulting in stresses or misalignment.
  7. Exhaust fans with hinge kits shall have wind restraint fasteners installed on the hinged side, same as the three (3) non-hinged sides.
  8. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.
  9. Do not install any equipment or duct that makes rigid connections with the building unless isolation is not specified.
  10. Prior to installation, bring to the Architect's/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.
  11. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or wedge-type concrete anchors. Consult Structural Engineer of record.
  12. Overstressing of the building structure shall not occur from overhead support of equipment. Bracing attached to structural members may present additional stresses. The Contractor shall submit loads to the Structural Engineer of record for approval in this event.
  13. Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.
  14. Provide reinforced clevis bolts where required.
  15. Do not brace a system to two independent structures such as a roof and wall.

**END OF SECTION**

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**SECTION 230553**  
**IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT-CPL**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Nameplates.
- B. Tags.
- C. Adhesive-backed duct markers.
- D. Stencils.
- E. Pipe markers.
- F. Ceiling tacks.

**1.02 RELATED REQUIREMENTS**

- A. Section 099123 - Interior Painting: Identification painting.

**1.03 REFERENCE STANDARDS**

- A. ASTM D709 - Standard Specification for Laminated Thermosetting Materials 2017.

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.
- E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.
- F. Project Record Documents: Record actual locations of tagged valves.

**PART 2 PRODUCTS**

**2.01 IDENTIFICATION APPLICATIONS**

- A. Air Handling Units: Nameplates.
- B. Air Terminal Units: Tags.
- C. Automatic Controls: Tags. Key to control schematic.
- D. Control Panels: Nameplates.
- E. Dampers: Ceiling tacks, where located above lay-in ceiling.
- F. Ductwork: Adhesive-backed duct markers or stencils.
- G. Heat Transfer Equipment: Nameplates.
- H. Instrumentation: Tags.
- I. Major Control Components: Nameplates.
- J. Piping: Pipe markers.
- K. Pumps: Nameplates.
- L. Relays: Tags.
- M. Small-sized Equipment: Tags.
- N. Tanks: Nameplates.
- O. Thermostats: Nameplates.
- P. Valves: Tags and ceiling tacks where located above lay-in ceiling.
- Q. Water Treatment Devices: Nameplates.

**2.02 NAMEPLATES**

- A. Manufacturers:
  - 1. Advanced Graphic Engraving, LLC: [www.advancedgraphicengraving.com/#sle](http://www.advancedgraphicengraving.com/#sle).
  - 2. Brimar Industries, Inc: [www.pipemarker.com/#sle](http://www.pipemarker.com/#sle).
  - 3. Craftmark Pipe Markers: [www.craftmarkid.com/#sle](http://www.craftmarkid.com/#sle).
  - 4. Kolbi Pipe Marker Co: [www.kolbipipemarkers.com/#sle](http://www.kolbipipemarkers.com/#sle).
  - 5. Seton Identification Products, a Tricor Direct Company: [www.seton.com/#sle](http://www.seton.com/#sle).
- B. Letter Color: White.
- C. Letter Height: 1/4 inch.
- D. Background Color: Black.
- E. Plastic: Comply with ASTM D709.

**2.03 TAGS**

- A. Manufacturers:
  - 1. Advanced Graphic Engraving: [www.advancedgraphicengraving.com/#sle](http://www.advancedgraphicengraving.com/#sle).
  - 2. Brady Corporation: [www.bradycorp.com/#sle](http://www.bradycorp.com/#sle).
  - 3. Brimar Industries, Inc: [www.pipemarker.com/#sle](http://www.pipemarker.com/#sle).
  - 4. Craftmark Pipe Markers: [www.craftmarkid.com/#sle](http://www.craftmarkid.com/#sle).
  - 5. Kolbi Pipe Marker Co: [www.kolbipipemarkers.com/#sle](http://www.kolbipipemarkers.com/#sle).
  - 6. Seton Identification Products, a Tricor Company: [www.seton.com/#sle](http://www.seton.com/#sle).
- B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- D. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

**2.04 ADHESIVE-BACKED DUCT MARKERS**

- A. Manufacturers:
  - 1. Brimar Industries, Inc: [www.pipemarker.com/#sle](http://www.pipemarker.com/#sle).
  - 2. Craftmark Pipe Markers: [www.craftmarkid.com/#sle](http://www.craftmarkid.com/#sle).
  - 3. Seton Identification Products, a Tricor Company: [www.seton.com/#sle](http://www.seton.com/#sle).
- B. Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch; printed with UV and chemical resistant inks.
- C. Style: Individual Label.
- D. Color: Green/White Green/White.

**2.05 STENCILS**

- A. Manufacturers:
  - 1. Brady Corporation: [www.bradycorp.com/#sle](http://www.bradycorp.com/#sle).
  - 2. Craftmark Pipe Markers: [www.craftmarkid.com/#sle](http://www.craftmarkid.com/#sle).
  - 3. Insite Solutions, LLC: [www.stop-painting.com/#sle](http://www.stop-painting.com/#sle).
  - 4. Kolbi Pipe Marker Co: [www.kolbipipemarkers.com/#sle](http://www.kolbipipemarkers.com/#sle).
  - 5. Seton Identification Products, a Tricor Company: [www.seton.com/#sle](http://www.seton.com/#sle).
- B. Stencils: With clean cut symbols and letters of following size:
  - 1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
  - 2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
  - 3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
  - 4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.

5. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
  6. Ductwork and Equipment: 2-1/2 inch high letters.
- C. Stencil Paint: As specified in Section 099123, semi-gloss enamel, colors complying with ASME A13.1.

## 2.06 PIPE MARKERS

- A. Manufacturers:
1. Brady Corporation: [www.bradycorp.com/#sle](http://www.bradycorp.com/#sle).
  2. Brimar Industries, Inc: [www.pipemarker.com/#sle](http://www.pipemarker.com/#sle).
  3. Craftmark Pipe Markers: [www.craftmarkid.com/#sle](http://www.craftmarkid.com/#sle).
  4. Kolbi Pipe Marker Co: [www.kolbipipemarkers.com/#sle](http://www.kolbipipemarkers.com/#sle).
  5. Seton Identification Products, a Tricolor Company: [www.seton.com/#sle](http://www.seton.com/#sle).
- B. Color: Comply with ASME A13.1.
- C. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- E. Color code as follows:
1. Heating, Cooling, and Boiler Feedwater: Green with white letters.

## 2.07 CEILING TACKS

- A. Manufacturers:
1. Craftmark Pipe Markers: [www.craftmarkid.com/#sle](http://www.craftmarkid.com/#sle).
- B. Description: Steel with 3/4 inch diameter color coded head.
- C. Color code as follows:
1. HVAC Equipment: Yellow.
  2. Fire Dampers and Smoke Dampers: Red.
  3. Heating/Cooling Valves: Blue.

## PART 3 EXECUTION

### 3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Section 099123 for stencil painting.

### 3.02 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Apply stencil painting in accordance with Section 099123.
- D. Install plastic pipe markers in accordance with manufacturer's instructions.
- E. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- F. Use tags on piping 3/4 inch diameter and smaller.
1. Identify service, flow direction, and pressure.
  2. Install in clear view and align with axis of piping.
  3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- G. Install ductwork with adhesive-backed duct markers. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

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- H. Locate ceiling tacks to locate dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

**END OF SECTION**

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## **SECTION 230593 TESTING, ADJUSTING, AND BALANCING FOR HVAC-CPL**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Testing, adjustment, and balancing of air systems.
- B. Testing, adjustment, and balancing of hydronic, steam, and refrigerating systems.
- C. Measurement of final operating condition of HVAC systems.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 019113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- B. Section 230800 - Commissioning of HVAC.

#### **1.03 REFERENCE STANDARDS**

- A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition 2016.
- B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems 2008 (Reaffirmed 2017).
- C. NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems 2015, with Errata (2017).
- D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing 2002.

#### **1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Installer Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.
- C. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
  - 1. Submit to Architect.
  - 2. Include at least the following in the plan:
    - a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
    - b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
    - c. Identification and types of measurement instruments to be used and their most recent calibration date.
    - d. Final test report forms to be used.
    - e. Procedures for formal deficiency reports, including scope, frequency and distribution.
- D. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
  - 1. Revise TAB plan to reflect actual procedures and submit as part of final report.
  - 2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
  - 3. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
  - 4. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
  - 5. Units of Measure: Report data in I-P (inch-pound) units only.
  - 6. Include the following on the title page of each report:
    - a. Name of Testing, Adjusting, and Balancing Agency.
    - b. Address of Testing, Adjusting, and Balancing Agency.
    - c. Telephone number of Testing, Adjusting, and Balancing Agency.

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- d. Project name.
- e. Project location.
- f. Project Architect.
- g. Project Contractor.
- h. Report date.

## **PART 2 PRODUCTS - NOT USED**

## **PART 3 EXECUTION**

### **3.01 GENERAL REQUIREMENTS**

- A. Perform total system balance in accordance with one of the following:
  - 1. AABC (NSTSB), AABC National Standards for Total System Balance.
  - 2. ASHRAE Std 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
  - 3. SMACNA (TAB).
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D. TAB Agency Qualifications:
  - 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
  - 2. Certified by one of the following:
    - a. AABC, Associated Air Balance Council: [www.aabc.com/#sle](http://www.aabc.com/#sle); upon completion submit AABC National Performance Guaranty.
    - b. NEBB, National Environmental Balancing Bureau: [www.nebb.org/#sle](http://www.nebb.org/#sle).
    - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: [www.tabbcertified.org/#sle](http://www.tabbcertified.org/#sle).
- E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

### **3.02 EXAMINATION**

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
  - 1. Systems are started and operating in a safe and normal condition.
  - 2. Temperature control systems are installed complete and operable.
  - 3. Final filters are clean and in place. If required, install temporary media in addition to final filters.
  - 4. Duct systems are clean of debris.
  - 5. Fans are rotating correctly.
  - 6. Fire and volume dampers are in place and open.
  - 7. Air coil fins are cleaned and combed.
  - 8. Access doors are closed and duct end caps are in place.
  - 9. Air outlets are installed and connected.
  - 10. Duct system leakage is minimized.
  - 11. Hydronic systems are flushed, filled, and vented.
  - 12. Pumps are rotating correctly.
  - 13. Service and balance valves are open.
- B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- C. Beginning of work means acceptance of existing conditions.

### **3.03 PREPARATION**

- A. Provide instruments required for testing, adjusting, and balancing operations.
- B. Provide additional balancing devices as required.



### **3.04 ADJUSTMENT TOLERANCES**

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
- B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
- C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

### **3.05 RECORDING AND ADJUSTING**

- A. Ensure recorded data represents actual measured or observed conditions.
- B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

### **3.06 AIR SYSTEM PROCEDURE**

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- E. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- F. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- G. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- H. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- I. Where modulating dampers are provided, take measurements and balance at extreme conditions.

### **3.07 WATER SYSTEM PROCEDURE**

- A. Adjust water systems to provide required or design quantities.
- B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- D. Effect system balance with automatic control valves fully open to heat transfer elements.
- E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
- F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

### 3.08 SCOPE

- A. Test, adjust, and balance the following:
  - 1. Packaged Roof Top Heating/Cooling Units.
  - 2. Air Coils.
  - 3. Air Handling Units.
  - 4. Fans.
  - 5. Air Terminal Units.
  - 6. Air Inlets and Outlets.

### 3.09 MINIMUM DATA TO BE REPORTED

- A. Electric Motors:
  - 1. Manufacturer.
  - 2. Model/Frame.
  - 3. HP/BHP.
  - 4. Phase, voltage, amperage; nameplate, actual, no load.
  - 5. RPM.
  - 6. Service factor.
  - 7. Starter size, rating, heater elements.
  - 8. Sheave Make/Size/Bore.
- B. V-Belt Drives:
  - 1. Identification/location.
  - 2. Required driven RPM.
  - 3. Driven sheave, diameter and RPM.
  - 4. Belt, size and quantity.
  - 5. Center to center distance, maximum, minimum, and actual.
- C. Air Cooled Condensers:
  - 1. Identification/number.
  - 2. Location.
  - 3. Manufacturer.
  - 4. Model number.
  - 5. Serial number.
  - 6. Entering DB air temperature, design and actual.
  - 7. Leaving DB air temperature, design and actual.
  - 8. Number of compressors.
- D. Cooling Coils:
  - 1. Identification/number.
  - 2. Location.
  - 3. Air flow, design and actual.
  - 4. Air pressure drop, design and actual.
- E. Heating Coils:
  - 1. Identification/number.
  - 2. Location.
  - 3. Air flow, design and actual.
  - 4. Air pressure drop, design and actual.
- F. Air Moving Equipment:
  - 1. Location.
  - 2. Manufacturer.
  - 3. Model number.
  - 4. Serial number.
  - 5. Air flow, specified and actual.
  - 6. Return air flow, specified and actual.
  - 7. Outside air flow, specified and actual.
  - 8. Total static pressure (total external), specified and actual.
  - 9. Inlet pressure.

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10. Discharge pressure.
  11. Sheave Make/Size/Bore.
  12. Number of Belts/Make/Size.
  13. Fan RPM.
- G. Return Air/Outside Air:
1. Identification/location.
  2. Design air flow.
  3. Actual air flow.
  4. Design return air flow.
  5. Actual return air flow.
  6. Design outside air flow.
  7. Actual outside air flow.
  8. Design outside/return air ratio.
  9. Actual outside/return air ratio.
- H. Exhaust Fans:
1. Location.
  2. Manufacturer.
  3. Model number.
  4. Serial number.
  5. Air flow, specified and actual.
  6. Total static pressure (total external), specified and actual.
  7. Inlet pressure.
  8. Discharge pressure.
  9. Sheave Make/Size/Bore.
  10. Number of Belts/Make/Size.
  11. Fan RPM.
- I. Duct Traverses:
1. System zone/branch.
  2. Duct size.
  3. Area.
  4. Design velocity.
  5. Design air flow.
  6. Test velocity.
  7. Test air flow.
  8. Duct static pressure.
- J. Flow Measuring Stations:
1. Identification/number.
  2. Location.
  3. Size.
  4. Manufacturer.
  5. Model number.
  6. Serial number.
  7. Design Flow rate.
  8. Design pressure drop.
  9. Actual/final pressure drop.
  10. Actual/final flow rate.
  11. Station calibrated setting.
- K. Terminal Unit Data:
1. Manufacturer.
  2. Type, constant, variable, single, dual duct.
  3. Identification/number.
  4. Location.
  5. Model number.
  6. Size.

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7. Minimum static pressure.
  8. Minimum design air flow.
  9. Maximum design air flow.
  10. Maximum actual air flow.
  11. Inlet static pressure.
- L. Air Distribution Tests:
1. Air terminal number.
  2. Room number/location.
  3. Terminal type.
  4. Terminal size.
  5. Area factor.
  6. Design velocity.
  7. Design air flow.
  8. Test (final) velocity.
  9. Test (final) air flow.
  10. Percent of design air flow.

**END OF SECTION**

**SECTION 230713  
DUCT INSULATION-CPL****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Duct insulation.
- B. Insulation jackets.

**1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 230553 - Identification for HVAC Piping and Equipment-CPL.
- C. Section 233100 - HVAC Ducts and Casings: Glass fiber ducts.

**1.03 REFERENCE STANDARDS**

- A. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate 2014.
- B. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric) 2014.
- C. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus 2017.
- D. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form 2020a.
- E. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications 2013 (Reapproved 2019).
- F. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation 2014 (Reapproved 2019).
- G. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation 2020.
- H. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material) 2019.
- I. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials 2016.
- J. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi 2015 (Reapproved 2021)e1.
- K. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2005 (Revised 2009).

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

**1.05 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, documented experience and approved by manufacturer.

**1.06 DELIVERY, STORAGE, AND HANDLING**

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

**1.07 FIELD CONDITIONS**

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

**PART 2 PRODUCTS****2.01 REGULATORY REQUIREMENTS**

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

**2.02 GLASS FIBER, FLEXIBLE**

- A. Manufacturer:
  - 1. CertainTeed Corporation: [www.certainteed.com/#sle](http://www.certainteed.com/#sle).
  - 2. Johns Manville: [www.jm.com/#sle](http://www.jm.com/#sle).
  - 3. JP Lamborn Co; Thermal Sleeve MT: [www.jpflex.com/#sle](http://www.jpflex.com/#sle).
  - 4. Knauf Insulation; Atmosphere Duct Wrap: [www.knaufinsulation.com/#sle](http://www.knaufinsulation.com/#sle).
  - 5. Owens Corning Corporation: [www.ocbuildingspec.com/#sle](http://www.ocbuildingspec.com/#sle).
  - 6. Substitutions: See Section 016000 - Product Requirements.
- B. Insulation: ASTM C553; flexible, noncombustible blanket.
  - 1. K value: 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
  - 2. Maximum Service Temperature: 1200 degrees F.
  - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C. Vapor Barrier Jacket:
  - 1. Kraft paper with glass fiber yarn and bonded to aluminized film.
  - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
  - 3. Secure with pressure sensitive tape.
- D. Vapor Barrier Tape:
  - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- E. Indoor Vapor Barrier Mastic:
  - 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- F. Outdoor Vapor Barrier Mastic:
  - 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- G. Tie Wire: Annealed steel, 16 gauge, 0.0508 inch diameter.

**2.03 GLASS FIBER, RIGID**

- A. Manufacturer:
  - 1. CertainTeed Corporation: [www.certainteed.com/#sle](http://www.certainteed.com/#sle).
  - 2. Johns Manville: [www.jm.com/#sle](http://www.jm.com/#sle).
  - 3. Knauf Insulation: [www.knaufinsulation.com/#sle](http://www.knaufinsulation.com/#sle).
  - 4. Owens Corning Corporation; 700 Series FIBERGLAS Insulation: [www.ocbuildingspec.com/#sle](http://www.ocbuildingspec.com/#sle).
  - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Insulation: ASTM C612; rigid, noncombustible blanket.
  - 1. K Value: 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
  - 2. Maximum Service Temperature: 450 degrees F.
  - 3. Maximum Water Vapor Absorption: 5.0 percent.
  - 4. Maximum Density: 8.0 lb/cu ft.
- C. Vapor Barrier Jacket:
  - 1. Kraft paper with glass fiber yarn and bonded to aluminized film.
  - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
  - 3. Secure with pressure sensitive tape.

- D. Vapor Barrier Tape:
  - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- E. Indoor Vapor Barrier Finish:
  - 1. Cloth: Untreated; 9 oz/sq yd weight, glass fabric.
  - 2. Vinyl emulsion type acrylic, compatible with insulation, black color.

## 2.04 JACKETS

- A. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire retardant lagging adhesive.
  - 1. Lagging Adhesive:
    - a. Manufacturers:
      - 1) Design Polymeric; DP 3050 Water Based, Zero VOC, Premium Quality, Lagging Adhesive, and Vapor Retarder: [www.designpoly.com/#sle](http://www.designpoly.com/#sle).
      - 2) Substitutions: See Section 016000 - Product Requirements
    - b. Compatible with insulation.
- B. Aluminum Jacket: ASTM B209 (ASTM B209M).
  - 1. Thickness: 0.016 inch sheet.
  - 2. Finish: Smooth.
  - 3. Joining: Longitudinal slip joints and 2 inch laps.
  - 4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
  - 5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

## 2.05 DUCT LINER

- A. Manufacturers:
  - 1. Armacell LLC; AP Coilflex: [www.armacell.us/#sle](http://www.armacell.us/#sle).
  - 2. CertainTeed Corporation: [www.certainteed.com/#sle](http://www.certainteed.com/#sle).
  - 3. Ductmate Industries, Inc, a DMI Company: [www.ductmate.com/#sle](http://www.ductmate.com/#sle).
  - 4. Johns Manville: [www.jm.com/#sle](http://www.jm.com/#sle).
  - 5. Knauf Insulation: [www.knaufinsulation.com/#sle](http://www.knaufinsulation.com/#sle).
  - 6. Owens Corning Corporation: [www.ocbuildingspec.com/#sle](http://www.ocbuildingspec.com/#sle).
  - 7. Substitutions: See Section 016000 - Product Requirements.
- B. Elastomeric Foam Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
  - 1. Minimum Service Temperature: Minus 40 degrees F.
  - 2. Maximum Service Temperature: 180 degrees F.
  - 3. Fungal Resistance: No growth when tested according to ASTM G21.
  - 4. Apparent Thermal Conductivity: Maximum of 0.28 at 75 degrees F.
  - 5. Minimum Noise Reduction Coefficients:
    - a. 1 inch Thickness: 0.40.
  - 6. Erosion Resistance: Does not show evidence of breaking away, flaking off, or delamination at velocities of 10,000 fpm per ASTM C1071.
  - 7. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation. Comply with ASTM C916.
- D. Liner Fasteners: Galvanized steel, self-adhesive pad with integral head.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Test ductwork for design pressure prior to applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.

- C. Insulated Ducts Conveying Air Below Ambient Temperature:
  - 1. Provide insulation with vapor barrier jackets.
  - 2. Finish with tape and vapor barrier jacket.
  - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
  - 4. Insulate entire system, including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- D. Insulated Ducts Conveying Air Above Ambient Temperature:
  - 1. Provide with standard vapor barrier jacket.
  - 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- E. Ducts Exposed in Mechanical Equipment Rooms or Finished Spaces (below 10 feet above finished floor): Finish with canvas jacket sized for finish painting.
- F. Exterior Applications: Provide insulation with vapor barrier jacket. Cover with with calked aluminum jacket with seams located on bottom side of horizontal duct section.
- G. Slope exterior ductwork to shed water.
- H. External Duct Insulation Application:
  - 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
  - 2. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
  - 3. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
- I. Duct and Plenum Liner Application:
  - 1. Adhere insulation with adhesive for 90 percent coverage.
  - 2. Secure insulation with mechanical liner fasteners. Refer to SMACNA (DCS) for spacing.
  - 3. Seal and smooth joints. Seal and coat transverse joints.
  - 4. Seal liner surface penetrations with adhesive.
  - 5. Duct dimensions indicated are net inside dimensions required for air-flow. Increase duct size to allow for insulation thickness.

### 3.03 SCHEDULES

- A. Exhaust Ducts Within 10 ft of Exterior Openings:
  - 1. Flexible Glass Fiber Duct Insulation: 1-1/2 inches thick.
  - 2. Rigid Glass Fiber Duct Insulation: 1-1/2 inches thick.
- B. Outside Air Intake Ducts:
  - 1. Insulation:
    - a. Flexible Glass Fiber Duct Insulation:
      - 1) Thickness required to provide an R value not less than R-12.
    - b. Rigid Glass Fiber Duct Insulation:
      - 1) Thickness required to provide an R value not less than R-12.
- C. Supply Ducts:
  - 1. First 10 ft from unit supply/return connections
    - a. Duct Liner
  - 2. Other than first 10 ft from supply connection
    - a. Flexible Glass Fiber Duct Insulation:
      - 1) Thickness required to provide an R value not less than R-6.
    - b. Rigid Glass Fiber Duct Insulation:
      - 1) Thickness required to provide an R value not less than R-6.
- D. Ducts Exposed to Outdoors:
  - 1. Insulation:
    - a. Flexible Glass Fiber Duct Insulation:
      - 1) Thickness required to provide an R value not less than R-12.
    - b. Rigid Glass Fiber Duct Insulation:
      - 1) Thickness required to provide an R value not less than R-12.
  - 2. Jacket:



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- a. Aluminum Jacket or Flexible Weather-Proofing Outdoor Jacket

**END OF SECTION**

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**SECTION 230719  
HVAC PIPING INSULATION-CPL**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Piping insulation.
- B. Flexible removable and reusable blanket insulation.
- C. Jackets and accessories.

**1.02 RELATED REQUIREMENTS**

- A. Section 232113 - Hydronic Piping: Placement of hangers and hanger inserts.
- B. Section 232300 - Refrigerant Piping: Placement of inserts.

**1.03 REFERENCE STANDARDS**

- A. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus 2019.
- B. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus 2019.
- C. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement 2007 (Reapproved 2013).
- D. ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement 2007 (Reapproved 2013).
- E. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form 2020a.
- F. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation 2019.
- G. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation 2021.
- H. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel 2008 (Reapproved 2018).
- I. ASTM D610 - Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces 2008 (Reapproved 2019).
- J. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- K. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials 2016.
- L. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

**1.05 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

**1.07 FIELD CONDITIONS**

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

## **PART 2 PRODUCTS**

### **2.01 REGULATORY REQUIREMENTS**

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

### **2.02 GLASS FIBER, RIGID**

- A. Manufacturers:
  - 1. CertainTeed Corporation: [www.certainteed.com/#sle](http://www.certainteed.com/#sle).
  - 2. Johns Manville Corporation: [www.jm.com/#sle](http://www.jm.com/#sle).
  - 3. Knauf Insulation; [ ]: [www.knaufinsulation.com/#sle](http://www.knaufinsulation.com/#sle).
  - 4. Owens Corning Corporation: [www.ocbuildingspec.com/#sle](http://www.ocbuildingspec.com/#sle).
  - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
  - 1. K Value: ASTM C177, 0.24 at 75 degrees F.
  - 2. Maximum Service Temperature: 850 degrees F.
  - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
- D. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
- E. Vapor Barrier Lap Adhesive: Compatible with insulation.
- F. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
- G. Insulating Cement: ASTM C449.

### **2.03 CELLULAR GLASS**

- A. Pipe and Tubing Insulation: ASTM C552, Type II, Grade 6.
  - 1. K Value: 0.35 at 100 degrees F.
  - 2. Service Temperature Range: From 250 degrees F to 800 degrees F.
  - 3. Water Vapor Permeability: 0.005 perm inch maximum per inch.
  - 4. Water Absorption: 0.5 percent by volume, maximum.
  - 5. Density: A minimum of 6.12 lb/cu ft.

### **2.04 FLEXIBLE ELASTOMERIC CELLULAR INSULATION**

- A. Manufacturers:
  - 1. Armacell LLC: [www.armacell.us/#sle](http://www.armacell.us/#sle).
  - 2. K-Flex USA LLC: [www.kflexusa.com/#sle](http://www.kflexusa.com/#sle).
  - 3. Substitutions: See Section 016000 - Product Requirements.
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
  - 1. Minimum Service Temperature: Minus 40 degrees F.
  - 2. Maximum Service Temperature: 180 degrees F.
  - 3. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

### **2.05 JACKETS**

- A. PVC Plastic.
  - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
    - a. Minimum Service Temperature: 0 degrees F.
    - b. Maximum Service Temperature: 150 degrees F.
    - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
    - d. Thickness: 10 mil.
    - e. Connections: Brush on welding adhesive.
  - 2. Covering Adhesive Mastic: Compatible with insulation.

## 2.06 ACCESSORIES

- A. General Requirements:
  - 1. Provide required accessories in accordance with and subject to the recommendations of the insulation manufacturer.
  - 2. Furnish compatible materials which do not contribute to corrosion, soften, or otherwise attack surfaces to which applied, in either the wet or dry state.
  - 3. Comply with ASTM C795 requirements for materials to be used on stainless steel surfaces.
  - 4. Supply materials that are asbestos free.
- B. Corrosion Inhibitors:
  - 1. Corrosion Control Gel:
    - a. Corrosion Protection: Comply with ASTM B117 and ASTM D610.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Test piping for design pressure, liquid tightness, and continuity prior to applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- D. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- E. Glass Fiber Insulated Pipes Conveying Fluids Above Ambient Temperature:
  - 1. Provide standard jackets, with or without vapor barrier, factory-applied, or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples.
  - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- F. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with PVC jacket and fitting covers.

### 3.03 SCHEDULE

- A. Heating Systems:
  - 1. Heating Water Supply and Return:
    - a. NPS 1-1/4 and Smaller: 1-1/2 inch thick Rigid Glass Fiber.
    - b. NPS 1-1/2 and Larger: 2 inch thick Rigid Glass Fiber.
- B. Cooling Systems:
  - 1. Cold Condensate Drains:
    - a. All Sizes: 1/2 inch thick Rigid Glass Fiber with Vapor Barrier.
    - b. All Sizes: 3/4 inch thick Flexible Elastomeric Cellular with Vapor Barrier.
  - 2. Condensate Drains from Cooling Coils:
    - a. All Sizes: 1/2 inch thick Rigid Glass Fiber with Vapor Barrier.
    - b. All Sizes: 3/4 inch thick Flexible Elastomeric Cellular with Vapor Barrier.
  - 3. Refrigerant Suction:
    - a. All Sizes: 1-1/2 inch thick Flexible Elastomeric Cellular with Vapor Barrier.
  - 4. Refrigerant Hot Gas:
    - a. All Sizes: 1-1/2 inch thick Flexible Elastomeric Cellular with Vapor Barrier.
- C. Outdoor Systems:
  - 1. Refrigerant Suction and Hot Gas:

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- a. All Sizes: 2 inch thick Flexible Elastomeric Cellular with Vapor Barrier and Aluminum Jacket.

**END OF SECTION**

**SECTION 230800  
COMMISSIONING OF HVAC**

**PART 1 GENERAL**

**1.01 SUMMARY**

- A. See Section 019113 - General Commissioning Requirements for overall objectives; comply with the requirements of Section 019113.
- B. This section covers the Contractor's responsibilities for commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.
- C. The Commissioning Authority (CA) directs and coordinates all commissioning activities and provides Prefunctional Checklists and Functional Test Procedures for Contractor's use.
- D. The entire HVAC system is to be commissioned, including commissioning activities for the following specific items:
  - 1. Control system.
  - 2. Major and minor equipment items.
  - 3. Terminal units.
  - 4. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.
- E. The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

**1.02 RELATED REQUIREMENTS**

- A. Section 250800 - Commissioning of Integrated Automation.

**1.03 REFERENCE STANDARDS**

- A. ASHRAE Guideline 1.1 - The HVAC&R Technical Requirements for the Commissioning Process 2007, with Errata (2012).

**1.04 SUBMITTALS**

- A. Updated Submittals: Keep the Commissioning Authority informed of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.
- B. Request integrated automation (controls) checklists and test procedures from Section 250800.
- C. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Authority.
- D. HVAC Control System O&M Manual Requirements. In addition to documentation specified elsewhere, compile and organize at minimum the following data on the control system:
  - 1. Specific step-by-step instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. Provide an index and clear table of contents. Include the detailed technical manual for programming and customizing control loops and algorithms.
  - 2. Full as-built set of control drawings.
  - 3. Full as-built sequence of operations for each piece of equipment.
  - 4. Full points list; in addition to the information on the original points list submittal, include a listing of all rooms with the following information for each room:
    - a. Floor.
    - b. Room number.
    - c. Room name.
    - d. Air handler unit ID.
    - e. Reference drawing number.
    - f. Air terminal unit tag ID.
    - g. Heating and/or cooling valve tag ID.
    - h. Minimum air flow rate.

- i. Maximum air flow rate.
5. Full print out of all schedules and set points after testing and acceptance of the system.
6. Full as-built print out of software program.
7. Electronic copy on disk of the entire program for this facility.
8. Marking of all system sensors and thermostats on the as-built floor plan and HVAC drawings with their control system designations.
9. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
10. Control equipment component submittals, parts lists, etc.
11. Warranty requirements.
12. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
13. Organize and subdivide the manual with permanently labeled tabs for each of the following data in the given order:
  - a. Sequences of operation.
  - b. Control drawings.
  - c. Points lists.
  - d. Controller and/or module data.
  - e. Thermostats and timers.
  - f. Sensors and DP switches.
  - g. Valves and valve actuators.
  - h. Dampers and damper actuators.
  - i. Program setups (software program printouts).
- E. Project Record Documents: See Section 017800 for additional requirements.
  1. Submit updated version of control system documentation, for inclusion with operation and maintenance data.
  2. Show actual locations of all static and differential pressure sensors (air, water and building pressure) and air-flow stations on project record drawings.
- F. Draft Training Plan: In addition to requirements specified in Section 017900, include:
  1. Follow the recommendations of ASHRAE Guideline 1.1.
  2. Control system manufacturer's recommended training.
  3. Demonstration and instruction on function and overrides of any local packaged controls not controlled by the HVAC control system.
- G. Training Manuals: See Section 017900 for additional requirements.
  1. Provide three extra copies of the controls training manuals in a separate manual from the O&M manuals.

## **PART 2 PRODUCTS**

### **2.01 TEST EQUIPMENT**

- A. Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing; unless otherwise noted such testing equipment will NOT become the property of Owner.
- B. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

## **PART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Cooperate with the Commissioning Authority in development of the Prefunctional Checklists and Functional Test Procedures.
- B. Furnish additional information requested by the Commissioning Authority.
- C. Prepare a preliminary schedule for HVAC pipe and duct system testing, flushing and cleaning, equipment start-up and testing, adjusting, and balancing start and completion for



use by the Commissioning Authority; update the schedule as appropriate.

- D. Notify the Commissioning Authority when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and testing, adjusting, and balancing will occur; when commissioning activities not yet performed or not yet scheduled will delay construction notify ahead of time and be proactive in seeing that the Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.
- E. Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning, as required.
- F. Provide test holes in ducts and plenums where directed to allow air measurements and air balancing; close with an approved plug.
- G. Provide temperature and pressure taps in accordance with Contract Documents.

### **3.02 INSPECTING AND TESTING - GENERAL**

- A. Submit startup plans, startup reports, and Prefunctional Checklists for each item of equipment or other assembly to be commissioned.
- B. Perform the Functional Tests directed by the Commissioning Authority for each item of equipment or other assembly to be commissioned.
- C. Provide two-way radios for use during the testing.
- D. Valve/Damper Stroke Setup and Check:
  - 1. For all valve/damper actuator positions checked, verify the actual position against the control system readout.
  - 2. Set pump/fan to normal operating mode.
  - 3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.
  - 4. Command valve/damper open; verify position is full open and adjust output signal as required.
  - 5. Command valve/damper to a few intermediate positions.
  - 6. If actual valve/damper position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).
- E. Isolation Valve or System Valve Leak Check: For valves not by coils.
  - 1. With full pressure in the system, command valve closed.
  - 2. Use an ultra-sonic flow meter to detect flow or leakage.
- F. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

### **3.03 TAB COORDINATION**

- A. TAB: Testing, adjusting, and balancing of HVAC.
- B. Coordinate commissioning schedule with TAB schedule.
- C. Review the TAB plan to determine the capabilities of the control system toward completing TAB.
- D. Provide all necessary unique instruments and instruct the TAB technicians in their use; such as handheld control system interface for setting terminal unit boxes, etc.
- E. Have all required Prefunctional Checklists, calibrations, startup and component Functional Tests of the system completed and approved by the Commissioning Authority prior to starting TAB.
- F. Provide a qualified control system technician to operate the controls to assist the TAB technicians or provide sufficient training for the TAB technicians to operate the system without assistance.

### **3.04 CONTROL SYSTEM FUNCTIONAL TESTING**

- A. Prefunctional Checklists for control system components will require a signed and dated certification that all system programming is complete as required to accomplish the requirements of Contract Documents and the detailed Sequences of Operation documentation submittal.

- B. Do not start Functional Testing until all controlled components have themselves been successfully Functionally Tested in accordance with Contract Documents.
- C. Using a skilled technician who is familiar with this building, execute the Functional Testing of the control system as required by the Commissioning Authority.
- D. Functional Testing of the control system constitutes demonstration and trend logging of control points monitored by the control system.
  - 1. The scope of trend logging is partially specified; trend log up to 50 percent more points than specified at no extra cost to Owner.
  - 2. Perform all trend logging specified in Prefunctional Checklists and Functional Test procedures.
- E. Functionally Test integral or stand-alone controls in conjunction with the Functional Tests of the equipment they are attached to, including any interlocks with other equipment or systems; further testing during control system Functional Test is not required unless specifically indicated below.
- F. Demonstrate the following to the Commissioning Authority during testing of controlled equipment; coordinate with commissioning of equipment.
  - 1. Setpoint changing features and functions.
  - 2. Sensor calibrations.
- G. Demonstrate to the Commissioning Authority:
  - 1. That all specified functions and features are set up, debugged and fully operable.
  - 2. That scheduling features are fully functional and setup, including holidays.
  - 3. That all graphic screens and value readouts are completed.
  - 4. Correct date and time setting in central computer.
  - 5. That field panels read the same time as the central computer; sample 10 percent of field panels; if any of those fail, sample another 10 percent; if any of those fail test all remaining units at no extra cost to Owner.
  - 6. Functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad; demonstrate 100 percent of panels and 10 percent of ports; if any ports fail, sample another 10 percent; if any of those fail, test all remaining units at no extra cost to Owner.
  - 7. Power failure and battery backup and power-up restart functions.
  - 8. Global commands features.
  - 9. Security and access codes.
  - 10. Occupant over-rides (manual, telephone, key, keypad, etc.).
  - 11. O&M schedules and alarms.
  - 12. Occupancy sensors and controls.
  - 13. All control strategies and sequences not tested during controlled equipment testing.
- H. If the control system, integral control components, or related equipment do not respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice, under any of the conditions, sequences, or modes tested, correct all systems, equipment, components, and software required at no additional cost to Owner.

### 3.05 OPERATION AND MAINTENANCE MANUALS

- A. See Section 017800 for additional requirements.
- B. Add design intent documentation furnished by Architect to manuals prior to submission to Owner.
- C. Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.
- D. Commissioning Authority will add commissioning records to manuals after submission to Owner.

### 3.06 DEMONSTRATION AND TRAINING

- A. See Section 017900 for additional requirements.
- B. Demonstrate operation and maintenance of HVAC system to Owner' personnel; if during any demonstration, the system fails to perform in accordance with the information included

- in the O&M manual, stop demonstration, repair or adjust, and repeat demonstration. Demonstrations may be combined with training sessions if appropriate.
- C. These demonstrations are in addition to, and not a substitute for, Prefunctional Checklists and demonstrations to the Commissioning Authority during Functional Testing.
  - D. Provide classroom and hands-on training of Owner's designated personnel on operation and maintenance of the HVAC system, control system, and all equipment items indicated to be commissioned. Provide the following minimum durations of training:
  - E. TAB Review: Instruct Owner's personnel for minimum [ ] hours, after completion of TAB, on the following:
    - 1. Review final TAB report, explaining the layout and meanings of each data type.
    - 2. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
    - 3. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
    - 4. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
    - 5. Other salient information that may be useful for facility operations, relative to TAB.
  - F. HVAC Control System Training: Perform training in at least three phases:
    - 1. Phase 1 - Basic Control System: Provide minimum of [ ] hours of actual training on the control system itself. Upon completion of training, each attendee, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
      - a. This training may be held on-site or at the manufacturer's facility.
      - b. If held off-site, the training may occur prior to final completion of the system installation.
      - c. For off-site training, Contractor shall pay expenses of up to two attendees.
    - 2. Phase 2 - Integrating with HVAC Systems: Provide minimum of [ ] hours of on-site, hands-on training after completion of Functional Testing. Include instruction on:
      - a. The specific hardware configuration of installed systems in this facility and specific instruction for operating the installed system, including interfaces with other systems, if any.
      - b. Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
      - c. Trend logging and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends; provide practice in setting up trend logging and monitoring during training session.
      - d. Every display screen, allowing time for questions.
      - e. Point database entry and modifications.
    - 3. Phase 3 - Post-Occupancy: Six months after occupancy conduct minimum of [ ] hours of training. Tailor training session to questions and topics solicited beforehand from Owner. Also be prepared to address topics brought up and answer questions concerning operation of the system.
  - G. Provide the services of manufacturer representatives to assist instructors where necessary.
  - H. Provide the services of the HVAC controls instructor at other training sessions, when requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

#### END OF SECTION

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**SECTION 230900  
INSTRUMENTATION AND CONTROL FOR HVAC****PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

**1.02 SUMMARY**

- A. Controls shall be compatible with the Johnson Facility Explorer Hardware/S software.
- B. Controls shall be integrated into the existing controls system.
- C. All instrumentation and controls devices recently installed under the EP C contract shall be removed during demolition and re-installed with new work as practicable.
- D. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- E. Related Sections include the following:
  - 1. Section 230519 "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.
  - 2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

**1.03 DEFINITIONS**

- A. DDC: Direct digital control.
- B. I/O: Input/output.
- C. MS/TP: Master slave/token passing.
- D. PC: Personal computer.
- E. PID: Proportional plus integral plus derivative.
- F. RTD: Resistance temperature detector.

**1.04 SUBMITTALS**

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
  - 1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
  - 2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
  - 3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
  - 2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
  - 3. Wiring Diagrams: Power, signal, and control wiring.
  - 4. Details of control panel faces, including controls, instruments, and labeling.
  - 5. Written description of sequence of operation.
  - 6. Schedule of dampers including size, leakage, and flow characteristics.
  - 7. Schedule of valves including flow characteristics.

8. DDC System Hardware:
  - a. Wiring diagrams for control units with termination numbers.
  - b. Schematic diagrams and floor plans for field sensors and control hardware.
  - c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:
  - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
  - b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
  - c. Written description of sequence of operation including schematic diagram.
  - d. Points list.

#### **1.05 PROJECT RECORD DOCUMENTS**

- A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
  1. Maintenance instructions and lists of spare parts for each type of control device
  2. Interconnection wiring diagrams with identified and numbered system components and devices.
  3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
  4. Calibration records and list of set points.

#### **1.06 QUALITY ASSURANCE**

- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with ASHRAE 135 for DDC system components.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. System Software: Update to latest version of software at Project completion.

#### **1.08 COORDINATION**

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
- B. Coordinate equipment and installation with Sections 26, 27, and 28, as appropriate, for systems integration requirements.

#### **1.09 COORDINATE SUPPLY OF CONDITIONED ELECTRICAL BRANCH CIRCUITS FOR CONTROL UNITS AND OPERATOR WORKSTATION.**

- A. Coordinate equipment with Section 262416 "Panelboards" to achieve compatibility with starter coils and annunciation devices.
- B. Coordinate equipment with Section 262419 "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.
- C. All external wiring of equipment, all temperature control wiring, external wiring of control circuits of magnetic starters, interlocking wiring, boiler wiring, Emergency Break Glass Stations, and mounting of control devices, etc., shall be included under Division 23. All external wiring shall be in conduit. Provide 120V power to all necessary control panels,

controllers, etc. from nearest spare panelboard circuit breaker location. Furnish and install necessary circuit breakers. If facility contains emergency power, connect circuit(s) to emergency panelboards.

## **PART 2 PRODUCTS**

### **2.01 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. Compatible with Johnson Facility Explorer.
  3. Compatible with the existing controls system, field verify and coordinate with owner

### **2.02 SERVICE REQUIREMENTS: THE MANUFACTURER'S SERVICE REPRESENTATIVE MUST BE LOCATED WITHIN 50 MILES OF THE PROJECT SITE AND HAVE A MAXIMUM SERVICE CALL RESPONSE TIME OF 24 HOURS. THE SERVICE REPRESENTATIVE MUST HAVE A MINIMUM OF 5 YEARS EXPERIENCE MAINTAINING THE CONTROL SYSTEM MANUFACTURER'S EQUIPMENT.**

### **2.03 CONTROL SYSTEM**

- A. Manufacturers:
1. Johnson Controls, Inc.; Controls Group. All Controls shall be compatible with the Johnson facility explorer system that is being installed in an upcoming energy performance contract and existing facility controls
- B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

### **2.04 DDC EQUIPMENT**

- A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
  2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
    - a. Global communications.
    - b. Discrete/digital, analog, and pulse I/O.
    - c. Monitoring, controlling, or addressing data points.
    - d. Software applications, scheduling, and alarm processing.
    - e. Testing and developing control algorithms without disrupting field hardware and controlled environment.
  3. Standard Application Programs:
    - a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
    - b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
    - c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
    - d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.

- e. Remote communications.
  - f. Maintenance management.
  - g. Units of Measure: Inch-pound and SI (metric).
- 4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
- 5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
- B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
  - 1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
  - 2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
    - a. Global communications.
    - b. Discrete/digital, analog, and pulse I/O.
    - c. Monitoring, controlling, or addressing data points.
  - 3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
  - 4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
- C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will not cause damage to controllers.
  - 1. Binary Inputs: Allow monitoring of on-off signals without external power.
  - 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
  - 3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
  - 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation.
  - 5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA).
  - 6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
  - 7. Universal I/Os: Provide software selectable binary or analog outputs.
- D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
  - 1. Output ripple of 5.0 mV maximum peak to peak.
  - 2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
  - 3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
  - 1. Minimum dielectric strength of 1000 V.
  - 2. Maximum response time of 10 nanoseconds.
  - 3. Minimum transverse-mode noise attenuation of 65 dB.
  - 4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

## 2.05 UNITARY CONTROLLERS

- A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
  - 1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.



2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
4. Enclosure: Dustproof rated for operation at 32 to 120 deg F.

## **2.06 ALARM PANELS**

### **2.07 UNITIZED CABINET WITH SUITABLE BRACKETS FOR WALL OR FLOOR MOUNTING. FABRICATE OF 0.06-INCH- THICK, FURNITURE-QUALITY STEEL OR EXTRUDED-ALUMINUM ALLOY, TOTALLY ENCLOSED, WITH HINGED DOORS AND KEYED LOCK AND WITH MANUFACTURER'S STANDARD SHOP-PAINTED FINISH. PROVIDE COMMON KEYING FOR ALL PANELS.**

- A. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.
  1. Alarm Condition: Indicating light flashes and horn sounds.
  2. Acknowledge Switch: Horn is silent and indicating light is steady.
  3. Second Alarm: Horn sounds and indicating light is steady.
  4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
  5. Contacts in alarm panel allow remote monitoring by independent alarm company.

## **2.08 ANALOG CONTROLLERS**

- A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
- B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.
- C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.
  1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.
- D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.
- E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.
  1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.
  2. Proportional band shall extend from 2 to 20 percent for 5 psig.
  3. Authority shall be 20 to 200 percent.
  4. Air-supply pressure of 18 psig, input signal of 3 to 15 psig, and output signal of zero to supply pressure.
  5. Gages: 2-1/2 inches in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

## **2.09 ELECTRONIC SENSORS**

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
- B. Thermistor Temperature Sensors and Transmitters:
  1. Manufacturers:
    - a. BEC Controls Corporation.

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- b. Ebtron, Inc.
  - c. Heat-Timer Corporation.
  - d. T.M. Instruments Inc.
  - e. MAMAC Systems, Inc.
  - f. RDF Corporation.
2. Accuracy: Plus or minus 0.5 deg F at calibration point.
  3. Wire: Twisted, shielded-pair cable.
  4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
  5. Averaging Elements in Ducts: 60 inches in length per 10 sq. ft. of duct cross-sectional area; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.
  6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
  7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    - a. Set-Point Adjustment: Concealed in public spaces and exposed in staff spaces.
    - b. Set-Point Indication: Concealed in public spaces and exposed in staff areas.
  8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
- C. RTDs and Transmitters:
1. Manufacturers:
    - a. BEC Controls Corporation.
    - b. MAMAC Systems, Inc.
    - c. RDF Corporation.
  2. Accuracy: Plus or minus 0.2 percent at calibration point.
  3. Wire: Twisted, shielded-pair cable.
  4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
  5. Averaging Elements in Ducts: 60 inches in length per 10 sq. ft. of duct cross-sectional area; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.; length as required.
  6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
  7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    - a. Set-Point Adjustment: Concealed in public spaces and exposed in staff spaces.
    - b. Set-Point Indication: Concealed in public spaces and exposed in staff areas.
  8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
- D. Humidity Sensors: Bulk polymer sensor element.
1. Manufacturers:
    - a. BEC Controls Corporation.
    - b. General Eastern Instruments.
    - c. MAMAC Systems, Inc.
    - d. ROTRONIC Instrument Corp.
    - e. TCS/Basys Controls.
    - f. Vaisala.
  2. Accuracy: 2 percent full range with linear output.
  3. Room Sensor Range: 20 to 80 percent relative humidity.
  4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    - a. Set-Point Adjustment: Concealed in public spaces and exposed in staff spaces.
    - b. Set-Point Indication: Concealed in public spaces and exposed in staff areas.
  5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
  6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 20 to plus 170 deg F.
  7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

- E. Pressure Transmitters/Transducers:
  - 1. Manufacturers:
    - a. BEC Controls Corporation.
    - b. General Eastern Instruments.
    - c. MAMAC Systems, Inc.
    - d. ROTRONIC Instrument Corp.
    - e. TCS/Basys Controls.
    - f. Vaisala.
  - 2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
    - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
    - b. Output: 4 to 20 mA.
    - c. Building Static-Pressure Range: 0- to 0.25-inch wg.
    - d. Duct Static-Pressure Range: 0- to 5-inch wg.
  - 3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
  - 4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
  - 5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
  - 6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.
- F. Room Sensor Cover Construction: Manufacturer's standard locking covers.
  - a. Set-Point Adjustment: Concealed in public spaces and exposed in staff spaces.
  - b. Set-Point Indication: Concealed in public spaces and exposed in staff areas.
- G. Room sensor accessories include the following:
  - 1. Insulating Bases: For sensors located on exterior walls.
  - 2. Adjusting Key: As required for calibration and cover screws.

## 2.10 STATUS SENSORS

- A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.
- B. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- C. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
- D. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
- E. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- F. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
- G. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.
  - 1. Manufacturers:
    - a. BEC Controls Corporation.
    - b. T.M. Instruments Inc.

## 2.11 THERMOSTATS

- A. Manufacturers:
  - 1. Erie Controls.

2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
  3. Heat-Timer Corporation.
  4. Sauter Controls Corporation.
  5. tekmar Control Systems, Inc.
  6. Theben AG - Lumilite Control Technology, Inc.
- B. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.
1. Label switches "FAN ON-OFF", "FAN HIGH-LOW-OFF", "FAN HIGH-MED-LOW-OFF", or as required based on the requirements.
  2. Mount on single electric switch box.
- C. Electric, solid-state, microcomputer-based room thermostat with remote sensor.
1. Automatic switching from heating to cooling.
  2. Preferential rate control to minimize overshoot and deviation from set point.
  3. Set up for four separate temperatures per day.
  4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
  5. Short-cycle protection.
  6. Programming based on every day of week.
  7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
  8. Battery replacement without program loss.
  9. Thermostat display features include the following:
    - a. Time of day.
    - b. Actual room temperature.
    - c. Programmed temperature.
    - d. Programmed time.
    - e. Duration of timed override.
    - f. Day of week.
    - g. System mode indications include "heating," "off," "fan auto," and "fan on."
- D. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.
- E. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.
1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
  2. Selector Switch: Integral, manual on-off-auto.
- F. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
1. Bulbs in water lines with separate wells of same material as bulb.
  2. Bulbs in air ducts with flanges and shields.
  3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
  4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
  5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
  6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
- G. Fire-Protection Thermostats: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, and the following:
1. Reset: Manual.

2. Reset: Automatic, with control circuit arranged to require manual reset at central control panel; with pilot light and reset switch on panel labeled to indicate operation.
- H. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
- I. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.
- J. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.
  1. Bulb Length: Minimum 20 feet.
  2. Quantity: One thermostat for every 20 sq. ft. of coil surface.
- K. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.
  1. Bulb Length: Minimum 20 feet.
  2. Quantity: One thermostat for every 20 sq. ft. of coil surface.
- L. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig, and cast housing with position indicator and adjusting knob.

## 2.12 HUMIDISTATS

- A. Manufacturers:
  1. MAMAC Systems, Inc.
  2. ROTRONIC Instrument Corp.
- B. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

## 2.13 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
  1. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
  2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
  3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
  4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
  5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
  6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
  7. Manual Positioning: Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 in.-lb. torque capacity shall have a manual crank.
- B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
  1. Manufacturers:
    - a. Belimo Aircontrols (USA), Inc.
  2. Valves: Size for torque required for valve close off at maximum pump differential pressure.

3. Dampers: Size for running torque calculated as follows:
  - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
  - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
  - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. of damper.
  - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
  - e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
  - f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Manual Positioning: Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 in.-lb. torque capacity shall have a manual crank.
8. Power Requirements (Two-Position Spring Return): 24-V ac.
9. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
10. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
11. Temperature Rating: 40 to 104 deg F, unless used for outdoor applications.
12. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
13. Run Time: 12 seconds open, 5 seconds closed.

## 2.14 CONTROL VALVES

- A. Manufacturers:
  1. Danfoss Inc.; Air Conditioning & Refrigeration Div.
  2. Erie Controls.
  3. Hayward Industrial Products, Inc.
  4. Magnatrol Valve Corporation.
  5. Neles-Jamesbury.
  6. Parker Hannifin Corporation; Skinner Valve Division.
  7. Pneuline Controls.
  8. Sauter Controls Corporation.
- B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- C. Hydronic system globe valves shall have the following characteristics:
  1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
  2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
  3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
    - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
    - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
  4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:
    - a. Two Position: Line size.
    - b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
    - c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
  5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
- D. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
  1. Body Style: Lug or Grooved.
  2. Disc Type: Aluminum bronze.
  3. Sizing: 1-psig maximum pressure drop at design flow rate.
- E. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
  1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
  2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
  3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
- F. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
  1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
  2. Thermostatic Operator: Liquid-filled remote sensor with integral adjustable dial.

## 2.15 DAMPERS

- A. Manufacturers:
  1. Air Balance Inc.
  2. Don Park Inc.; Autodamp Div.
  3. TAMCO (T. A. Morrison & Co. Inc.).
  4. United Enertech Corp.
  5. Vent Products Company, Inc.
- B. Dampers: AMCA-rated, parallel and opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches. Blades shall be airfoil type suitable for wide-open face velocity of 2000 fpm.
  1. Provide parallel blade design for two-position applications.
  2. Provide opposed-blade design for modulating applications.
  3. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
  4. Operating Temperature Range: From minus 40 to plus 200 deg F.
  5. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
  6. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.
  7. Sections: Damper sections shall not exceed 48 in. x 60 in. Each section shall have at least one damper actuator.
  8. Linkages: Dampers shall have exposed linkages.

## 2.16 CONTROL CABLE

- A. Electronic and fiber-optic cables for control wiring are specified in Section 271500 "Communications Horizontal Cabling."

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.

**3.02 INSTALLATION**

- A. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- B. Connect and configure equipment and software to achieve sequence of operation specified.
- C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install wall-mounted devices 60 inches above the floor.
  - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- D. Install guards on thermostats in the following locations:
  - 1. Entrances.
  - 2. Public areas.
  - 3. Where indicated.
- E. Install automatic dampers according to Section 233300 "Air Duct Accessories."
- F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- G. Install labels and nameplates to identify control components according to Section 230553 "Identification for HVAC Piping and Equipment."
- H. Install hydronic instrument wells, valves, and other accessories according to Section 232116 Hydronic Piping Specialties."
- I. Install steam and condensate instrument wells, valves, and other accessories according to Section 232216 Steam and Condensate Piping Specialties."
- J. Install refrigerant instrument wells, valves, and other accessories according to Section 232300 "Refrigerant Piping."
- K. Install duct volume-control dampers according to Section 233113 "Metal Ducts".
- L. Install electronic and fiber-optic cables according to Section 271500 "Communications Horizontal Cabling."

**3.03 ELECTRICAL WIRING AND CONNECTION INSTALLATION**

- A. Install raceways, boxes, and cabinets according to Section 260533 "Raceways and Boxes for Electrical Systems."
- B. Install building wire and cable according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Install signal and communication cable according to Section 271500 "Communications Horizontal Cabling."
  - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
  - 2. Install exposed cable in raceway.
  - 3. Install concealed cable in raceway.
  - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
  - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
  - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
  - 7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.



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**3.04 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
  - 2. Test and adjust controls and safeties.
  - 3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 4. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
  - 5. Test each point through its full operating range to verify that safety and operating control set points are as required.
  - 6. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
  - 7. Test each system for compliance with sequence of operation.
  - 8. Test software and hardware interlocks.
- C. DDC Verification:
  - 1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
  - 2. Check instruments for proper location and accessibility.
  - 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
  - 4. Check instrument tubing for proper fittings, slope, material, and support.
  - 5. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
  - 6. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
  - 7. Check temperature instruments and material and length of sensing elements.
  - 8. Check control valves. Verify that they are in correct direction.
  - 9. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
  - 10. Check DDC system as follows:
    - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    - c. Verify that spare I/O capacity has been provided.
    - d. Verify that DDC controllers are protected from power supply surges.
- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

**3.05 ADJUSTING**

- A. Calibrating and Adjusting:
  - 1. Calibrate instruments.
  - 2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
  - 3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
  - 4. Control System Inputs and Outputs:
    - a. Check analog inputs at 0, 50, and 100 percent of span.
    - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    - c. Check digital inputs using jumper wire.
    - d. Check digital outputs using ohmmeter to test for contact making or breaking.

- e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
  5. Flow:
    - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    - b. Manually operate flow switches to verify that they make or break contact.
  6. Pressure:
    - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
  7. Temperature:
    - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    - b. Calibrate temperature switches to make or break contacts.
  8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
  9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
  10. Provide diagnostic and test instruments for calibration and adjustment of system.
  11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Adjust initial temperature and humidity set points.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

### 3.06 TRAINING

- A. Provide training for a designated staff of Owner's representatives. Training shall be provided via classroom and on-site training. Training shall be tailored to Owner's requirements.
- B. Provide Owner training for the equivalent of 10 hours each for 3 persons.
- C. Training shall enable students to accomplish the following objectives.
  1. Proficiently operate system
  2. Understand control system architecture and configuration
  3. Understand DDC system components
  4. Understand system operation, including DDC system control and optimizing routines (algorithms)
  5. Adjust and change system setpoints, time schedules, and holiday schedules
  6. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
  7. Understand system drawings and Operation and Maintenance manual
  8. Understand job layout and location of control components
  9. Access data from DDC controllers
  10. Create, delete, and modify alarms, including configuring alarm reactions
  11. Create, delete, and modify point trend logs (graphs) and multi-point trend graphs
  12. Configure and run reports
  13. Add, remove, and modify system's physical points
  14. Create, modify, and delete application programming
  15. Add operator interface stations
  16. Add a new controller to system
  17. Download firmware and advanced applications programming to a controller
  18. Configure and calibrate I/O points

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- 19. Maintain software and prepare backups
- 20. Interface with job-specific, third-party operator software
- 21. Add new users and understand password security procedures
- D. Instructors shall be factory-trained and experienced in presenting this material.
- E. Perform classroom training using a network of working controllers representative of installed hardware.

**END OF SECTION**

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## SECTION 230923.11 - CONTROL VALVES

### 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 control valves and actuators for DDC systems.
- B. Related Requirements:
  - 1. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.

#### 1.3 DEFINITIONS

- A. Cv: Design valve coefficient.
- B. DDC: Direct-digital control.
- C. NBR: Nitrile butadiene rubber.
- D. PTFE: Polytetrafluoroethylene
- E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
  - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
  - 3. Product description with complete technical data, performance curves, and product specification sheets.
  - 4. Installation, operation, and maintenance instructions, including factors affecting performance.
- B. Delegated-Design Submittal:
  - 1. Schedule and design calculations for control valves and actuators, including the following:
    - a. Flow at project design and minimum flow conditions.
    - b. Pressure differential drop across valve at project design flow condition.
    - c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.

- d. Design and minimum control valve coefficient with corresponding valve position.
- e. Maximum close-off pressure.
- f. Leakage flow at maximum system pressure differential.
- g. Torque required at worst case condition for sizing actuator.
- h. Actuator selection indicating torque provided.

## 1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Control valve installation location shown in relationship to room, duct, pipe, and equipment.
  - 2. Size and location of wall access panels for control valves installed behind walls.
  - 3. Size and location of ceiling access panels for control valves installed above inaccessible ceilings.

## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

- 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. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- C. Delegated Design: Engage a qualified engineer, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.
- D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.
- F. Environmental Conditions:
  - 1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.
    - a. Hazardous Locations: Explosion-proof rating for condition.
- G. Determine control valve sizes and flow coefficients by ISA 75.01.01.
- H. Control valve characteristics and rangeability shall comply with ISA 75.11.01.
- I. Selection Criteria:

1. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
2. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
3. Modulating straight-through pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
4. Fail positions unless otherwise indicated:
  - a. Chilled Water: Close.
  - b. Heating Hot Water: Open.
5. Rotary-type control valves, such as ball and butterfly valves, shall have Cv falling between 65 and 75 degrees of valve full open position and minimum valve Cv between 15 and 25 percent of open position.
6. Selection shall consider viscosity, flashing, and cavitation corrections.
7. Valves shall have stable operation throughout full range of operation, from design to minimum Cv.
8. Minimum Cv shall be calculated at **10** percent of design flow, with a coincident pressure differential equal to the system design pump head.
9. In water systems, select modulating pressure independent control valves at terminal equipment for a design Cv based on a pressure drop of **5 psig** at design flow unless otherwise indicated or recommended by the control valve manufacturer.

## 2.2 BALL-STYLE CONTROL VALVES

### A. Pressure-Independent Ball Valves NPS 2 (DN 50) and Smaller:

1. Performance:
  - a. Pressure Rating: 600 psig (4137 kPa) for NPS 1 (DN 25) and 400 psig (2528 kPa) for NPS 1-1/2 and NPS 2 (DN 38 and DN 50).
  - b. Close-off pressure of 200 psig (1379 kPa).
  - c. Process Temperature Range: Between zero to 212 deg F (minus 18 to plus 100 deg C).
  - d. Rangeability: 100 to 1.
2. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig (34 to 345 kPa).
3. Body: Forged brass, nickel plated, and with threaded ends.
4. Ball: Chrome-plated brass.
5. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.
6. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
7. Ball Seats: Reinforced PTFE.
8. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
9. Flow Characteristic: Equal percentage.

## 2.3 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

- A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.
- B. Position indicator and graduated scale on each actuator.
- C. Type: Motor operated, with or without gears, electric and electronic.
- D. Voltage: **Voltage selection delegated to professional designing control system.**
- E. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
- F. Function properly within a range of 85 to 120 percent of nameplate voltage.
- G. Construction:
  - 1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
  - 2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
  - 3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- H. Field Adjustment:
  - 1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
  - 2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.
- I. Two-Position Actuators: Single direction, spring return or reversing type.
- J. Modulating Actuators:
  - 1. Operation: Capable of stopping at all points across full range and starting in either direction from any point in range.
  - 2. Control Input Signal:
    - a. Three Point, Tristate, or Floating Point: Clockwise and counterclockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
    - b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for **zero to 10 and 4 to 20 mA** signals.
    - c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
    - d. Programmable Multi-Function:
      - 1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
      - 2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.



- 3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

K. Position Feedback:

1. **Where indicated, equip** two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of **open and close** position.
2. **Where indicated, equip** modulating actuators with a position feedback through **current or voltage** signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

L. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

M. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

N. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

O. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from **[5 to 95]** percent relative humidity, non-condensing.

P. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

Q. Stroke Time:

1. Operate valve from fully closed to fully open within **[15]** seconds.
2. Operate valve from fully open to fully closed within **[15]** seconds.
3. Move valve to failed position within **[5]** seconds.
4. Select operating speed to be compatible with equipment and system operation.

R. Sound:

1. Spring Return: [62] dBA.
2. Non-Spring Return: [45] dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL VALVE APPLICATIONS

- A. Control Valves:
  1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
  2. Hydronic Hot Water Heating and Chilled Water Cooling: **Pressure-independent ball valves.**

3.3 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.
- D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.
- F. Fastening Hardware:
  1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
  2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
  3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

- G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

### 3.4 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

### 3.5 CONTROL VALVES

- A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.
- B. Install flanges or unions to allow drop-in and -out valve installation.
- C. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve.
- D. **Install pressure temperature taps in piping upstream and downstream of each control valve.**
- E. Valve Orientation:
  - 1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
  - 2. Install valves in a position to allow full stem movement.
  - 3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.
- F. Clearance:
  - 1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
  - 2. Install valves with at least **12 inches (300 mm)** of clear space around valve and between valves and adjacent surfaces.
- G. Threaded Valves:
  - 1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
  - 2. Align threads at point of assembly.
  - 3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
  - 4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.
- H. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

### 3.6 CONNECTIONS

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

### 3.7 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with valve identification on valve.

### 3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

### 3.9 CHECKOUT PROCEDURES

- A. Control Valve Checkout:
  1. Check installed products before continuity tests, leak tests, and calibration.
  2. Check valves for proper location and accessibility.
  3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
  4. For pneumatic products, verify air supply for each product is properly installed.
  5. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.
  6. Verify that control valves are installed correctly for flow direction.
  7. Verify that valve body attachment is properly secured and sealed.
  8. Verify that valve actuator and linkage attachment are secure.
  9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
  10. Verify that valve ball, disc, and plug travel are unobstructed.
  11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

### 3.10 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

- C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
- D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11



**SECTION 230923.14 - FLOW INSTRUMENTS**

**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. Airflow Measurement Devices (AMD) with Temperature Output and Airflow Alarming Capability.
  - 2. Airflow transmitters.
- B. Related Requirements:
  - 1. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.14.

**1.3 DEFINITIONS**

- A. Ethernet: Local area network based on IEEE 802.3 standards.
- B. FEP: Fluorinated ethylene propylene.
- C. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.
- D. PEEK: Polyetheretherketone.
- E. PTFE: Polytetrafluoroethylene.
- F. PPS: Polyphenylene sulfide.
- G. RS-485: A TIA standard for multipoint communications using two twisted pairs.
- H. RTD: Resistance temperature detector.
- I. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product, including the following:
  - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical

- power requirements, and limitations of ambient operating environment, including temperature and humidity.
- 3. Product description with complete technical data, performance curves, and product specification sheets.
- 4. Installation instructions, including factors affecting performance.
- 5. Product certificates.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and mounting details.
  - 2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
  - 4. Include diagrams for air and process signal tubing.
  - 5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.
- C. Delegated-Design Submittal:
  - 1. Schedule and design calculations for flow instruments, including the following.
    - a. Flow at Project design and minimum flow conditions.
    - b. Pressure drop at Project design and minimum flow conditions.

## 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS AND PRODUCTS

- A. EBTRON, Inc. is the basis of design for all Airflow Measurement devices.
  - 1. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
    - a. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
  - 2. Substitution requests for acceptance less than 60 days prior to bid date or products submitted in non-conformance with the requirements of this specification will not be considered.
    - a. For any product to be considered for substitution, a written document shall be submitted to the engineer detailing exceptions and compliance, section-by-section with supporting documentation, before an approval will be considered.
    - b. Any product submitted as an equal shall be expected to comply with all performance capabilities and functional aspects of this specification.
  - 3. Excluded devices:
    - a. Measurement technologies using “chip-in-glass”, “chip-in-epoxy” or other “chip” type thermistors for the heated sensor component are not acceptable.
    - b. Pitot tubes, pitot arrays, piezo-rings and other differential pressure measurement devices.
    - c. Vortex shedding airflow measurement devices.



## 2.2 AIRFLOW MEASUREMENT STATIONS AND SENSORS

### A. General

1. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.
2. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.
  - a. Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
3. Airflow measurement shall be field configurable to determine the average Actual or Standard mass airflow rate.
  - a. Actual airflow rate calculations shall have the capability of being corrected by the transmitter for altitudes other than sea level.
4. Temperature measurement shall be field configurable with velocity weighted average as the default, or manual selection of arithmetic average temperature.

### B. Sensor Probes

1. Sensor probes shall be constructed of gold anodized 6063 aluminum alloy tube.
2. Sensor probe mounting brackets shall be constructed of 304 stainless steel.
3. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper.
  - 1) PVC jacketed internal wiring is not acceptable.
4. Probe internal wiring connections shall consist of solder joints and spot welds.
  - 1) Internal wiring connections shall be sealed and protected from the elements. They shall be capable of direct exposure to water without affecting instrument operation.
  - 2) Connectors of any type within the probe are not acceptable.
  - 3) Printed circuit boards within the probe are not acceptable.
5. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67° F to 392° F (-55° C to 200° C) and continuous and direct UV exposure.
  - 1) Plenum rated PVC jacket cables are not acceptable.
6. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
7. Each sensor probe shall contain one or more independently wired sensing nodes.
8. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter in the field.
  - 1) Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Upon request, the manufacture shall provide a written independent laboratory test result of 100% survival rate in a 30 day saltwater and acid vapor test.
  - 2) Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
  - 3) Devices with exposed leads are not acceptable.
9. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
10. Each sensor node shall be individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA)

primary velocity standard and have an accuracy of  $\pm 2\%$  of reading over the entire calibrated airflow range of 0 to 5,000 FPM (25.4 m/s).

- a) Upon request the manufacture shall submit for AMD approval a copy of the NIST report of calibration used for the reference standard used.
  - b) Devices claiming NIST traceability to third party laboratories and not directly to NIST are not acceptable
  - c) Devices calibrated against standards other than the NIST LDA are not acceptable.
11. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
  12. The installed airflow accuracy shall be:
    - a) Ducts -  $\pm 3\%$  of reading when installed in accordance with the manufactures recommended placement guidelines.
    - b) Non-ducted Outdoor Air intakes - better than or equal to  $\pm 5\%$  of reading when installed in accordance with the manufactures recommended placement guidelines.
  13. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
  14. Each sensing node shall have a temperature accuracy of  $\pm 0.15^\circ \text{ F}$  ( $0.08^\circ \text{ C}$ ) over an operating range of  $-20^\circ \text{ F}$  to  $160^\circ \text{ F}$ . ( $-28.9^\circ \text{ C}$  to  $71.1^\circ \text{ C}$ ) and humidity range of 0 to 100% RH.
  15. The number of independent sensor nodes provided shall be as follows for large rectangular ducts:

Area ft <sup>2</sup> [m <sup>2</sup> ]	# Sensor Nodes
$\leq 0.5$ [ $\leq 0.046$ ]	1
$> 0.5 \ \& \ \leq 1$ [ $\leq 0.092$ ]	2
$> 1 \ \& \ \leq 2$ [ $> 0.092 \ \& \ \leq 0.185$ ]	4
$> 2 \ \& \ \leq 4$ [ $> 0.185 \ \& \ \leq 0.371$ ]	6
$> 4 \ \& \ \leq 8$ [ $> 0.371 \ \& \ \leq 0.743$ ]	8
$> 8 \ \& \ \leq 12$ [ $> 0.743 \ \& \ \leq 1.11$ ]	12
$> 12 \ \& \ \leq 14$ [ $> 1.11 \ \& \ \leq 1.30$ ]	14
$> 14$ [ $> 1.30$ ]	16

- 1) A total of 4 probes shall be required for openings with an aspect ratio  $\leq 1.5$  and with an area  $\geq 25 \text{ ft}^2$  ( $\geq 2.32 \text{ m}^2$ ).

16. The number of independent sensor nodes provided shall be as follows for round or small duct systems:

Diameter - in [mm]	# Sensor Nodes
4 [101.6]	1
$\geq 5 \ \& \ \leq 16$ [ $\geq 127 \ \& \ \leq 406.4$ ]	2

D. Transmitter – Large Duct Systems

1. A remotely located microprocessor-based transmitter shall be provided for each measurement location.
2. The transmitter shall be comprised of a main circuit board and interchangeable interface card.
3. All printed circuit board interconnects, edge fingers, receptacle plug pins and PCB test points shall be gold plated.
4. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
5. All integrated circuitry shall be temperature rated as ‘industrial-grade’. Submissions containing ‘commercial-grade’ integrated circuitry are not acceptable.
6. The transmitter shall be capable of determining the airflow rate and temperature average of all connected sensor nodes in an array for a single location.
  - a. Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (Bluetooth).
7. The transmitter shall be capable of providing a high and/or low airflow alarm with user-defined set point and % of set point tolerance. Alarm shall be capable of being manually or automatically reset and low-limit cutoff value may be selected to disable the alarm. An alarm delay function shall also be field defined.
8. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
9. The transmitter shall be capable of field configuration, diagnostics and include Field Output Adjustment Wizard that allows for a one or two point field adjustment to factory calibration for installations that require adjustment.
10. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
11. The transmitter shall be provided one of the following output options:
  - a. two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals (AO1=airflow, AO2=temperature or alarm) and one RS-485 BACnet/Modbus connection, or
  - b. two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals (AO1=airflow, AO2=temperature or alarm) and one Ethernet BACnet/Modbus connection, or one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection, or
  - c. two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals (AO1=airflow, AO2=temperature or alarm) and one proprietary wireless connection to EBTRON “Commissioner” based devices, or
  - d. One RS 485 BACnet/Modbus network connection and one Ethernet BACnet/Modbus or
  - e. One Lonworks Free Topology network connection, or
  - f. One thumb drive data logger (no output).

12. The analog signal capability shall include two output terminals: the first (AO1), shall provide the total airflow rate and the second output (AO2) shall be field configurable to provide one of the following:
  - a. temperature
  - b. low and/or high airflow user-defined set point alarm, or
  - c. system status alarm
13. The network communications RS-485 (BACnet MS/TP or Modbus RTU) or Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) shall provide: the average airflow rate, temperature, hi and/or low airflow set point alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures. Individual node airflow rates and temperatures shall NOT be available via the network with Lon.
14. The transmitter shall be provided with a Bluetooth low energy interface card to interface with Android or iOS devices. Provide free Android or iOS software that allows real-time airflow and temperature monitoring and airflow and temperature traverses. Software shall capture, save or e-mail airflow and temperature data, transmitter settings and diagnostics information.
15. The transmitter shall have an on-off power switch. Isolation transformers shall not be required.
16. The transmitter shall be powered by 24 VAC (22.8 to 26.4 under load) @20 V-A maximum and use a switching power supply that is over-current and over-voltage protected.
17. The transmitter shall use a "watchdog" timer circuit to ensure automatic reset after power disruption, transients and brown-outs.
18. Each transmitter shall have an operating temperature range of -20° F to 120° F (-28.9° C to 48.9° C) and humidity range of 5 to 95% RH.
19. Listings and Certifications
  - a. The AMD shall be UL/cUL 873 Listed as an assembly.
    - 1) Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.
  - b. All network-capable AMD models supplied with RS-485 interface and BACnet protocol shall be BTL Listed.
  - c. The AMD shall be tested for compliance with the EMC Directive's requirements and be certified to carry the CE Mark for European Union Shipments.

E. Transmitter – Round duct / Small Duct Systems

1. An integral microprocessor-based transmitter shall be provided for each measurement location, with simple DIP switch user interface for set up.
2. All printed circuit board interconnects and test points shall be gold plated.
3. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
4. The transmitter shall be capable of determining the average airflow rate and average velocity-weighted temperature of the sensor nodes in the array.
5. The transmitter shall be capable of identifying an AMD malfunction and ignore any sensor node that is in a fault condition.

6. The transmitter shall be provided with one of the following:
  - a. One scalable, protected and field selectable analog output signal for airflow (0-5/1-5 VDC or 0-10/2-10 VDC, AO1= Airflow)
  - b. Two scalable, protected and field selectable analog output signals (0-5/1-5 VDC or 0-10/2-10 VDC, AO1= Airflow, AO2= Temperature)
  - c. One non-isolated RS-485 network connection (field selectable BACnet MS/TP or Modbus RTU). Provide individual 24 VAC transformers at each network transmitter requiring isolated RS-485 connection.
7. The transmitter shall provide a sensor diagnostic system on board, with system status alarm (trouble indication), with visual indication of LED on the circuit board.
8. Network communications shall provide the average airflow rate, temperatures, individual sensor node airflow rates and individual sensor node temperatures.
9. The transmitter shall be powered by 24 VAC (22.8 to 26.4 under load) @5 V-A.
10. The transmitter shall use a "watchdog" timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

F. Performance and calibration

1. Each sensing node shall have an airflow accuracy of  $\pm 3\%$  of reading (typical)  $\pm 4\%$  max. from 0 to 3,000 FPM (15.24 m/s) over a temperature range of 0° F to 160° F (-18° to 71° C). Airflow accuracy shall be maintained at lower operating temperatures of -20° F to 160° F (-29° C to 71° C) but the velocity range shall be limited to 0 – 2,000 FPM (10.2 m/s).
  - a. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
  - b. Devices whose overall performance at the host controller input terminals is the combined accuracy of the transmitter and sensor probes shall demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
2. Each sensor node shall be factory calibrated at a minimum of 7 airflow rates including zero (still air), to NIST Traceable standards.
3. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
4. Each sensing node shall have a temperature accuracy of  $\pm 0.15^\circ\text{F}$  ( $\pm 0.08^\circ\text{C}$ ) over a calibrated range of -20° F to 160° F (-28.9° C to 71.1° C).
5. Minimum calibrated and operating temperature range for the sensor probes shall be -20° F to 160° F (-28.9° C to 71.1° C).
6. Operating temperature range for the transmitter shall be -20° F to 120° F (-28.9° C to 48.9° C).

G. Listings and Certifications

1. The AMD shall be UL 60730-1 and 60730-2-9 Listed as an assembly and subscribed to the UL Follow-up Services.
  - a. Devices claiming compliance with the UL Listing based on individual UL component listings are not acceptable.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
  - 1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
  - 2. Do not begin installation without submittal approval of mounting location.
- E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
- F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- G. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTRUMENT APPLICATIONS**

- A. Select from the specified manufacturers instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

#### **3.3 INSTALLATION, AIR FLOW STATIONS**

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.
- D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

#### **3.4 INSTALLATION, LIQUID FLOW MEASUREMENT**

#### **3.5 ELECTRIC POWER**

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

### 3.6 AIR FLOW INSTRUMENTS INSTALLATION

- A. Install in accordance with manufacturer's placement guidelines. A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.
- B. Airflow Sensors:
  - 1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
  - 2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

### 3.7 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

### 3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

### 3.9 CHECKOUT PROCEDURES

- A. Description:
  - 1. Check out installed products before continuity tests, leak tests, and calibration.
  - 2. Check instruments for proper location and accessibility.
  - 3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
  - 4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
- B. Flow Instrument Checkout:
  - 1. Verify that sensors are installed correctly with respect to flow direction.
  - 2. Verify that sensor attachment is properly secured and sealed.
  - 3. Verify that processing tubing attachment is secure and isolation valves have been provided.
  - 4. Inspect instrument tag against approved submittal.
  - 5. Verify that recommended upstream and downstream distances have been maintained.

### 3.10 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
  2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
  3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
  4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
  5. Provide diagnostic and test equipment for calibration and adjustment.
  6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
  7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
  8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
  9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
- B. Analog Signals:
1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
  2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
  3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- C. Digital Signals:
1. Check digital signals using a jumper wire.
  2. Check digital signals using an ohmmeter to test for contact.
- D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- E. Switches: Calibrate switches to make or break contact at set points indicated.
- F. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
  2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.
- 3.11 MAINTENANCE SERVICE
- A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance. Include annual preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
- 3.12 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION 230923.14



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## **SECTION 230934 VARIABLE-FREQUENCY MOTOR CONTROLLERS-CPL**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Variable-frequency motor controllers for low-voltage (600 V and less) AC motor applications.
- B. Overcurrent protective devices for motor controllers, including overload relays.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 230529 - Hangers and Supports for HVAC Piping and Equipment-CPL.
- B. Section 230553 - Identification for HVAC Piping and Equipment-CPL: Identification products and requirements.
- C. Section 260526 - Grounding and Bonding for Electrical Systems.
- D. Section 260573 - Power System Studies: Additional criteria for selection and adjustment of equipment and associated protective devices specified in this section.

#### **1.03 REFERENCE STANDARDS**

- A. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code) 2013 (Corrigendum 2019).
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts 2000, with Errata (2008).
- D. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices 2017.
- E. NEMA ICS 6 - Industrial Control and Systems: Enclosures 1993 (Reaffirmed 2016).
- F. NEMA ICS 7 - Standard for Industrial Control and Systems: Adjustable-Speed Drives 2020.
- G. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems 2014.
- H. NEMA ICS 7.2 - Application Guide for AC Adjustable Speed Drive Systems 2015.
- I. NEMA ICS 61800-2 - Adjustable Speed Electrical Power Drive Systems, Part 2: General Requirements-Rating Specifications for Low Voltage Adjustable Frequency AC Power Drive Systems 2005.
- J. NEMA MG 1 - Motors and Generators 2018.
- K. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- L. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- M. UL 508A - Industrial Control Panels Current Edition, Including All Revisions.
- N. UL 61800-5-1 - Standard for Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements – Electrical, Thermal, and Energy Current Edition, Including All Revisions.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate work to provide motor controllers suitable for use with actual motors to be installed.
  - 2. Coordinate work to provide controllers and associated wiring suitable for interface with control devices to be installed.
  - 3. Coordinate arrangement with dimensions and clearance requirements of actual equipment to be installed.
  - 4. Verify with manufacturer that conductor terminations are suitable for use with conductors to be installed.

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5. Notify Architect of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for motor controllers, enclosures, overcurrent protective devices, and other installed components and accessories.
- C. Shop Drawings: Indicate dimensions, voltage, controller sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
  1. Include wiring diagrams showing factory and field connections.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
  1. Include contact information for entity providing contract maintenance and trouble call-back service.
- F. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- G. Maintenance Materials: Furnish following for Owner's use in maintenance of project.
  1. See Section 016000 - Product Requirements, for additional provisions.
  2. Air Filters: Two of each different type.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
  1. Authorized service facilities located within 200 miles of project site.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory wrapping or provide additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to internal components, enclosure, and finish.

#### **1.08 FIELD CONDITIONS**

- A. Maintain field conditions within required service conditions during and after installation.

#### **1.09 WARRANTY**

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide minimum 18 month manufacturer warranty covering repair or replacement due to defective materials or workmanship.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. ABB: [www.abb.com/#sle](http://www.abb.com/#sle).
- B. Square D.
- C. Yaskawa Electric Corp.
- D. Substitutions: See Section 016000 - Product Requirements.
- E. Source Limitations: Furnish variable-frequency motor controllers and associated components produced by a single manufacturer and obtained from a single supplier.

## 2.02 VARIABLE-FREQUENCY MOTOR CONTROLLERS

- A. Provide variable-frequency motor control system consisting of required controller assemblies, operator interfaces, control power transformers, instrumentation and control wiring, sensors, accessories, system programming, etc. as necessary for complete operating system.
- B. Provide products listed, classified, and labeled as suitable for purpose intended.
- C. Variable-Frequency Motor Controller:
  - 1. Configuration: Packaged controller with across-the-line bypass.
  - 2. Rectifier/Converter: Diode-based, 6-pulse type.
  - 3. Control Method: Vector; closed-loop, with feedback.
  - 4. Filtering: Provide input/line reactor and output/load reactor.
- D. Controller Assemblies: Comply with NEMA ICS 7, NEMA ICS 7.1, and NEMA ICS 61800-2; list and label as complying with UL 61800-5-1 or UL 508A as applicable.
- E. Provide controllers selected for actual installed motors and coupled mechanical loads in accordance with NEMA ICS 7.2, NEMA MG 1 Part 30, and recommendations of manufacturers of both controller and load, where not in conflict with specified requirements; considerations include, but are not limited to:
  - 1. Motor type (e.g., induction, reluctance, and permanent magnet); consider NEMA MG 1 design letter or inverter duty rating for induction motors.
  - 2. Motor load type (e.g., constant torque, variable torque, and constant horsepower); consider duty cycle, impact loads, and high inertia loads.
  - 3. Motor nameplate data.
  - 4. Requirements for speed control range, speed regulation, and braking.
  - 5. Motor suitability for bypass starting method, where applicable.
- F. Devices on Load Side of Controller: Suitable for application across full controller output frequency range.
- G. Operating Requirements:
  - 1. Input Voltage Tolerance: Plus/minus 10 percent of nominal.
  - 2. Input Frequency Tolerance: Plus/minus 5 percent of nominal.
  - 3. Efficiency: Minimum of 96 percent at full speed and load.
  - 4. Input Displacement Power Factor: Minimum of 0.96 throughout speed and load range.
  - 5. Overload Rating:
    - a. Variable Torque Loads: Minimum of 110 percent of nominal for 60 seconds.
    - b. Constant Torque Loads: Minimum of 150 percent of nominal for 60 seconds.
- H. Power Conversion System: Microprocessor-based, pulse width modulation type consisting of rectifier/converter, DC bus/link, and inverter.
  - 1. Rectifier/Converter: Diode-based, 6-pulse type unless otherwise indicated.
- I. Control System:
  - 1. Provide microprocessor-based control system for automatic control, monitoring, and protection of motors. Include sensors, wiring, and connections necessary for functions and status/alarm indications specified.
  - 2. Provide integral operator interface for controller programming, display of status/alarm indications, fault reset, and local control functions including motor run/stop, motor forward/reverse selection, motor speed increase/decrease, and local/remote control selection.
  - 3. Control Functions:
    - a. Control Method: Selectable vector and scalar/volts per hertz unless otherwise indicated.
      - 1) Scalar/Volts per Hertz Control: Provide IR compensation for improved low-speed torque.
      - 2) Vector Control: Provide selectable autotuning function.
    - b. Adjustable acceleration and deceleration time; linear and S-curve ramps; selectable coast to stop.
    - c. Selectable braking control; DC injection or flux braking.

- d. Adjustable minimum/maximum speed limits.
- e. Adjustable pulse width modulation switching carrier frequency.
- f. Adjustable motor slip compensation.
- g. Selectable autorestart after noncritical fault; programmable number of time delay between restart attempts.
- 4. Status Indications:
  - a. Motor run/stop status.
  - b. Motor forward/reverse status.
  - c. Local/remote control status.
  - d. Output voltage.
  - e. Output current.
  - f. Output frequency.
  - g. DC bus voltage.
  - h. Motor speed.
  - i. Elapsed run time.
  - j. Discrete input/output status.
  - k. Analog input/output values.
- 5. Protective Functions/Alarm Indications:
  - a. Overcurrent.
  - b. Motor overload.
  - c. Undervoltage.
  - d. Overvoltage.
  - e. Controller overtemperature.
  - f. Input/output phase loss.
  - g. Output short circuit protection.
  - h. Output ground fault protection.
- 6. Inputs:
  - a. Digital Input(s): Three.
  - b. Analog Input(s): Two.
- 7. Outputs:
  - a. Analog Output(s): One.
  - b. Relay Output(s): Two.
- 8. Communications: Compatible with connected systems. Provide accessories necessary for proper interface.
  - a. Serial Communications: RS-485; support for Modbus RTU protocol.
  - b. Ethernet Communications: Support for Modbus TCP protocol.
- 9. Features:
  - a. Password-protected security access.
  - b. Event log.
- J. Power Conditioning/Filtering:
  - 1. Provide DC link choke or input/line reactor for each controller unless otherwise indicated or required.
  - 2. Reactor Impedance: 3 percent, unless otherwise indicated or required.
- K. Packaged Controllers: Controllers factory-mounted in separate enclosure with externally operable disconnect and specified accessories.
  - 1. Disconnects: Circuit breaker or disconnect switch type.
    - a. Disconnect Switches: Fusible type or nonfusible type with separate input fuses.
    - b. Provide externally operable handle with means for locking in OFF position. Provide safety interlock to prevent opening cover with disconnect in ON position with capability of overriding interlock for testing purposes.
    - c. Provide auxiliary interlock for disconnection of external control power sources where applicable.
  - 2. Provide door-mounted remote operator interface.
  - 3. Packaged Controllers with Bypass: Provide contactors and controls to enable removal of variable-frequency controller from circuit.
    - a. Bypass Method: Manual, unless otherwise indicated.

- b. Bypass Configuration: 3-contactor type, with contactors for bypass, drive output, and drive input.
    - c. Bypass Motor Starting Method: Full-voltage (across-the-line) with overload relay, unless otherwise indicated or required.
    - d. Overload Relays: Solid state or bimetallic thermal type.
  - 4. Pilot Devices Required:
    - a. Furnish local pilot devices for each unit as specified below unless otherwise indicated on drawings, except where equivalent function is provided by remote operator interface.
    - b. Packaged Controllers with Bypass:
      - 1) Bypass Mode Selector Switch: DRIVE/OFF/BYPASS.
      - 2) Motor Control Selector Switch: HAND/OFF/AUTO.
      - 3) Indicating Lights: For drive/bypass mode status, drive/bypass run status, and drive/bypass fault status.
- L. Service Conditions:
  - 1. Provide controllers and associated components suitable for operation under following service conditions without derating:
    - a. Altitude: Less than 3,300 feet.
    - b. Ambient Temperature: Between 32 degrees F and 104 degrees F.
  - 2. Provide controllers and associated components suitable for operation at indicated ratings under service conditions at installed location.
- M. Short Circuit Current Rating:
  - 1. Provide controllers with listed short circuit current rating not less than available fault current at installed location as determined by short circuit study performed in accordance with Section 260573.
  - 2. Provide line/input reactors where specified by manufacturer for required short circuit current rating.
- N. Conductor Terminations: Suitable for use with conductors to be installed.
- O. Enclosures:
  - 1. Comply with NEMA ICS 6.
  - 2. NEMA 250 Environment Type or Equivalent IEC 60529 Rating: Unless otherwise indicated, as specified for following installation locations:
    - a. Outdoor Locations: Type 3R or Type 4.
  - 3. Finish: Manufacturer's standard unless otherwise indicated.
  - 4. Cooling: Forced air or natural convection as determined by manufacturer.
  - 5. Enclosure Space Heaters:
    - a. Provide in each controller enclosure installed outdoors and in unconditioned indoor spaces.
    - b. Size according to manufacturer's recommendations for worst case ambient temperature to prevent condensation.
    - c. Heater Control: Thermostat.
    - d. Heater Power Source: Provide connection to transformer factory-installed in enclosure or suitable external branch circuit as indicated or as required.

## 2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Overload Relays:
  - 1. Provide overload relays and, where applicable, associated current elements/heaters selected for actual installed motor nameplate data, in accordance with manufacturer's recommendations and NFPA 70; include consideration for motor service factor and ambient temperature correction, where applicable.
  - 2. Comply with NEMA ICS 2.
  - 3. Inverse-Time Trip Class Rating: Class 20 unless otherwise indicated or required.
  - 4. Trip-free operation.
  - 5. Visible trip indication.
  - 6. Resettable:
    - a. Employ manual reset unless otherwise indicated.

- b. Do not employ automatic reset with two-wire control.

## **2.04 ACCESSORIES**

- A. Auxiliary Contacts:
  - 1. Comply with NEMA ICS 5.
  - 2. Provide number and type of contacts indicated or required to perform necessary functions, including holding (seal-in) circuit and interlocking, plus one normally open (NO) and one normally closed (NC) spare contact for each bypass motor starter, minimum.
- B. Pilot Devices:
  - 1. Comply with NEMA ICS 5; heavy-duty type.
  - 2. Pushbuttons: Unless otherwise indicated, provide momentary, nonilluminated type with flush button operator; normally open or normally closed as indicated or as required.
  - 3. Selector Switches: Unless otherwise indicated, provide maintained, nonilluminated type with knob operator; number of switch positions as indicated or as required.
  - 4. Indicating Lights: Push-to-test type unless otherwise indicated.
  - 5. Provide LED lamp source for indicating lights and illuminated devices.
- C. Control and Timing Relays:
  - 1. Comply with NEMA ICS 5.
  - 2. Provide number and type of relays indicated or required to perform necessary functions.
- D. Control Power Transformers:
  - 1. Size to accommodate burden of contactor coil(s) and connected auxiliary devices.
  - 2. Include primary and secondary fuses.

## **2.05 SOURCE QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Factory test controllers in accordance with NEMA ICS 61800-2.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that ratings of controllers are consistent with indicated requirements.
- C. Verify that mounting surfaces are ready to accept controllers.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.
- C. Do not exceed manufacturer's recommended maximum cable length between controller and motor.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required support and attachment in accordance with Section 230529.
- F. Install controllers plumb and level.
- G. Provide grounding and bonding in accordance with Section 260526.
- H. Install field-installed devices, components, and accessories.
- I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- J. Set field-adjustable settings of controllers and associated components according to installed motor requirements, in accordance with recommendations of manufacturers of controller and load.

**3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.17. Insulation-resistance test on control wiring listed as optional is not required.
- D. Packaged Controllers with Bypass: Test for proper operation in both drive and bypass modes.
- E. Test for proper interface with other systems.
- F. Correct deficiencies and replace damaged or defective controllers or associated components.

**3.04 ADJUSTING**

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

**3.05 CLEANING**

- A. Clean dirt and debris from controller enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

**3.06 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. See Section 017900 - Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of controllers to Owner, and correct deficiencies or make adjustments as directed.
- D. Training: Train Owner's personnel on operation, adjustment, and maintenance of controllers and associated devices.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.
  - 3. Location: At project site.

**3.07 PROTECTION**

- A. Protect installed controllers from subsequent construction operations.

**3.08 MAINTENANCE**

- A. See Section 017000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.

**END OF SECTION**

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**SECTION 230993  
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS****SEQUENCE OF OPERATIONS FOR HVAC CONTROLS****1.01 SUMMARY**

- A. This Section includes control sequences for HVAC systems, subsystems and equipment as well as basic requirements for sequences of operations for Division 23 equipment.

**1.02 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to the work of this Section.

**1.03 SUBMITTALS**

- A. Submittals shall demonstrate compliance with technical requirements by reference to each subsection of this specification.
- B. Sequences of Operation: Provide complete documentation of the sequences of operation required by this project, as hereinafter specified:
  - 1. Include narrative sequence of operation for each HVAC system, subsystem, and component as defined herein, within other specification sections referenced herein, and/or defined on the project Drawings.
  - 2. Narratives shall not be verbatim copies of the sequences provided herein but shall reflect the actual sequence of operation as applied by the contractor.
  - 3. Sequences of operation must include setpoints and/or control ranges, digital alarms, analog alarm setpoints (both high and low), time delays, I/O point names, hardware/software interlocks, analog control mode (e.g., proportional [P] or proportional plus integral [PI]), and any other specifics needed for the user to fully understand and utilize the DDC system for operation of each HVAC system and its individual components in compliance with the design intent.
  - 4. Sequences of operation for each item of equipment that is controlled by integral original equipment manufacturer (OEM) controls, with or without control logic through the DDC system, shall be incorporated in the applicable narrative.
- C. Control Schematics: Provide schematic diagrams of each HVAC system/subsystem sufficient to define the location of all control sensors, final control devices, etc. that are utilized as part of any sequence of operation and that confirm all input and output points required by any sequence of operation.
- D. User Interface Graphics: Provide draft copies of proposed graphic displays for each mechanical system type depicting the mechanical system, components, instruments, and controlled function status and value.

**1.04 CLOSEOUT SUBMITTALS**

- A. Section 01 70 00 – Execution and Closeout Requirements: Closeout procedures.
- B. Project Record Documents: Record “As Built” condition for each mechanical system including system schematics, locations of components, set points, and sequence of operations.

**PART 2 PRODUCTS (NOT USED)****PART 3 EXECUTION****3.01 GENERAL REQUIREMENTS**

- A. Sequences of operation specified herein, which indicate the functional intent of HVAC systems, subsystems, and/or components operation, are general in nature and may not fully define every aspect of programming that may be required to fulfill the design intent. Contractor shall provide all programming necessary to obtain the sequences/system operation indicated, resulting in stable HVAC system operation in accordance with the design intent.
- B. DEFINITIONS
  - 1. The following standard abbreviations, along with abbreviations defined on the Drawings, shall apply to all control schematics and sequences:

SEQUENCE OF OPERATIONS  
FOR HVAC CONTROLS

Abbreviation	Definition	Abbreviation	Definition
I/O Points		HVAC Components/Conditions	
AI	Analog Input	ACWS, ACWR	Air-Conditioning Water Supply, Return
AO	Analog Output	AHU	Air-Handling Unit
AV	Analog Value	BCU	Blower Coil Unit
DI	Digital (Binary) Input	CAV	Constant Air Volume
DO	Digital (Binary) Output	CC	Cooling Coil
DV	Digital (Binary) Value	CDWS, CDWR	Condenser Water Supply, Return
Control Conditions/Actions		CHWS, CHWR	Chilled Water Supply, Return
BP	Barometric Pressure	FCU	Fan Coil Unit
BTU	British Thermal Unit	HC	Heating Coil
DA	Direct Acting	HX	Heat Exchanger
DB	Dry Bulb	HWS, HWR	Hot Water Supply, Return
DP	Differential Pressure	HRU	Air Handler with Heat Recovery
DPT	Dew Point Temperature	OA	Outdoor Air
DT	Differential Temperature (Range)	OEM	Original Equipment Manufacturer
NC	Normally Closed	PHC	Preheat Coil
NO	Normally Open	RA	Return Air
P	Pressure; Proportional	RF	Return Air Fan
RA	Reverse Acting	SA	Supply Air
SP	Static Pressure	SF	Supply Fan
T	Temperature	VA	Ventilation Air
TP	Total Pressure	VAV	Variable Air Volume
VP	Velocity Pressure	XA	Relief Air
WB	Wet Bulb	XF	Relief Air Fan

## C. Other Definitions:

1. DDC: Direct digital control.
2. BAS: Building automation system.

## D. Sequences of operation shall incorporate the following control point/object requirements, as applicable:

Point Description	Hardware Point				Software Point				GRAPHIC
	AI	AO	DI	BI	AV	DV	SCHED	TREND	
BTU	X							X	X
Damper End Switch			X						X
DP	X							X	X
DPT					X			X	X
DT					X			X	X
Drain Pan Water Level Sensor			X						X

Electrical Power	X						X	X
Enthalpy				X			X	X
Flow (Air, Water, Steam, etc.)	X						X	X
Gas Concentration	X						X	X
Humidity	X						X	X
Occupancy/Vacancy			X				X	X
Occupied/Unoccupied				X		x	X	X
On/Off				X		x	X	X
Open/Close				X			X	X
Output (Percent)		X					X	X
Position (Percent from Normal)					X		X	X
P	X						X	X
Speed (% , set point)		X					X	
Speed (% , feedback)	X						X	X
Status			X				X	X
T	X						X	X

- E. HVAC control set points are defined or implied within the sequences of operation specified hereinafter and/or elsewhere on the Drawings.
- Where a set point is not explicitly defined or implied, determine the appropriate set point based on scheduled performance data for HVAC equipment. Confirm set point with A/E.
  - Defined or implied set points and set point reset requirements shall, as necessary, be adjusted based on test data provided by the testing/adjusting/balancing (TAB) subcontractor and control system calibration and verification testing as required by Section 230900 to provide stable, satisfactory HVAC systems operation in compliance with the design intent.
  - AO set points and control ranges shall be user-adjustable.
  - DO points that depend on a specific analog value to change shall be user-adjustable.
  - The minimum speed setting for each pump and fan under VFD control shall be as low as possible, while avoiding inertial stalling. Adjust each VFD minimum speed and ramp-up and -down times based on test data provided by the TAB subcontractor. Default times for acceleration/deceleration shall be 30 seconds for motors less than 40 hp and 60 seconds for motors 40 hp and larger.

### 3.02 GENERAL SEQUENCES OF OPERATION AND SCHEDULING

#### A. SYSTEM DESCRIPTION – GENERAL

- All systems shall maintain the scheduled or otherwise noted minimum outside air ventilation rate (based on 15 cfm or 20 cfm per person) during occupied hours.
- Provide normally open hot water and normally closed chilled water control valves.
- Provide normally open return air damper and normally closed outside air dampers and operators.
- Mode of operation (occupied/unoccupied) including building warm-up and pull-down cycles, as well as all system functions shall be programmable and controlled by the DDC system.
- Shutdown of air handling units and fans due to a fire alarm shall be by the Electrical Contractor. The fire alarm system will send a signal to the DDC system for monitoring purposes only. The DDC system will provide a staggered restart of the units once the alarm is cleared.
- All setpoints shall be adjustable.

#### B. EMERGENCY STOP SEQUENCE

- The following elements shall be incorporated into sequences of operation, whether specifically defined in individual sequences of operation hereinafter or not, and shall

initiate an alarm upon occurrence of any emergency stop:

APPLICATION	CONFIGURATION	EMERGENCY STOP REQUIREMENTS	
FCU/BCU/AHU SUPPLY AIR FAN(S) AND RETURN/RELIEF AIR FAN(S).	UNIT SERVES A SINGLE SPACE AND IS INCAPABLE OF SPREADING SMOKE BEYOND THE SPACE IN WHICH SMOKE IS GENERATED.	DUCT SMOKE DETECTORS ARE REQUIRED IN BOTH THE SUPPLY AND RETURN DUCTS OF AHU'S UNLESS THE SPACE SERVED BY THE AHU IS SERVED BY SMOKE DETECTION DEVICES. EMERGENCY STOP OF ALL UNIT FANS SHALL BE INITIATED BY AUXILIARY CONTACTS OF DUCT SMOKE DETECTORS OR BY FIRE ALARM SYSTEM SHUTDOWN RELAY/SOFTWARE INTERLOCK.	
	UNIT SERVES MULTIPLE SPACES AND IS CAPABLE OF SPREADING SMOKE BEYOND THE SPACE IN WHICH SMOKE IS GENERATED.	UNIT AIRFLOW $\leq$ 2,000 CFM	DUCT SMOKE DETECTORS ARE REQUIRED IN BOTH THE SUPPLY AND RETURN DUCTS OF AHU'S UNLESS EACH SPACE SERVED BY THE AHU IS SERVED BY SMOKE DETECTION DEVICES. EMERGENCY STOP OF ALL UNIT FANS SHALL BE INITIATED BY AUXILIARY CONTACTS OF DUCT SMOKE DETECTORS OR BY FIRE ALARM SYSTEM SHUTDOWN RELAY/SOFTWARE INTERLOCK.
		UNIT AIRFLOW > 2,000 CFM	DUCT SMOKE DETECTORS REQUIRED IN BOTH UNIT RETURN AIR AND SUPPLY AIR. EMERGENCY STOP OF ALL UNIT FANS SHALL BE INITIATED BY AUXILIARY CONTACTS OF DUCT SMOKE DETECTORS OR BY FIRE ALARM SYSTEM SHUTDOWN RELAY/SOFTWARE INTERLOCK.
		UNIT AIRFLOW > 15,000 CFM, SERVING 2 OR MORE STORIES	DUCT SMOKE DETECTORS REQUIRED IN BOTH UNIT RETURN AIR AND SUPPLY AIR. ADDITIONAL SMOKE DETECTOR REQUIRED IN THE RETURN AIR AT EACH STORY. EMERGENCY STOP OF ALL UNIT FANS SHALL BE INITIATED BY AUXILIARY CONTACTS OF DUCT SMOKE DETECTORS OR BY FIRE ALARM SYSTEM SHUTDOWN RELAY/SOFTWARE INTERLOCK.
	UNIT WITH RETURN OR RELIEF FAN(S).	IF A SUPPLY FAN IS STOPPED BY ANY SAFETY INTERLOCK, ALL ASSOCIATED SUPPLY AND RETURN/RELIEF FAN(S) SHALL BE COMMANDED "OFF" VIA SOFTWARE INTERLOCK.	
		IF RETURN/RELIEF FAN(S) IS STOPPED BY ANY SAFETY INTERLOCK, THE ASSOCIATED SUPPLY FAN(S) SHALL BE COMMANDED "OFF" VIA SOFTWARE INTERLOCK.	
	UNIT WITH SUPPLY AND/OR RETURN AIR SMOKE	IF SUPPLY OR RETURN AIR SMOKE ISOLATION DAMPER FAILS TO OPEN UPON UNIT START-UP OR CLOSES WHILE UNIT IS RUNNING, AS INDICATED BY	

	<b>ISOLATION DAMPERS.</b>	<b>DAMPER END SWITCH, EMERGENCY STOP SHALL BE INITIATED FOR ALL SYSTEM FANS.</b>

**C. SCHEDULES OF OPERATION**

1. "ON/OFF" schedule(s) shall establish HVAC systems and/or equipment start/stop times, define applicable operating setpoints, and define when specific sequences of operation are to be utilized.
  - a. "ON" hour is defined as the estimated latest hour at which the HVAC system/equipment may be commanded "ON" so that setpoint conditions are maintained within the space(s) served at the "OCCUPIED" period start hour. The actual "ON" hour is adjusted by the "Optimum Start" application as required by the manufacturer or per the "Pre-Purge" sequence required per the "Demand Ventilation" sequence, whichever is longer.
    - 1) A control algorithm shall compare the outside air temperature to space temperature to calculate start time for each air handling system.
  - b. "OFF" hour is defined as the hour at which the HVAC system/equipment shall be commanded "OFF" unless "Post Purge" cycle is required by the manufacturer or per the "Demand Ventilation" sequence, whichever is longer.
  - c. Assign each AHU a stagger start number to keep too many units from starting at the same time. In effect, this flattens load peaks. This includes start-up on emergency power.
  - d. The program shall minimize the total energy consumption during daily start-up of each heating/cooling system.
  - e. Each system shall have an independent modular program.
2. "OCCUPIED/UNOCCUPIED" schedule(s) shall determine ventilation modes.
  - a. The time period between the "ON" hour and the scheduled "OCCUPIED" period start hour may be defined as the "PRE-OCCUPANCY" period, the length of which varies based on "Optimum Start" application. By default, the period between end of the "OCCUPIED" period and the "ON" hour is defined as the "UNOCCUPIED" period.
  - b. All HVAC equipment shall operate in occupied/unoccupied modes as determined by the DDC building time clock system and school calendar. Obtain the building occupancy schedule from the Owner.
  - c. Recess mode – scheduled by the system operators. This mode is the same as normal occupancy mode except for an expanded range of set points. Heating set point is reduced to 63 Deg. F (adj.) and cooling set point is increased to 80 Deg. F (adj.). Individual spaces may be removed from subscribing to recess mode by the system operator by toggling a software flag.
3. Shoulder mode – runs from school closing until 9pm Monday thru Friday adjustable by schedule. Spaces are maintained at normal or recess set points as applicable. Ventilation is off unless the occupancy schedule is set to on or occupancy is sensed by an occupancy sensor (if equipped).

**D. I/O INPUT POINT MONITORING and ALARM INITIATION:**

1. MONITOR each DI and DV point for alarm condition.
2. Set digital point alarm condition the basis of field adjusted differential setpoints.
  - a. Where start/stop or other two-position control sequence is based on a digital input status condition or input sensed variable value(s) (AI or AV), set time delays or digital filters to prevent any equipment item or final control element from "short-cycling" in response to small changes of the sensed variable(s).
  - b. Incorporate user-adjustable time inhibit alarm(s) to prevent nuisance alarms and/or "tripping" under normal operation and during equipment start-up and shut-down.
3. Analog inputs (AI or AV):

- a. Set high and/or low alarm setpoints for each point.
- b. The following default values shall be used if alarm setpoints are not defined within a specific sequence operation or indicated on the Drawings:
  - 1) 5°F below low setpoint of comfort zone or
  - 2) 5°F above high setpoint of comfort zone
  - 3) ≤38°F
  - 4) ≥60°F
  - 5) ≤90°F

#### E. OUTPUT POINT CONTROL

1. Set each control loop to utilize one of the following control modes:
  - a. Digital (binary) output: Two position (e.g., on off, slow fast)
  - b. Analog output: Proportional (P) or proportional + integral (PI) function control, as follows:

Controlled Variable	Control Mode
Space Temperature	P
Mixed Air Temperature	PI
Coil Discharge Temperature	PI (cooling), P (heating)
Airflow	PI (with wide proportional band and fast reset rate)
Fan Static Pressure (Fan Speed)	PI
Humidity	P
Dewpoint Temperature	P
Other (not listed above or indicated on the Drawings)	Consult A-E

#### F. EQUIPMENT MAINTENANCE MANAGEMENT

1. Provide operator-defined maintenance "lockout" for each HVAC component. When initiated, any component defined to be locked out for maintenance shall be deleted from any applicable control sequence of operation.
2. The control system shall continuously totalize hours for selected equipment controlled and/or monitored for use by the maintenance management program.

### 3.03 SITE CONDITIONS

#### A. OUTDOOR AIR CONDITION REFERENCE

1. Locate sensors to monitor ambient (outdoor) air conditions on a north-facing wall of the building, sheltered from both direct sunlight and prevailing wind(s).
  - a. Mount Barometric pressure sensor at least 8 feet above the roof and away from exhaust fans. Install sensor in a wind-proof enclosure.
2. MONITOR ambient outdoor air conditions as AI points:
  - a. DB Temperature (°F)
    - 1) Two (2) outside air temperature sensors are to be provided as general inputs to the DDC system. The pair of readings shall be averaged for use by the system. If an individual reading is found to be out of range by comparison, then the other reading shall be used, and an alarm shall be generated.
  - b. RH (%)
  - c. CO2 level (ppm)
  - d. Barometric pressure (in WC)
3. Compute enthalpy (Btu/Lb.) as AV point as a function of monitored DB and RH.
4. Compute DPT (°F) as AV point as a function of monitored DB and RH.
5. Compute WB temperature (°F) as AV point as a function of monitored DB and RH.
6. Monitor CO2 for reference to indoor air quality for HVAC systems that utilize demand ventilation.
7. AI and AV point values shall serve as global inputs to any sequence of operation requiring an ambient outdoor air condition as a control or computational variable.
8. Monitor outdoor pressure for reference to AHU unit building pressurization control to verify outdoor reference accuracy. If there is greater than 0.05" WC pressure

difference in outdoor pressure measurements, initiate an alarm notification.

### 3.04 DEMAND CONTROL VENTILATION – OCCUPIED MODES:

- A. Applicability:
  - 1. AHU's 1, 2, 3 & 4.
- B. Overview:
  - 1. The HVAC system sequence of operation steps for normal thermal control is unchanged by incorporation of the outside air quantity/ventilation control sequence below. The control sequence below represents a function that will override the normal thermal controls as required to maintain outside air requirements during occupied modes.
  - 2. If multiple CO<sub>2</sub> sensors are required, the CO<sub>2</sub> sensor with the highest ppm reading shall be used for controls reference.
  - 3. During occupied modes, the outside air damper shall never be positioned below the established minimum O.A. specified except in case of alarm. Refer to equipment specific sequences and the equipment schedules for minimum O.A. requirements.
  - 4. Provide provision for extended commissioning (one year) to check calibration of CO<sub>2</sub> sensor, monitor/test CO<sub>2</sub> levels to ensure target person ventilation rates are met and maintained and the lag time is within the limit prescribed by ASHRAE 62.
  - 5. Note: CO<sub>2</sub> sensors shall work with DDC system to provide space CO<sub>2</sub> level record keeping every 15 minutes for 3 years.
  - 6. CO<sub>2</sub> Concentration "Set Points":
    - a. All Spaces: 600 ppm maximum.
- C. Note: Outside air CO<sub>2</sub> concentration shall be measured.
  - 1. Equipment outside Air Damper Control:
    - a. CO<sub>2</sub> readings shall be compared to the CO<sub>2</sub> set point. If the reading is less than 100 ppm above outside air CO<sub>2</sub> level the DDC system shall maintain the base ventilation rate at the scheduled "standard occupancy minimum outdoor air" quantity (O.A. damper occupied minimum position). If the CO<sub>2</sub> reading rises 100 ppm above outside air CO<sub>2</sub> concentration, then the DDC system shall start to modulate the outside air dampers open utilizing a proportional-integral (PI) loop to reduce the CO<sub>2</sub> concentration in the space. The outside air damper shall be open for full occupancy when the CO<sub>2</sub> level reaches the set point. Once the space CO<sub>2</sub> level drops below 100 ppm above outside air CO<sub>2</sub> level the outside air dampers shall move to maintain the scheduled "standard occupancy minimum outdoor air" quantity (O.A. damper occupied minimum position).
    - b. If the DDC SYSTEM determines that it is beneficial to use additional outside air for cooling, then it shall override the demand-controlled ventilation algorithm to modulate the dampers to an increased open position as required.
    - c. START-UP PURGE CYCLE (30 MINUTES PRIOR TO OCCUPIED MODES): When the unit starts the outdoor air damper shall open initiating a timed purge cycle. The outdoor air damper shall modulate to maintain the mixed airflow with outside air percentage at 100% of full occupancy load. The purge period shall be adjustable and shall initially be set for 30 minutes.
    - d. POST PURGE CYCLE (use prior to changing for occupied mode to un-occupied mode): System shall not change from occupied mode to unoccupied mode until space CO<sub>2</sub> level drops to ambient level.

### 3.05 PROJECT SPECIFIC EQUIPMENT

- A. CONSTANT VOLUME AIR HANDLING UNITS – AHU-1 & AHU-2
  - 1. System Description: AHU's 1&2 provide constant volume ventilation, heating and cooling to the gymnasium areas. Heating is by a hydronic heating coil and cooling by a dx coil with a remote condensing unit. A relief fan provides a path for relief air.
  - 2. General:
    - a. Start/stop air-handling system supply air fan(s) in accordance with "GENERAL SEQUENCES OF OPERATION AND SCHEDULING".
    - b. Unit automatically indexed to "occupied" or "unoccupied" cycle by the DDC.
    - c. Unit automatically switches from heating to cooling modes.

- d. Unit shall not run if "Emergency Stop" conditions apply.
- 3. Unoccupied Mode:
  - a. Heating set point is inversely proportional to outside air temperature based on the following schedule:
    - 1) At 55 Deg. F (adj.) outside air and above the set point is 45 Deg. F (adj.)
    - 2) At 10 Deg. F (adj.) outside air and below the set point is 65 Deg. F (adj.).
  - b. The AHU hot water coil control valve shall modulate to control the discharge temperature at 95 deg. F (adjustable).
  - c. Outside air shall not be admitted during unoccupied mode operation.
  - d. Relief Air Fan: Shall remain off with automatic damper closed during unoccupied mode.
- 4. Occupied Mode:
  - a. AHU Supply Fan: Shall run continuously.
  - b. Outside Air Damper:
    - 1) Refer to Demand Control Ventilation Sequences.
    - 2) Open to maintain outside air as scheduled. The outside air damper shall never be positioned below this minimum during occupied mode except in case of emergency.
    - 3) Modulate outside air damper beyond scheduled minimum position as follows:
      - (a) Provide make-up air to spaces necessary to maintain building pressurization.
      - (b) As required for economizer cooling.
    - 4) Air Flow Station: An airflow station shall be provided as required to measure and record the outdoor air flow rates.
    - 5) Relief Air Fan:
      - (a) Run continuously.
      - (b) Associated damper shall be interlocked open.
      - (c) Modulate speed to maintain slightly positive space pressurization of 0.05" W.C. +/- 0.05" W.C. (adjustable). Balancer to determine optimum setting per testing adjusting and balancing specification.
- 5. Space Temperature Control:
  - a. Provide space temperature sensor
  - b. Occupied Heating
    - 1) Minimum temperature reset schedule:
      - (a) 85 degree LAT at 0 degree OAT.
      - (b) 65 degree LAT at 55 degree OAT.
    - 2) Modulate between min/max to maintain space set point.
    - 3) Maintain Unit LAT by modulating the hydronic control valve.
  - c. Airside Economizer Control:
    - 1) When the outdoor air temperature is greater than 55°F and the outdoor enthalpy is less than the space enthalpy, modulate the [maximum] outdoor air so that the system operates with 100% outdoor air supply.
- 6. Low Limit Thermostat Control and Alarm:
  - a. Stop air-handling system fan when supply air temperature falls to 38°F and initiate an alarm.
- 7. Fire shut down shall be provided by the DDC. When air fan coil unit is shut down, the outside air dampers shall close, and the mixing dampers shall position to 100% return air.
- B. CONSTANT VOLUME AIR HANDLING UNITS – AHU-3 & AHU-4
  - 1. System Description: AHU's 1&2 provide constant volume ventilation, heating and cooling to the cafeteria, serving and kitchen areas. Heating is by a hydronic heating coil and cooling by a dx coil with a remote condensing unit. A relief fan is speed modulated based on building pressurization to hold a slight positive pressure. Hydronic fin tube heaters provide additional heat during occupied mode and serve as primary heating during unoccupied mode. If the AHU is required to run for heating during unoccupied mode, the outdoor air damper will remain closed and the return



- damper open.
2. General:
    - a. Start/stop air-handling system supply air fan(s) in accordance with "GENERAL SEQUENCES OF OPERATION AND SCHEDULING".
    - b. Unit automatically indexed to "occupied" or "unoccupied" cycle by the DDC.
    - c. Unit automatically switches from heating to cooling modes.
    - d. Unit shall not run if "Emergency Stop" conditions apply.
  3. Unoccupied Mode:
    - a. Heating set point is inversely proportional to outside air temperature based on the following schedule:
      - 1) At 55 Deg. F (adj.) outside air and above the set point is 45 Deg. F (adj.)
      - 2) At 10 Deg. F (adj.) outside air and below the set point is 65 Deg. F (adj.).
    - b. Primary heat shall be by the fin tube heat. The AHU shall remain off unless the fin tube cannot maintain set point.
    - c. The AHU's shall be enabled to run if the fin tube is at 100% heating capacity and the space temperature drops more than 3 Deg. F (adj.) below the set point.
    - d. The AHU hot water coil control valve shall modulate to control the discharge temperature at 95 deg. F (adjustable).
    - e. Outside air shall not be admitted during unoccupied mode operation.
    - f. Relief Air Fan: Shall remain off with automatic damper closed during unoccupied mode.
  4. Occupied Mode:
    - a. AHU Supply Fan: Shall run continuously.
    - b. Outside Air Damper:
      - 1) Refer to Demand Control Ventilation sequences.
      - 2) Open to maintain outside air as scheduled. The outside air damper shall never be positioned below this minimum during occupied mode except in case of emergency.
      - 3) Modulate outside air damper beyond scheduled minimum position as follows:
        - (a) Provide make-up air to spaces necessary to maintain building pressurization.
        - (b) As required for economizer cooling.
      - 4) Air Flow Station: An airflow station shall be provided as required to measure and record the outdoor air flow rates.
      - 5) Relief Air Fan:
        - (a) Run continuously.
        - (b) Associated damper shall be interlocked open.
        - (c) Modulate speed to maintain slightly positive space pressurization of 0.05" W.C. +/- 0.05" W.C. (adjustable). Balancer to determine optimum setting per testing adjusting and balancing specification.
  5. Space Temperature Control:
    - a. Provide space temperature sensor
    - b. Occupied Heating
      - 1) Minimum temperature reset schedule:
        - (a) 85 degree LAT at 0 degree OAT.
        - (b) 65 degree LAT at 55 degree OAT.
      - 2) Modulate between min/max to maintain space set point.
      - 3) Maintain Unit LAT by modulating the steam control valve.
    - c. Airside Economizer Control:
      - 1) When the outdoor air temperature is greater than 55°F and the outdoor enthalpy is less than the space enthalpy, modulate the [maximum] outdoor air so that the system operates with 100% outdoor air supply.
  6. Low Limit Thermostat Control and Alarm:
    - a. Stop air-handling system fan when supply air temperature falls to 38°F and initiate an alarm.

- 
7. Fire shut down shall be provided by the DDC. When air fan coil unit is shut down, the outside air dampers shall close and the mixing dampers shall position to 100% return air.
- C. ROOF TOP UNIT:
1. All Occupied Modes:
    - a. Unit Supply Fan:
      - 1) Run continuously.
    - b. Unit Exhaust Fan:
      - 1) Run continuously.
  2. Occupied Heating Mode – space temperature below set point.
    - a. Heating coil HC-1/2 (Above the ceiling in the associated space): Modulate coil control valve (CV) to maintain space temperature set point.
    - b. Space Temperature Set Points:
    - c. Heating = 69 degrees (adjustable).
    - d. LAT Temperature Set Points:
      - 1) Minimum temperature reset schedule:
        - (a) 65 degree LAT at 0 degree OAT.
        - (b) 55 degree LAT at 55 degree OAT.
    - e. Heat exchanger face and bypass damper: Modulate damper as recommended by the unit manufacturer for the heat exchanger defrost cycle.
  3. Occupied Cooling Mode – space temperature below set point. – where applicable
    - a. Unit mounted DX cooling coil: Modulate DX compressor to maintain space temperature set point.
    - b. Space Temperature Set Points:
      - 1) Cooling = 75 degrees (adjustable).
    - c. LAT Temperature Set Points:
      - 1) Cooling = 55 degree LAT at 88 degree OAT
  4. Occupied Economizer Cooling Mode – when there is call for cooling and the outdoor air temperature is below the space temperature.
    - a. Economizer cooling set point: 74°F.
  5. All Unoccupied Modes:
    - a. Space Temperature Set Points:
      - 1) Heating = 60 degrees.
      - 2) Cooling = 85 degrees.
      - 3) There shall be a 5 degree deadband for heating and cooling set points.
    - b. Heating Coil HC-1/2 (Above the ceiling in the associated space):
      - 1) All same as occupied mode with following exceptions:
        - (a) Enable and disable unit only to meet temperature set point.
        - (b) Disable exhaust fan.
        - (c) Open recirculation damper.
  6. Warm-up Mode.:
    - a. All units shall start per optimum start program.
      - 1) Optimum start duration shall be determined based on outside air temperature.
      - 2) During the optimum start period, the heating set-point shall be linearly ramped up from unoccupied heating set-point to occupied heating set point.
    - b. Systems shall operate as described in unoccupied heating mode with temperature set point equal to occupied mode.
  7. Alarms – Provide an alarm for each of the following:
    - a. Fan motor failures.
    - b. Discharge Air Temperature low/high limits.
    - c. Space Temperature low/high limits +/-5°F.
    - d. VFD Fault.
- D. Fan Coil Unit with Outdoor Air:
1. The DDC system seven-day time clock shall provide occupied/unoccupied scheduling of the fan coil units.

2. During occupied mode, the fan shall run continuously. Actuate outside and return air dampers.
  3. Modulate the heating control valve to maintain setpoint. The discharge high limit temperature setpoint shall be set at 125°F and generate an alarm. The sensor shall intermittently start and stop the fan and open the heating control valve.
- E. VERTICAL UNIT VENTILATOR WITH HYDRONIC HEATING, PACKAGED DX COOLING, HYDRONIC FIN TUBE HEATING.
1. System Description: The vertical unit ventilator provides constant volume ventilation and heating. Heating is by a hydronic heat exchanger within the UV unit and hydronic fin tube in the space. The fin tube provides additional heat during occupied mode and serves as primary heating during unoccupied mode. An integrated refrigerant coil and condensing unit provides cooling. Pressurization air is released through the unit ventilator exhaust / relief fan. Free cooling is activated based on enthalpy.
  2. Start / Stop Control:
    - a. Start/stop unit ventilator and associated relief air fans and dampers, as applicable, in accordance with "GENERAL SEQUENCES OF OPERATION AND SCHEDULING".
    - b. Unit shall not run if "Emergency Stop" conditions apply.
  3. Unoccupied Mode:
    - a. Heating set point is inversely proportional to outside air temperature based on the following schedule:
      - 1) At 55 Deg. F (adj.) outside air and above the set point is 45 Deg. F (adj.)
      - 2) At 10 Deg. F (adj.) outside air and below the set point is 65 Deg. F (adj.).
    - b. Primary heat shall be by the fin tube heat. The UV shall remain off unless the fin tube cannot maintain set point.
    - c. The UV shall be enabled to run if the fin tube is at 100% heating capacity and the space temperature drops more than 3 Deg. F (adj.) below the set point. Outside air shall not be admitted during unoccupied mode operation.
  4. Occupied Mode:
    - a. Unit Ventilator shall run continuously.
    - b. Outside Air Damper:
      - 1) Open to maintain outside air quantity as scheduled. The outside air damper shall never be positioned below this minimum during occupied mode except in case of emergency.
      - 2) Modulate outside air damper beyond scheduled minimum position as follows:
        - (a) As required for economizer cooling.
  5. Space Temperature Control:
    - 1) Provide space temperature sensor
    - 2) Occupied Heating
      - (a) Minimum temperature reset schedule:
        - (b) 85 degree LAT at 0 degree OAT.
        - (c) 75 degree LAT at 55 degree OAT.
        - (d) 90 degrees maximum or temperature listed on schedules.
        - (e) Modulate UV control valve between min/max to maintain space heating set point.
    - b. Occupied Cooling Mode – when there is call for cooling.
      - 1) DX system: Modulate cooling to the reset schedule below.
      - 2) Reset Schedule:
 

AHU discharge Temperature (°F)	Outdoor Air (°F)
62	58
55	85

        - (a) Above reset schedule shall automatically adjust if average space temperature falls below or above set point.
        - (b) Airside Economizer Control:
          - 3) During "ON" periods, ENABLE airside economizer control.

- 4) When the air-handling system is providing cooling, as evidenced by the space temperature being above the maximum comfort temperature setpoint, and the outdoor air temperature is at or below 55°F, maintain space temperature at setpoint by modulating the [maximum] outdoor air, return air, and relief air dampers
  - 5) When the outdoor air temperature is greater than 55°F and the outdoor enthalpy is less than the space enthalpy, modulate the [maximum] outdoor air and relief air dampers 100% "OPEN" and the return air damper 100% "CLOSED" via AO points so that the system operates with 100% outdoor air supply. Maintain space temperature by modulating cooling.
  - 6) When the outdoor air enthalpy is greater than the space enthalpy maintain space temperature setpoint by dx cooling.
6. Low Limit Thermostat Control and Alarm:
    - a. Stop UV system fan when supply air temperature falls to 38°F and initiate an alarm.
- F. EXHAUST FANS, TOILET ROOMS:
1. Unoccupied Mode: Fan shall be disabled, and associated damper interlocked shut in unoccupied mode.
  2. Occupied Mode: Fan shall be enabled and associated damper interlocked open in occupied mode.
- G. GRAVITY RELIEF AND INTAKE HOOD CONTROL
1. Unoccupied Mode: Damper shall remain shut.
  2. Occupied Mode: Motorized damper shall be opened.
- H. DUCTLESS SPLIT SYSTEM:
1. Factory compressor circuit controls.
  2. Room temperature reference to the BAS.
  3. Drain Pan level sensor.
  4. If space temperature exceeds 82 deg F, the BAS shall alarm.
  5. If the drain pan level sensor is activated, the BAS shall alarm.
- I. Radiant Heaters/Fin Tube Radiation: FT
1. With the DDC system indexed to occupied mode, the space sensor shall call for heating and the heating valve shall modulate or open/close to maintain occupied (adj.) space temperature setpoint.
  2. With the DDC system indexed to unoccupied mode, the space sensor shall call for heating and the heating valve shall modulate or open/close to maintain unoccupied (adj.) space temperature.
- J. EXHAUST FAN CONTROL
1. General Information:
    - a. Each fan shall be able to be individually scheduled and have independent start/stop control.
    - b. The fan is wired normally open and fails off.
    - c. The exhaust air damper is normally closed. The exhaust damper opens when the exhaust fan starts.
  2. Common Mode Control:
    - a. When the fan is off, the exhaust air damper shall fail to normally closed position.
  3. Occupied Mode:
    - a. The fan shall run continuously, and its associated damper shall open.
  4. Unoccupied Mode:
    - a. The fan shall be off.
      - 1) END OF SECTION 23 09 93

**END OF SECTION**

## SECTION 231000 - VARIABLE TORQUE A-C DRIVE CONTROLLERS

### PART 1 - GENERAL

#### 1.1 WORK INCLUDED

- A. Variable frequency A-C drive controllers for mechanical equipment.
- B. Furnish all labor, materials, equipment and service to perform all operations required for the complete installation and related work as required in all contract documents.

#### 1.2 SUBMITTALS

- A. Submit manufacturer's product data shop, drawings, samples, and installation instructions in accordance with the General Conditions.
- B. Shop drawings of VFD, reactors, and wiring diagrams shall be provided with list of parts including fuses and breakers.
- C. Contract Closeout Reports.
- D. Project Record Documents.
- E. Operation and Maintenance Data.
- F. Warranty.

#### 1.3 QUALITY ASSURANCE

- A. The drives shall consist of two major performance-matched components. The VFD manufacturer shall furnish a Variable Torque AC Drive Controller and a performance matched energy efficient motor and will assume responsibility for matching the motor and controller.
- B. The manufacturer of the VFD described in this specification shall have a minimum of twenty (20) years experience in the design, construction and application of adjustable frequency controls and motors.
- C. The VFD manufacturer shall perform, but not be limited to, the following quality assurance controls, procedures and tests to insure VFD performance of ALL manufactured VFD controllers:
  - 1. Circuit Testing:
    - a. All circuits are pre-burned tested for in-circuit component parameters and functional performance.
    - b. All regulator, power supply, and keypad circuits are burned-in for 20 hours. This procedure consists of ten-two hour cycles during which the temperature is varied from -20C to +70C at the rate of 5C per minute. There are dwell times of 30 minutes (hot) and 58 minutes (cold) during each cycle.
    - c. All burned-in circuits are post-burn tested for functional performance.
  - 2. Hi-Pot Testing:
    - a. Post-assembly, all drives are subjected to high potential testing at 2,000 VAC, 2 milliamps maximum, for 1 second.
  - 3. Drive Setup and Functional Tests:
    - a. SET-UP: the following VFD variables are factory set prior to shipping:
      - 1) Acceleration ramp
      - 2) Deceleration ramp
      - 3) MIN and MAX Speed

- 4) Current limit
- 5) Volts / Hertz Ratio
- b. FINAL TEST: the following VFD functional checks are made and verified prior to shipping:
  - 1) Fault and Function-loss circuit operation
  - 2) Auto-reset function
  - 3) Reversing function
  - 4) Load test using an actual motor at full speed and full load for five (5) minutes while phase currents, phase voltages and motor speed are monitored.

## 1.4 CODES AND STANDARDS

- A. The VFD and all options shall be UL listed and so labeled. Additionally, the VFD Package when fully assembled with selected options into the common cabinet shall be UL listed and so labeled as a complete system.
- B. AFC (Adjustable Frequency Controller) with all options shall comply with all applicable requirements of the latest standards ANSI; NEMA ICS 1, 2, 3 and 6; National Electrical Code (NEC); NEPU-70; IEEE P598.
- C. AFC shall comply to IEEE-519-1993 standards and the VFD systems shall not produce more than 5% THD voltage waveform distortion on the power distribution system.
- D. The AFC shall comply with Radio Frequency Noise Standard FCC Part15, Subpart J.

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. Manufacturer's catalog numbers are used as illustrations. Similar products of the following manufacturers are acceptable equals. All similar items shall be by one manufacturer.
  1. ABB
  2. Square D
  3. Yaskawa

### 2.2 GENERAL

- A. The variable torque AC drive shall consist of a solid-state adjustable frequency controller with all accessories and performed matched energy efficient motor manufactured by the same vendor.
- B. The AFC shall convert voltage indicated on drawings, + 10%, 3 phase, 60 Hz utility power to an adjustable voltage/frequency, three phase, AC power for stepless motor control from 10% to 110% of base motor speed. The output waveform shall be an adjustable pulse width modulated using flux-vector control. Pulse width modulated types using IGBT Technology shall not be acceptable.
- C. VFD shall be current rated at 8 kHz carrier frequency for VFD's 1-75 HP and 4 kHz for VFD's 100-400 HP. All HP ratings shall meet or exceed Table 430-150 of the National Electric Code. Three Phase Motor Full Load Currents, HP, Maximum Current, and Rated Voltage shall appear on the drive nameplate.

- D. VFD shall not generate damaging voltage pulses at the motor terminals when applied within 500 feet of each other. Both Drive and Motor shall comply with NEMA MG1 section 30.40.4.2 which specifies these limits at a maximum peak.

## **2.3 DRIVE FUNCTIONS**

- A. The VFD shall have the following basic features:
1. An electronic overload circuit designed to protect an AC motor operated by the VFD output from extended overload operation on an inverse time basis. This Electronic overload shall be ULä and NEC recognized as adequate motor protection. No additional hardware such as motor overload relays or motor thermostats shall be required.
  2. An LED display mounted on the door of the cabinet that digitally indicates:
    - a. Frequency output
    - b. Voltage output
    - c. Current output
    - d. Motor RPM
    - e. Input kW
    - f. Elapsed Time
    - g. Time Stamped Fault Indication
    - h. DC Bus Volts
- B. The VFD shall have the capability of riding through power dips up to 10 seconds without a controller trip depending on load and operating condition. In this extended ride through, the drive shall use the energy generated by the rotating fan as a power source for all electronic circuits.
- C. RS232 Port and Windows based software for Configuration, Control, and Monitoring.
- D. An isolated 0-20mA, 4-20mA or 0-4, 0-8, 0-10 volt analog speed input follower.
- E. An isolated 0-10 V or 4-20 mA output signal proportional to speed or load.
- F. Provide a Modbus to BACnet interface card. Coordinate requirements with controls vendor.

## **2.4 PROTECTIVE CIRCUITS AND FEATURES**

- A. The VFD shall include the following protective circuits and features:
1. Motor current exceeds 200% of drive continuous current rating.
  2. Output phase-to-phase short circuit condition.
  3. Total ground fault under any operating condition.
  4. High input line voltage.
  5. Low input line voltage.
  6. Loss of input or output phase.
  7. External fault. (This protective circuit shall permit wiring of remote N.C. safety contact to shut down the drive). User supplied end switches, thermal switches, fire-stats, freeze-stats inputs will be connected to this VFD supplied circuit.
  8. Metal oxide varistors for surge suppression shall be provided at the VFD input terminals.

## **2.5 GENERAL OPTIONS AND MODIFICATIONS**

- A. The following options shall be included as specified:
1. Input line fuses shall provide protection for the input rectification circuit using Class J fuses with interrupting rating of 200,000 AIC. The series interrupting rating of the VFD and fuses shall be a minimum of 30,000 AIC and shall be stated in the VFD Instruction Manual as required by UL

2. A main input disconnect shall mount within the standard NEMA 1 or NEMA 12 enclosure for positive power disconnect of the VFD. It shall have the capability for door padlocking.
3. A three phase 5% impedance Input Line Reactor shall be provided to minimize drive harmonics on the AC line and protect the drive from damaging electrical system transients.
4. Temperature Control System interface card for direct connection from the bus architecture. All configuration and control functions can be accessed through this card. Allows direct communication between the microprocessor and the host system. Fault diagnostics, start/stop, speed commands, and all drive feedback's shall be available over a single RS485 communication connection. Discrete signals such as Interlock Open shall also be mapped through the drive terminal strip to the system. The card shall have the ability to be used in a "monitor only" mode where control shall be from a AHU or similar type controller directly wired to the drive.
5. Provide manual bypass.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. VFD's shall be furnished and programmed by the unit manufacture.
- B. The VFD manufacturer shall maintain and staff local service engineers and must maintain a reasonable supply of spare parts for the VFD's to meet ordinary repair requirements within 100 miles of the installation site. Warehousing of spare parts shall be open to the Engineer for observation.
- C. The manufacturer of the equipment provided shall warrant his equipment against defects in workmanship and parts failure for one (1) year form date of start-up. This warranty shall cover all parts, labor and travel related expenses.

END OF SECTION 23 10 00



**SECTION 232113  
HYDRONIC PIPING****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Hydronic system requirements.
- B. Heating water piping, above grade.
- C. Radiant heating piping system.
- D. Equipment drains and overflows.
- E. Pipe hangers and supports.
- F. Unions, flanges, mechanical couplings, and dielectric connections.
- G. Valves:
- H. Flow controls.

**1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 083100 - Access Doors and Panels.
- C. Section 230516 - Expansion Fittings and Loops for HVAC Piping.
- D. Section 230523 - General-Duty Valves for HVAC Piping-CPL.
- E. Section 230548 - Vibration and Seismic Controls for HVAC.
- F. Section 230553 - Identification for HVAC Piping and Equipment-CPL.
- G. Section 230719 - HVAC Piping Insulation-CPL.
- H. Section 232114 - Hydronic Specialties.
- I. Section 232500 - HVAC Water Treatment: Pipe cleaning.
- J. Section 253516 - Integrated Automation Sensors and Transmitters: Pipe-mounted product furnishing.
- K. Section 253519 - Integrated Automation Control Valves: Product furnishing.

**1.03 REFERENCE STANDARDS**

- A. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2018.
- B. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2018.
- C. ASME B31.9 - Building Services Piping 2020.
- D. ASTM B32 - Standard Specification for Solder Metal 2020.
- E. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- F. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- G. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications 2007 (Reapproved 2019).
- H. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding 2011 (Amended 2012).
- I. AWWA C606 - Grooved and Shouldered Joints 2015.
- J. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018.

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.

**1.05 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.

- B. Installer Qualifications: Company specializing in performing work of the type specified in this section, with documented experience.

## **PART 2 PRODUCTS**

### **2.01 HYDRONIC SYSTEM REQUIREMENTS**

- A. Comply with ASME B31.9 and applicable federal, state, and local regulations.
- B. Piping: Provide piping, fittings, hangers, and supports as required, as indicated, and as follows:
1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
  2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
  3. Grooved mechanical joints may be used in accessible locations only.
    - a. Accessible locations include those exposed on interior of building, in pipe chases, and in mechanical rooms, aboveground outdoors, and as approved by Architect.
    - b. Use rigid joints unless otherwise indicated.
  4. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
- C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
- D. Valves: Provide valves where indicated:
1. Provide drain valves where indicated, and if not indicated, provide at least at main shut-off, low points of piping, bases of vertical risers, and at equipment. Use 3/4 inch gate valves with cap; pipe to nearest floor drain.

### **2.02 HEATING WATER PIPING, ABOVE GRADE**

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn, using one of the following joint types:
1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings.
    - a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
    - b. Braze: AWS A5.8M/A5.8 BCuP copper/silver alloy.
  2. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.

### **2.03 RADIANT HEATING PIPING**

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A) annealed.
1. Fittings: ASME B16.22, wrought copper.
  2. Joints: Braze, AWS A5.8M/A5.8 BCuP copper/silver alloy.

### **2.04 EQUIPMENT DRAINS AND OVERFLOWS**

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn; using one of the following joint types:
1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.

### **2.05 PIPE HANGERS AND SUPPORTS**

- A. Provide hangers and supports that comply with MSS SP-58.
1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
- B. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge-shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.

### **2.06 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS**

- A. Unions for Pipe 2 Inches and Less:

- B. Flanges for Pipe 2 Inches and Greater:
- C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
  - 1. Dimensions and Testing: In accordance with AWWA C606.
  - 2. Mechanical Couplings: Comply with ASTM F1476.
  - 3. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
  - 4. When pipe is field grooved, provide coupling manufacturer's grooving tools.
- D. Dielectric Connections:
  - 1. Unions:
    - a. 1/2 to 1 Inches: Brass solder to galvanized FPT.
    - b. 1/2 to 2 Inches: Brass solder to galvanized FPT.
    - c. 1/2 to 1 Inches: Brass to galvanized FPT or FIP (Female Iron Pipe).
    - d. 3/4 to 1/2 Inch Reducer: Brass solder to galvanized FPT.
    - e. Service: 250 psi, minus 20 to 180 deg F.

## 2.07 FLOW CONTROLS

- A. Construction: Class 125, Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.
- B. Calibration: Control flow within 10 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, minimum pressure 2 psi.

## PART 3 EXECUTION

### 3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.
- C. Remove scale and dirt on inside and outside before assembly.
- D. Prepare piping connections to equipment using jointing system specified.
- E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- F. After completion, fill, clean, and treat systems. See Section 232500 for additional requirements.

### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and to avoid interference with use of space.
- D. Group piping whenever practical at common elevations.
- E. Sleeve pipe passing through partitions, walls, and floors.
- F. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified [\_\_\_\_\_].
- G. Slope piping and arrange to drain at low points.
- H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. See Section 230516.
  - 1. Flexible couplings may be used in header piping to accommodate thermal growth, thermal contraction in lieu of expansion loops.
  - 2. Use flexible couplings in expansion loops.

**END OF SECTION**

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## **SECTION 232114 HYDRONIC SPECIALTIES**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Air vents.
- B. Strainers.
- C. Pressure-temperature test plugs.
- D. Balancing valves.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 232113 - Hydronic Piping.

#### **1.03 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description and model.

#### **1.04 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

### **PART 2 PRODUCTS**

#### **2.01 AIR VENTS**

- A. Manufacturers:
  - 1. Armstrong International, Inc: [www.armstronginternational.com/#sle](http://www.armstronginternational.com/#sle).
  - 2. ITT Bell & Gossett: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  - 3. Taco, Inc: [www.taco-hvac.com/#sle](http://www.taco-hvac.com/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Manual Type: Short vertical sections of 2-inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.
- C. Float Type:
  - 1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
- D. Washer Type:
  - 1. Brass with hygroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring-loaded ball check valve.

#### **2.02 STRAINERS**

- A. Manufacturers:
  - 1. American Wheatley, a company of Global Flow Products, LLC: [www.wheatleyhvac.com/#sle](http://www.wheatleyhvac.com/#sle).
  - 2. Armstrong International, Inc: [www.armstronginternational.com/#sle](http://www.armstronginternational.com/#sle).
  - 3. Flexicraft Industries: [www.flexicraft.com/#sle](http://www.flexicraft.com/#sle).
  - 4. Grinnell Products: [www.grinnell.com/#sle](http://www.grinnell.com/#sle).
  - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Y-Type, Size 2 inch and Smaller:
  - 1. Threaded body with 1/32 inch stainless steel perforated screen and blow-off plug for minimum working pressure of 175 psi.

#### **2.03 PRESSURE-TEMPERATURE TEST PLUGS**

- A. Manufacturers:
  - 1. Ferguson Enterprises Inc: [www.fnw.com/#sle](http://www.fnw.com/#sle).
  - 2. Peterson Equipment Company Inc: [www.petesplug.com/#sle](http://www.petesplug.com/#sle).
  - 3. Sisco Manufacturing Company Inc: [www.siscomfg.com/#sle](http://www.siscomfg.com/#sle).

- 4. Substitutions: See Section 016000 - Product Requirements.
- B. Construction: Brass body designed to receive temperature or pressure probe with removable protective cap, and Neoprene rated for minimum 200 degrees F.
- C. Application: Use extended length plugs to clear insulated piping.

#### **2.04 BALANCING VALVES**

- A. Manufacturers:
  - 1. American Wheatley, a company of Global Flow Products, LLC: [www.wheatleyhvac.com/#sle](http://www.wheatleyhvac.com/#sle).
  - 2. Armstrong International, Inc: [www.armstronginternational.com/#sle](http://www.armstronginternational.com/#sle).
  - 3. Bell & Gossett, a brand of Xylem, Inc: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  - 4. Ferguson Enterprises Inc: [www.fnw.com/#sle](http://www.fnw.com/#sle).
  - 5. Hays Fluid Controls: [www.haysfluidcontrols.com/#sle](http://www.haysfluidcontrols.com/#sle).
  - 6. ITT Bell & Gossett: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  - 7. Taco, Inc: [www.taco-hvac.com/#sle](http://www.taco-hvac.com/#sle).
  - 8. Substitutions: See Section 016000 - Product Requirements.
- B. Size 2 inch and Smaller:
  - 1. Provide ball or globe style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and NPT threaded or soldered connections.
  - 2. Metal construction materials consist of bronze or brass.
  - 3. Non-metal construction materials consist of Teflon, EPDM, or engineered resin.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION**

- A. Install specialties in accordance with manufacturer's instructions.
- B. Provide manual air vents at system high points and as indicated.
- C. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
- D. Provide valved drain and hose connection on strainer blowdown connection.

**END OF SECTION**

## SECTION 232116 - HYDRONIC PIPING SPECIALTIES

### 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 special-duty valves and specialties for the following:
1. Hot-water heating piping.
  2. Chilled-water piping.
  3. Condenser-water piping.
  4. Glycol cooling-water piping.
  5. Makeup-water piping.
  6. Condensate-drain piping.
  7. Blowdown-drain piping.
  8. Air-vent piping.
  9. Safety-valve-inlet and -outlet piping.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
  2. Air-control devices.
  3. Hydronic specialties.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

#### 1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

#### 1.6 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

### 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: 150 psig at 200 deg F
2. Chilled-Water Piping: 150 psig at 200 deg F
3. Condenser-Water Piping: 150 psig at 150 deg F.
4. Glycol Cooling-Water Piping: 150 psig at 150 deg F.
5. Makeup-Water Piping: 80 psig at 150 deg F
6. Condensate-Drain Piping: 150 deg F
7. Blowdown-Drain Piping: 200 deg F
8. Air-Vent Piping: 200 deg F
9. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

## 2.2 VALVES

- A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."
- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC."
- C. Bronze, Calibrated-Orifice, Balancing Valves:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Armstrong Pumps, Inc.
    - b. Bell & Gossett Domestic Pump.
    - c. Flow Design Inc.
    - d. Gerand Engineering Co.
    - e. Griswold Controls.
    - f. Nexus Valve, Inc.
    - g. Taco.
    - h. Tour & Andersson; available through Victaulic Company.
  2. Body: Bronze or Ametal (copper-alloy), ball, globe, or plug type with calibrated orifice or venturi
  3. Ball: Brass or stainless steel.
  4. Plug: Resin.
  5. Seat: PTFE or EPDM.
  6. End Connections: Threaded or socket.
  7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
  8. Handle Style: Lever, with memory stop to retain set position.
  9. CWP Rating: Minimum 250 psig.
  10. Maximum Operating Temperature: 230 deg F.
- D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Armstrong Pumps, Inc.
    - b. Bell & Gossett Domestic Pump.
    - c. Flow Design Inc.
    - d. Gerand Engineering Co.
    - e. Griswold Controls.
    - f. Taco.
    - g. Tour & Andersson; available through Victaulic Company.
  2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.



3. Ball: Brass or stainless steel.
  4. Stem Seals: EPDM O-rings.
  1. Disc: Ametal (copper-alloy) or glass and carbon-filled PTFE.
  2. Seat: PTFE.
  3. End Connections: Flanged or grooved.
  4. Pressure Gage Connections: Integral seals for portable differential pressure meter.
  5. Handle Style: Handwheel, Lever, with memory stop to retain set position.
  6. CWP Rating: Minimum 250 psig.
  7. Maximum Operating Temperature: 230 deg F.
- E. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Amtrol, Inc.
    - b. Armstrong Pumps, Inc.
    - c. Bell & Gossett Domestic Pump.
    - d. Conbraco Industries, Inc.
    - e. Spence Engineering Company, Inc.
    - f. Watts Regulator Co.
  2. Body: Bronze or brass.
  3. Disc: Glass and carbon-filled PTFE.
  4. Seat: Brass.
  5. Stem Seals: EPDM O-rings.
  6. Diaphragm: EPT.
  7. Low inlet-pressure check valve.
  8. Inlet Strainer: bronze, removable without system shutdown.
  9. Valve Seat and Stem: Noncorrosive.
  10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- F. Diaphragm-Operated Safety Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Amtrol, Inc.
    - b. Armstrong Pumps, Inc.
    - c. Bell & Gossett Domestic Pump.
    - d. Conbraco Industries, Inc.
    - e. Spence Engineering Company, Inc.
    - f. Watts Regulator Co.
  2. Body: Bronze or brass.
  3. Disc: Glass and carbon-filled PTFE.
  4. Seat: Brass.
  5. Stem Seals: EPDM O-rings.
  6. Diaphragm: EPT.
  7. Wetted, Internal Work Parts: Brass and rubber.
  8. Inlet Strainer: bronze, removable without system shutdown.
  9. Valve Seat and Stem: Noncorrosive.
  10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- G. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Flow Design Inc.
  - b. Griswold Controls.
  - c. Nexus Valve, Inc.
  - d. Victaulic Company
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig
9. Maximum Operating Temperature: 250 deg F.

## **2.3 AIR-CONTROL DEVICES**

### **A. Manual Air Vents:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Amtrol, Inc.
  - b. Armstrong Pumps, Inc.
  - c. Bell & Gossett Domestic Pump.
  - d. Nexus Valve, Inc.
  - e. Taco, Inc.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

### **B. Automatic Air Vents:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Amtrol, Inc.
  - b. Armstrong Pumps, Inc.
  - c. Bell & Gossett Domestic Pump.
  - d. Nexus Valve, Inc.
  - e. Taco, Inc.
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

### **C. Expansion Tanks:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Amtrol, Inc.
    - b. Armstrong Pumps, Inc.
    - c. Bell & Gossett Domestic Pump.
    - d. Taco, Inc.
  2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  3. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
  4. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
  5. Gage Glass: Full height with dual manual shutoff valves, [3/4-inch-] <Insert dimension> diameter gage glass, and slotted-metal glass guard.
- D. Diaphragm or Bladder-Type Expansion Tanks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Amtrol, Inc.
    - b. Armstrong Pumps, Inc.
    - c. Bell & Gossett Domestic Pump.
    - d. Taco, Inc.
  2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  3. Diaphragm or Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
  4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
- E. Tangential-Type Air Separators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Amtrol, Inc.
    - b. Armstrong Pumps, Inc.
    - c. Bell & Gossett Domestic Pump.
    - d. Taco, Inc.
    - e. Spirotherm.
  2. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
  3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
  4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
  5. Blowdown Connection: Threaded.
  6. Size: Match system flow capacity.

**F. Air Purgers:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Amtrol, Inc.
  - b. Armstrong Pumps, Inc.
  - c. Bell & Gossett Domestic Pump.
  - d. Taco, Inc.
2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig.
4. Maximum Operating Temperature: 250 deg F.

**2.4 HYDRONIC PIPING SPECIALTIES**

**A. Y-Pattern Strainers:**

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 60-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

**B. Y-Pattern Grooved End Strainers:**

1. Body: Ductile iron body with blow-down port fitted with pipe plug.
2. End Connections: Grooved
3. Strainer Screen: Stainless-steel, 60-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 300 psig (2068 kPa).

**C. Basket Strainers:**

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

**D. T-Pattern Strainers:**

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

**E. Stainless-Steel Bellow, Flexible Connectors:**

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

**F. Spherical, Rubber, Flexible Connectors:**

1. Body: Fiber-reinforced rubber body.
  2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
  3. Performance: Capable of misalignment.
  4. CWP Rating: 150 psig.
  5. Maximum Operating Temperature: 250 deg F.
- G. Expansion Fittings: Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping." Section 15124 "Expansion Fittings and Loops for HVAC Piping."

### PART 3 - EXECUTION

#### 3.1 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install calibrated-orifice, balancing valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

#### 3.2 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- D. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
- E. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
  1. Install tank fittings that are shipped loose.
  2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.
- F. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

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**SECTION 232123  
HYDRONIC CONDENSATE PUMPS****PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

**1.02 SUMMARY**

- A. Section Includes:
  - 1. Automatic condensate pump units.

**1.03 DEFINITIONS**

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

**1.04 CLOSEOUT SUBMITTALS**

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

**PART 2 PRODUCTS****2.01 AUTOMATIC CONDENSATE PUMP UNITS**

- A. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- (1800-mm-) minimum, electrical power cord with plug.
- B. Capacities and Characteristics: Refer to Schedule

**PART 3 EXECUTION****3.01 PUMP INSTALLATION**

- A. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

**3.02 CONNECTIONS**

- A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install check valve and gate or ball valve on each condensate pump unit discharge.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

**3.03 STARTUP SERVICE**

- A. Perform startup service.
  - 1. Check piping connections for tightness.
  - 2. Start motor.

**END OF SECTION**

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**SECTION 232300  
REFRIGERANT PIPING****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Piping.
- B. Refrigerant.
- C. Moisture and liquid indicators.
- D. Valves.
- E. Strainers.
- F. Filter-driers.
- G. Flexible connections.
- H. Exterior penetration accessories.

**1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 230719 - HVAC Piping Insulation-CPL.
- C. Section 236313 - Air Cooled Refrigerant Condensers.

**1.03 REFERENCE STANDARDS**

- A. AHRI 710 - Performance Rating of Liquid-Line Driers 2009.
- B. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2018.
- C. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes 2018.
- D. ASME B31.5 - Refrigeration Piping and Heat Transfer Components 2020.
- E. ASME B31.9 - Building Services Piping 2020.
- F. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- G. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- H. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service 2020.
- I. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding 2011 (Amended 2012).
- J. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018.

**1.04 SYSTEM DESCRIPTION**

- A. Where more than one piping system material is specified ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- B. Provide pipe hangers and supports in accordance with ASME B31.5 unless indicated otherwise.
- C. Valves:
- D. Filter-Driers:
  - 1. Use a filter-drier immediately ahead of liquid-line controls, such as thermostatic expansion valves, solenoid valves, and moisture indicators.

**1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.

**PART 2 PRODUCTS****2.01 REGULATORY REQUIREMENTS**

- A. Comply with ASME B31.9 for installation of piping system.

## 2.02 PIPING

- A. Copper Tube: ASTM B280, H58 hard drawn or O60 soft annealed.
  - 1. Fittings: ASME B16.22 wrought copper.
  - 2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.
- B. Copper Tube to 7/8 inch OD: ASTM B88 (ASTM B88M), Type K (A), annealed.
  - 1. Fittings: ASME B16.26 cast copper.
  - 2. Joints: Flared.
- C. Pipe Supports and Anchors:
  - 1. Provide hangers and supports that comply with MSS SP-58.
    - a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
  - 2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron adjustable swivel, split ring.
  - 3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
  - 4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
  - 5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
  - 6. Vertical Support: Steel riser clamp.
  - 7. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
  - 8. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
  - 9. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

## 2.03 REFRIGERANT

- A. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.

## 2.04 MOISTURE AND LIQUID INDICATORS

- A. Manufacturers:
  - 1. Henry Technologies: [www.henrytech.com/#sle](http://www.henrytech.com/#sle).
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: [www.parker.com/#sle](http://www.parker.com/#sle).
  - 3. Sporlan, a Division of Parker Hannifin: [www.parker.com/#sle](http://www.parker.com/#sle).
- B. Indicators: Single port type, UL listed, with copper or brass body, flared or solder ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum temperature of 200 degrees F and maximum working pressure of 500 psi.

## 2.05 VALVES

- A. Manufacturers:
  - 1. Hansen Technologies Corporation: [www.hantech.com/#sle](http://www.hantech.com/#sle).
  - 2. Henry Technologies: [www.henrytech.com/#sle](http://www.henrytech.com/#sle).
  - 3. Flomatic Valves: [www.flomatic.com/#sle](http://www.flomatic.com/#sle).

## 2.06 STRAINERS

## 2.07 FILTER-DRIERS

- A. Performance:
  - 1. Flow Capacity - Liquid Line: [ ] ton, minimum, rated in accordance with AHRI 710.
  - 2. Pressure Drop: 2 psi, maximum, when operating at full connected evaporator capacity.
  - 3. Design Working Pressure: 350 psi, minimum.
- B. Cores: Molded or loose-fill molecular sieve desiccant compatible with refrigerant, activated alumina, activated charcoal, and filtration to 40 microns, with secondary filtration to 20 microns; of construction that will not pass into refrigerant lines.
- C. Construction: UL listed.
  - 1. Connections: As specified for applicable pipe type.

**2.08 FLEXIBLE CONNECTORS**

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

**2.09 EXTERIOR PENETRATION ACCESSORIES**

- A. Flashing Panels for Exterior Wall Penetrations: Premanufactured components and accessories as required to preserve integrity of building envelope; suitable for conduits and facade materials to be installed.

**PART 3 EXECUTION****3.01 PREPARATION**

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

**3.02 INSTALLATION**

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- E. Pipe Hangers and Supports:
  - 1. Install in accordance with ASME B31.5.
  - 2. Support horizontal piping as indicated.
  - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
  - 4. Place hangers within 12 inches of each horizontal elbow.

**3.03 SCHEDULES**

- A. Hanger Spacing for Copper Tubing.
  - 1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 1/4 inch.
  - 2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 1/4 inch.
  - 3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.
  - 4. 1-5/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.

**END OF SECTION**

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**SECTION 233100  
HVAC DUCTS AND CASINGS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Metal ductwork.
- B. Casings and plenums.
- C. Duct cleaning.

**1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 099123 - Interior Painting: Weld priming, paint or coating.
- C. Section 230593 - Testing, Adjusting, and Balancing for HVAC-CPL.
- D. Section 230713 - Duct Insulation-CPL: External insulation and duct liner.
- E. Section 233300 - Air Duct Accessories.
- F. Section 233600 - Air Terminal Units.
- G. Section 233700 - Air Outlets and Inlets.

**1.03 REFERENCE STANDARDS**

- A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel 2019.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process 2020.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- D. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements 2015.
- E. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements 2015.
- F. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements 2015.
- G. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements 2016.
- H. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- I. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems 2018.
- J. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2005 (Revised 2009).
- K. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors current edition, including all revisions.

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration prior to start of work for [ ] pressure class and higher systems.
- C. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

**PART 2 PRODUCTS**

**2.01 DUCT ASSEMBLIES**

- A. Regulatory Requirements: Construct ductwork to comply with NFPA 90A standards.
- B. Ducts: Galvanized steel, unless otherwise indicated.
- C. Low Pressure Supply (Heating Systems): 1/2 inch wg pressure class, galvanized steel.
- D. Return and Relief: 1/2 inch wg pressure class, galvanized steel.

- E. General Exhaust: 1/2 inch wg pressure class, galvanized steel.
- F. Outside Air Intake: 1/2 inch wg pressure class, galvanized steel.
- G. Transfer Air and Sound Boots: 1/2 inch wg pressure class, fibrous glass.

## 2.02 MATERIALS

- A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G60/Z180 coating.
- B. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
  - 1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
  - 2. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
- C. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.
- D. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
  - 1. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
  - 2. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
  - 3. Concrete Screw Type Anchors: Complying with ICC-ES AC193.
  - 4. Masonry Screw Type Anchors: Complying with ICC-ES AC106.
  - 5. Concrete Adhesive Type Anchors: Complying with ICC-ES AC308.

## 2.03 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA (DCS) and as indicated.
- B. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation.
- C. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- D. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).

## 2.04 MANUFACTURED DUCTWORK AND FITTINGS

- A. Flat Oval Ducts: Machine made from round spiral lockseam duct.
  - 1. Manufacture in accordance with SMACNA (DCS).
  - 2. Fittings: Manufacture at least two gauges heavier metal than duct.
  - 3. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- B. Spiral Ducts: Round spiral lockseam duct with galvanized steel outer wall.
  - 1. Manufacture in accordance with SMACNA (DCS).
- C. Round Ducts: Round lockseam duct with galvanized steel outer wall.
  - 1. Manufacture in accordance with SMACNA (DCS).
- D. Round Duct Connection System: Interlocking duct connection system in accordance with SMACNA (DCS).

## 2.05 CASINGS AND PLENUMS

- A. Fabricate casings in accordance with SMACNA (DCS) and construct for operating pressures indicated.
- B. Mount floor mounted casings on 4 inch high concrete curbs. At floor, rivet panels on 8 inch centers to angles. Where floors are acoustically insulated, provide liner of galvanized 18 gauge, 0.0478 inch expanded metal mesh supported at 12 inch centers, turned up 12 inches at sides with sheet metal shields.
- C. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for

cleaning and inspection.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install, support, and seal ducts in accordance with SMACNA (DCS).
- B. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- C. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal cap with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- D. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- E. At exterior wall louvers, seal duct to louver frame and install blank-out panels.

### **3.02 CLEANING**

- A. See Section 017419 - Construction Waste Management and Disposal, for additional requirements.
- B. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment that could be harmed by excessive dirt with temporary filters, or bypass during cleaning.

**END OF SECTION**

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## 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. Sealants and gaskets.
  - 5. Hangers and supports.
- 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. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. All ductwork in the pool and spectator area shall be constructed of aluminum.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:
  - 1. Sealants and gaskets.
- B. 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. Fittings.
  - 6. Reinforcement and spacing.
  - 7. Seam and joint construction.
  - 8. Equipment installation based on equipment being used on Project.
  - 9. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
  - 10. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
- C. Delegated-Design Submittal:
  - 1. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for seismic restraints.

## 1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: 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 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.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- C. 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.
- 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 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 in diameter with butt-welded longitudinal seams.
  2. Fabricate flat-oval ducts larger than 72 inches 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: G90.
  2. Finishes for Surfaces Exposed to View: Mill phosphatized.

- C. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- 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 minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

## **2.4 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. 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, 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.
- C. 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, 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.
- D. 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."
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg 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.

## **2.5 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, "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.

## **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, 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.
- 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."

### **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: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Where practical, install concrete inserts before placing concrete.
  - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "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 of each elbow and within 48 inches 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.
- 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 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.

### **3.6 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."

### **3.7 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 of 2-Inch wg or Higher: Test representative duct sections, selected by Engineer 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. Do not pressurize systems above maximum design operating pressure.
  6. Give seven days' advance notice for testing.
- C. Duct system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

### 3.8 START UP

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

### 3.9 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
1. Underground Ducts: Concrete-encased, stainless steel.
- B. Supply Ducts:
1. Ducts Connected to Fan Coil Units and Terminal Units:
    - a. Pressure Class: Positive 2-inch wg
    - b. Minimum SMACNA Seal Class: C.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
  2. Ducts Connected to Constant-Volume Air-Handling Units:
    - a. Pressure Class: Positive 3-inch wg
    - b. Minimum SMACNA Seal Class: B.
    - c. SMACNA Leakage Class for Rectangular: 6.
    - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- C. Return Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
    - a. Pressure Class: Positive or negative 2-inch wg
    - b. Minimum SMACNA Seal Class: C.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
  2. Ducts Connected to Air-Handling Units:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: B.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- D. Exhaust Ducts:
1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
    - a. Pressure Class: Negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
  2. Ducts Connected to Air-Handling Units:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
    - a. Pressure Class: Positive or negative 1-inch wg.
    - b. Minimum SMACNA Seal Class: C.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.



2. Ducts Connected to Air-Handling Units:
  - a. Pressure Class: Positive or negative 2-inch wg.
  - b. Minimum SMACNA Seal Class: B.
  - c. SMACNA Leakage Class for Rectangular: 12.
  - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- F. Intermediate Reinforcement:
  1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
  2. Stainless-Steel Ducts:
    - a. Exposed to Airstream: Match duct material.
    - b. Not Exposed to Airstream: Match duct material.
  3. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.
- G. 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 or Lower: 90-degree tap.
    - b. Velocity 1000 to 1500 fpm: Conical tap.
    - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

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## **SECTION 233300 AIR DUCT ACCESSORIES**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Air turning devices/extractors.
- B. Backdraft dampers - metal.
- C. Backdraft dampers - fabric.
- D. Combination fire and smoke dampers.
- E. Combination fire and smoke dampers - corridor dampers.
- F. Duct access doors.
- G. Duct test holes.
- H. Fire dampers.
- I. Flexible duct connectors.
- J. Smoke dampers.
- K. Volume control dampers.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 233100 - HVAC Ducts and Casings.
- C. Section 253523 - Integrated Automation Control Dampers: Product furnishing.

#### **1.03 REFERENCE STANDARDS**

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- B. NFPA 92 - Standard for Smoke Control Systems 2018.
- C. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2005 (Revised 2009).
- D. UL 33 - Safety Heat Responsive Links for Fire-Protection Service Current Edition, Including All Revisions.
- E. UL 555 - Standard for Fire Dampers Current Edition, Including All Revisions.
- F. UL 555S - Standard for Smoke Dampers Current Edition, Including All Revisions.

#### **1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide for shop fabricated assemblies including volume control dampers. Include electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Provide instructions for fire dampers.

#### **1.05 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

### **PART 2 PRODUCTS**

#### **2.01 AIR TURNING DEVICES/EXTRACTORS**

- A. Manufacturers:
  - 1. Carlisle HVAC Products; Dynair Hollow Vane and Rail (Double Wall Vane): [www.carlislehvac.com/#sle](http://www.carlislehvac.com/#sle).
  - 2. Elgen Manufacturing Company, Inc; [ ]: [www.elgenmfg.com/#sle](http://www.elgenmfg.com/#sle).
  - 3. Krueger-HVAC, Division of Air System Components; [ ]: [www.krueger-hvac.com/#sle](http://www.krueger-hvac.com/#sle).
  - 4. Ruskin Company; [ ]: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 5. Titus HVAC, a brand of Johnson Controls; [ ]: [www.titus-hvac.com/#sle](http://www.titus-hvac.com/#sle).
  - 6. Substitutions: See Section 016000 - Product Requirements.

**2.02 BACKDRAFT DAMPERS - METAL**

- A. Manufacturers:
  - 1. Louvers & Dampers, Inc, a brand of Mestek, Inc: [www.louvers-dampers.com/#sle](http://www.louvers-dampers.com/#sle).
  - 2. Nailor Industries, Inc: [www.nailor.com/#sle](http://www.nailor.com/#sle).
  - 3. Ruskin Company: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 4. United Enertech: [www.unitedenertech.com/#sle](http://www.unitedenertech.com/#sle).
- B. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

**2.03 BACKDRAFT DAMPERS - FABRIC**

- A. Fabric Backdraft Dampers: Factory-fabricated.
  - 1. Blades: Neoprene coated fabric material.
  - 2. Birdscreen: 1/2 inch nominal mesh of galvanized steel or aluminum.
  - 3. Maximum Velocity: 1000 fpm (5 mps) face velocity.

**2.04 COMBINATION FIRE AND SMOKE DAMPERS**

- A. Manufacturers:
  - 1. Ruskin Company; [ ]: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- C. Provide factory sleeve and collar for each damper.
- D. Multiple Blade Dampers: Fabricate with 16 gauge, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
- E. Operators: UL listed and labelled spring return electric type suitable for 120 volts, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on interior of duct and link to damper operating shaft.

**2.05 COMBINATION FIRE AND SMOKE DAMPERS - CORRIDOR DAMPERS**

- A. Products furnished per Section 253523.
- B. Manufacturers:
  - 1. Substitutions: See Section 016000 - Product Requirements.
- C. Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- D. Multiple Blade Dampers: Fabricate with 16 gauge, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
- E. Operators: UL listed and labelled spring return electric type suitable for 120 volts, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on interior of duct and link to damper operating shaft.

**2.06 DUCT ACCESS DOORS**

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.
- B. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, install minimum 1 inch thick insulation with sheet metal cover.
  - 1. Less Than 12 inches Square: Secure with sash locks.
  - 2. Up to 18 inches Square: Provide two hinges and two sash locks.
  - 3. Up to 24 by 48 inches: Three hinges and two compression latches with outside and inside handles.

**2.07 DUCT TEST HOLES**

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

**2.08 FIRE DAMPERS**

- A. Manufacturers:
  - 1. Ruskin Company; [\_\_\_\_]: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- C. Horizontal Dampers: Galvanized steel, 22 gauge, 0.0299 inch frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket.
- D. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream except for 1.0 inch pressure class ducts up to 12 inches in height.
- E. Multiple Blade Dampers: 16 gauge, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.
- F. Fusible Links: UL 33, separate at 160 degrees F with adjustable link straps for combination fire/balancing dampers.

**2.09 FLEXIBLE DUCT CONNECTORS**

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

**2.10 SMOKE DAMPERS**

- A. Manufacturers:
  - 1. Ruskin Company; [\_\_\_\_]: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Fabricate in accordance with NFPA 90A and UL 555S, and as indicated.

**2.11 VOLUME CONTROL DAMPERS**

- A. Products furnished per Section 253523.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Single Blade Dampers:
  - 1. Fabricate for duct sizes up to 6 by 30 inch.
- D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 by 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
  - 1. Blade: 18 gauge, 0.0478 inch, minimum.
- E. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.

**PART 3 EXECUTION****3.01 INSTALLATION**

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 233100 for duct construction and pressure class.
- B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- C. Provide duct test holes where indicated and required for testing and balancing purposes.

- D. Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by Authorities Having Jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- E. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92.
- F. Demonstrate re-setting of fire dampers to Owner's representative.

**END OF SECTION**

## **SECTION 233423 HVAC POWER VENTILATORS**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Roof exhausters.
- B. Roof ventilators.
- C. Roof intake fans.
- D. Upblast roof exhausters.

#### **1.02 REFERENCE STANDARDS**

- A. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program 2015.
- B. AMCA 99 - Standards Handbook 2016.
- C. AMCA 204 - Balance Quality and Vibration Levels for Fans 2005 (Reaffirmed 2012).
- D. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating 2016.
- E. AMCA 300 - Reverberant Room Method for Sound Testing of Fans 2014.
- F. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data 2014.

#### **1.03 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.
- C. Manufacturer's Instructions: Indicate installation instructions.
- D. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Carnes, a division of Carnes Company Inc: [www.carnes.com/#sle](http://www.carnes.com/#sle).
- B. Greenheck Fan Corporation: [www.greenheck.com/#sle](http://www.greenheck.com/#sle).
- C. Loren Cook Company: [www.lorencook.com/#sle](http://www.lorencook.com/#sle).
- D. PennBarry, Division of Air System Components: [www.pennbarry.com/#sle](http://www.pennbarry.com/#sle).
- E. Twin City Fan & Blower: [www.tcf.com/#sle](http://www.tcf.com/#sle).
- F. Substitutions: See Section 016000 - Product Requirements.

#### **2.02 POWER VENTILATORS - GENERAL**

- A. Static and Dynamically Balanced: Comply with AMCA 204.
- B. Performance Ratings: Comply with AMCA 210, bearing certified rating seal.
- C. Sound Ratings: Comply with AMCA 301, tested to AMCA 300, bearing certified sound ratings seal.
- D. Fabrication: Comply with AMCA 99.
- E. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

#### **2.03 ROOF EXHAUSTERS**

- A. Basis of Design: Loren Cook Company[<>]: [www.lorencook.com/#sle](http://www.lorencook.com/#sle).
- B. Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.

- C. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.
- D. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

## **2.04 UPBLAST ROOF EXHAUSTERS**

- A. Direct Drive Fan:
  - 1. Fan Wheel:
    - a. Type: Non-overloading, backward inclined centrifugal.
    - b. Material: Aluminum, statically and dynamically balanced.
  - 2. Housing:
    - a. Construct of heavy gauge aluminum including curb cap, windband, and motor compartment.
    - b. Rigid internal support structure.
    - c. One-piece fabricated or fully welded curb-cap base to windband for leak proof construction.
    - d. Construct drive frame assembly of heavy gauge steel, mounted on vibration isolators.
    - e. Provide breather tube for fresh air motor cooling and wiring.
- B. Shafts and Bearings:
  - 1. Fan Shaft:
    - a. Ground and polished steel with anti-corrosive coating.
    - b. First critical speed at least 25 percent over maximum cataloged operating speed.
  - 2. Bearings:
    - a. Permanently sealed or pillow block type.
    - b. Minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
    - c. 100 percent factory tested.
- C. Drive Assembly:
  - 1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
  - 2. Belts: Static free and oil resistant.
  - 3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
  - 4. Motor pulley adjustable for final system balancing.
  - 5. Readily accessible for maintenance.
- D. Drain Trough: Allows for single-point drainage of water, grease, and other residues.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with cadmium plated steel lag screws to roof curb.
- C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.

**END OF SECTION**



## **SECTION 233700 AIR OUTLETS AND INLETS**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Diffusers:
  - 1. Rectangular ceiling diffusers.
  - 2. Slot ceiling diffusers.
- B. Registers/grilles:
  - 1. Ceiling-mounted, exhaust and return register/grilles.
  - 2. Ceiling-mounted, linear exhaust and return register/grilles.
  - 3. Ceiling-mounted, supply register/grilles.
- C. Louvers:
- D. Gravity ventilators.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 099123 - Interior Painting: Painting of ducts visible behind outlets and inlets.

#### **1.03 REFERENCE STANDARDS**

- A. AMCA 511 - Certified Ratings Program for Air Control Devices 2010.
- B. AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers 2015, with Editorial Revision (2018).
- C. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets 2006 (Reaffirmed 2021).
- D. SMACNA (ASMM) - Architectural Sheet Metal Manual 2012.

#### **1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.
- C. Project Record Documents: Record actual locations of air outlets and inlets.

#### **1.05 QUALITY ASSURANCE**

- A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Krueger-HVAC: [www.krueger-hvac.com/#sle](http://www.krueger-hvac.com/#sle).
- B. Price Industries: [www.price-hvac.com/#sle](http://www.price-hvac.com/#sle).
- C. Ruskin Company: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
- D. Titus, a brand of Air Distribution Technologies: [www.titus-hvac.com/#sle](http://www.titus-hvac.com/#sle).
- E. Substitutions: See Section 016000 - Product Requirements.

#### **2.02 RECTANGULAR CEILING DIFFUSERS**

- A. Type: Provide square and rectangular, multi-louvered diffuser to discharge air in 360 degree and four way pattern.
- B. Connections: Round.
- C. Frame: Provide surface mount, snap-in, inverted T-bar, spline, and [ ] type. In plaster ceilings, provide plaster frame and ceiling frame.
- D. Fabrication: Steel or Aluminum with baked enamel finish.
- E. Color: As indicated.

**2.03 CEILING SLOT DIFFUSERS**

- A. Type: Continuous 1 inch wide slot, two slots wide, with adjustable vanes for left, right, or vertical discharge.
- B. Fabrication: Aluminum extrusions with factory baked enamel finish.
- C. Color: As indicated.
- D. Frame: 1-1/4 inch margin with countersunk screw mounting and gasket, mitered end border.
- E. Plenum: Integral, galvanized steel, insulated.

**2.04 CEILING SUPPLY REGISTERS/GRILLES**

- A. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille, one-way deflection.
- B. Frame: 1-1/4 inch margin with countersunk screw mounting and gasket.
- C. Construction: Made of aluminum extrusions with factory enamel finish.
- D. Color: As indicated.
- E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

**2.05 CEILING EXHAUST AND RETURN REGISTERS/GRILLES**

- A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, vertical face.
- B. Frame: 1-1/4 inch margin with countersunk screw mounting.
- C. Fabrication: Steel with 20 gauge, 0.0359 inch minimum frames and 22 gauge, 0.0299 inch minimum blades, steel and aluminum with 20 gauge, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.
- D. Color: As indicated.
- E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

**2.06 CEILING LINEAR EXHAUST AND RETURN GRILLES**

- A. Type: Streamlined blades with 90 degree one-way deflection, 1/8 by 3/4 inch on 1/4 inch centers.
- B. Frame: 1-1/4 inch margin, extra heavy for floor mounting, with countersunk screw mounting.
- C. Fabrication: Steel with 20 gauge, 0.0359 inch minimum frames and 22 gauge, 0.0299 inch minimum blades, steel and aluminum with 20 gauge, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.
- D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

**2.07 LOUVERS**

- A. Type: 4 inch deep frame with blades on 45 degree slope with center baffle and return bend, heavy channel frame, 1/2 inch square mesh screen over intake or exhaust end.
- B. Fabrication: 16 gauge, 0.0598 inch (1.52 mm) thick galvanized steel thick galvanized steel welded assembly, with factory prime coat finish.
- C. Color: To be selected by Architect from manufacturer's full range.
- D. Mounting: Furnish with interior flat flange for installation.

**2.08 GRAVITY VENTILATORS**

- A. Hood Intake and Relief Gravity Ventilator:
  - 1. Manufacturers:
    - a. American Coolair Corporation: [www.coolair.com/#sle](http://www.coolair.com/#sle).
    - b. Greenheck Fan Corporation: [www.greenheck.com/#sle](http://www.greenheck.com/#sle).
    - c. Loren Cook Company: [www.lorencook.com/#sle](http://www.lorencook.com/#sle).

- d. Substitutions: See Section 016000 - Product Requirements.
- 2. General:
  - a. Performance ratings and factory testing to be in accordance with AMCA 511 and AMCA 550.
  - b. Equipment to bear permanently affixed manufacturer's nameplate listing model and serial number.
- 3. Options/Accessories:
  - a. Roof Curbs:

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.
- C. Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement.
- D. Install diffusers to ductwork with air tight connection.
- E. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- F. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 099123.

**END OF SECTION**

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## 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. Rectangular and square ceiling diffusers.
  2. Fixed face grilles.
  3. Drum Diffuser.

#### 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; and performance data including throw and drop, static-pressure drop, and noise ratings.
  2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.
- C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

#### 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.

### PART 2 - PRODUCTS

#### 2.1 CEILING DIFFUSERS

- A. Rectangular and Square Ceiling Diffusers:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
    - a. Anemostat Products; a Mestek company.
    - b. Krueger.
    - c. METALAIRE, Inc.

- d. Nailor Industries Inc.
- e. Price Industries. – Basis of design
- f. Titus.

## **2.2 REGISTERS AND GRILLES**

### **A. Fixed Face Grille And Drum Diffuser:**

- 1. **Basis-of-Design Product:** Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - a. Anemostat Products; a Mestek company.
  - b. Krueger.
  - c. Nailor Industries Inc.
  - d. Price Industries. – Basis of design
  - e. Titus.

## **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. Install diffusers, registers, and grilles level and plumb.
- B. 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.
- C. 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

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**SECTION 236213**  
**PACKAGED AIR-COOLED REFRIGERANT COMPRESSOR AND CONDENSER UNITS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Condensing unit package.
- B. Charge of refrigerant and oil.
- C. Controls and control connections.
- D. Refrigerant piping connections.
- E. Motor starters.
- F. Electrical power connections.

**1.02 RELATED REQUIREMENTS**

- A. Section 220513 - Common Motor Requirements for Plumbing Equipment.
- B. Section 220548 - Vibration and Seismic Controls for Plumbing Piping and Equipment: Placement of vibration isolators.
- C. Section 230513 - Common Motor Requirements for HVAC Equipment-CPL.
- D. Section 230993 - Sequence of Operations for HVAC Controls.
- E. Section 232300 - Refrigerant Piping.

**1.03 REFERENCE STANDARDS**

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment 2008, Including All Addenda.
- B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants 2019, with Errata (2020).
- C. ASHRAE Std 23.1 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Pressures of the Refrigerant 2019.
- D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights specialties and accessories, electrical nameplate data, and wiring diagrams. Include equipment served by condensing units in submittal, or submit at same time, to ensure capacities are complementary.
- C. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Include schematic layouts showing condensing units, cooling coils, refrigerant piping, and accessories required for complete system.
- D. Design Data: Indicate pipe and equipment sizing.
- E. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

**1.05 QUALITY ASSURANCE**

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

**1.06 WARRANTY**

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.

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- B. Provide a five year warranty to include coverage for refrigerant compressors.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Refer to Equipment Schedules
- B. Substitutions: See Section 016000 - Product Requirements.

### **2.02 PERFORMANCE REQUIREMENTS**

### **2.03 MANUFACTURED UNITS**

- A. Units: Self-contained, packaged, factory assembled and pre-wired units suitable for outdoor use consisting of cabinet, compressors, condensing coil and fans, integral sub-cooling coil, controls, liquid receiver, wind deflector, and screens.
- B. Construction and Ratings: In accordance with AHRI 210/240. Test in accordance with ASHRAE Std 23.1.
- C. Performance Ratings: Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE Std 90.1.
- D. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.

### **2.04 CASING**

- A. House components in welded steel frame with galvanized steel panels with weather resistant, baked enamel finish.
- B. Mount starters, disconnects, and controls in weatherproof panel provided with full opening access doors. Provide mechanical interlock to disconnect power when door is opened.
- C. Provide removable access doors or panels with quick fasteners and piano hinges.

### **2.05 CONDENSER COILS**

- A. Coils: Aluminum fins mechanically bonded to seamless copper tubing. Provide sub-cooling circuits. Air test under water to 425 psig, and vacuum dehydrate. Seal with holding charge of nitrogen.

### **2.06 FANS AND MOTORS**

- A. Vertical discharge direct driven propeller type condenser fans with fan guard on discharge. Equip with roller or ball bearings with grease fittings extended to outside of casing.
- B. Weatherproof motors suitable for outdoor use, single phase permanent split capacitor or 3 phase, with permanent lubricated ball bearings and built in current and thermal overload protection. Refer to Section 23 0513.

### **2.07 COMPRESSORS**

- A. Compressor: Semi-hermetic reciprocating type.
- B. Mounting: Statically and dynamically balance rotating parts and mount on spring vibration isolators.
- C. Lubrication System: Reversible, positive displacement oil pump with oil charging valve, oil level sight glass, and magnetic plug or strainer.
- D. Motor: Constant speed 1800 rpm suction gas cooled with electronic sensor and winding over temperature protection, designed for across-the-line starting. Furnish with starter.
- E. Capacity Reduction Equipment: Suction valve unloaders, with lifting mechanism operated by electrically actuated solenoid valve, with unloaded compressor start; controlled from suction pressure.
- F. Sump Oil Heater: Evaporates refrigerant returning to sump during shut down. Energize heater continuously when compressor is not operating.



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## **2.08 REFRIGERANT CIRCUIT**

- A. Provide each unit with one refrigerant circuit, factory supplied and piped. Refer to Section 232300.
- B. For each refrigerant circuit, provide:
- C. For heat pump units, provide reversing valve, suction line accumulator, discharge muffler, flow control check valve, and solid-state defrost control utilizing thermistors.

## **2.09 CONTROLS**

- A. On unit, mount weatherproof steel control panel, NEMA 250, containing power and control wiring, molded case disconnect switch, factory wired with single point power connection.
- B. For each compressor, provide across-the-line starter, non-recycling compressor overload, starter relay, and control power transformer or terminal for controls power. Provide manual reset current overload protection. For each condenser fan, provide across-the-line starter with starter relay.
- C. Provide safety controls arranged so any one will shut down machine:
  - 1. High discharge pressure switch (manual reset) for each compressor.
  - 2. Low suction pressure switch (automatic reset) for each compressor.
  - 3. Oil Pressure switch (manual reset).
- D. Provide the following operating controls:
  - 1. Refer to Section 230993.
- E. Provide controls to permit operation down to 0 degrees F ambient temperature.
- F. Gauges: Prepiped for suction and discharge refrigerant pressures and oil pressure for each compressor.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install in accordance with manufacturer's installation instructions.
- B. Complete structural, mechanical, and electrical connections in accordance with manufacturer's installation instructions.
- C. Install units on vibration isolation. Refer to Section 220548.
- D. Provide connection to refrigeration piping system and evaporators. Refer to Section 232300. Comply with ASHRAE Std 15.

### **3.02 SYSTEM STARTUP**

- A. Supply initial charge of refrigerant and oil for each refrigeration system. Replace losses of oil or refrigerant prior to end of correction period.
- B. Charge system with refrigerant and test entire system for leaks after completion of installation. Repair leaks, put system into operation, and test equipment performance.

**END OF SECTION**

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**SECTION 237300  
INDOOR AIR-HANDLING UNITS**

**PART 1 GENERAL**

**1.01 SUMMARY**

- A. Section includes modular factory fabricated air-handling units and accessories.
- B. Related Sections:
  - 1. Section 23 07 00 - HVAC Insulation: Product requirements for insulation for placement by this section.
  - 2. Section 23 09 23 - Direct-Digital Control System for HVAC: Controls remote from unit.
  - 3. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation applying to units in this section.
  - 4. Section 23 21 13 - Hydronic Piping: Product requirements for chilled water and hot water piping connections to air handling units.
  - 5. Section 23 21 16 - Hydronic Piping Specialties: Product requirements for hydronic piping specialties for placement by this section.
  - 6. Section 23 33 00 - Air Duct Accessories: Product requirements for flexible duct connections for placement by this section.
  - 7. Section 26 05 03 - Equipment Wiring Connections: Execution requirements for electric connections specified by this section.

**1.02 REFERENCES**

- A. American Bearing Manufacturers Association:
  - 1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
  - 2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- B. Air Movement and Control Association International, Inc.:
  - 1. AMCA 99 - Standards Handbook.
  - 2. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
  - 3. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
  - 4. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
  - 5. AMCA Standard 500-D - Laboratory Methods of Testing Dampers for Rating.
  - 6. ANSI/AMCA Standard 610 - Laboratory Methods of Testing Airflow Measuring Stations for Rating.
  - 7. AMCA Publication 611 - Certified Ratings Program - Airflow Measurement Performance
- C. Air-Conditioning and Refrigeration Institute:
  - 1. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
  - 2. ARI 430 - Central-Station Air-Handling Units.
  - 3. ARI Guideline D - Application and Installation of Central Station Air-Handling Units.
- D. National Electrical Manufacturers Association:
  - 1. NEMA MG 1 - Motors and Generators.
- E. Sheet Metal and Air Conditioning Contractors:
  - 1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.
- F. Underwriters Laboratories Inc.:
  - 1. UL 900 - Air Filter Units.
  - 2. UL - Fire Resistance Directory.

**1.03 QUALITY ASSURANCE**

- A. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with current AHRI Standard 410.
- B. Air handling units with fan sections utilizing single fans shall be rated and certified in accordance with AHRI Standard.
- C. Air handling units with fan sections utilizing multiple fans shall be rated in accordance with AHRI Standard 430 for airflow, static pressure, and fan speed performance.

- D. Airflow monitoring station: Certify airflow measurement station performance in accordance with AMCA 611.
- E. Outside Air Damper Leakage: Test in accordance with AMCA 500.

#### **1.04 SUBMITTALS**

- A. Section 01 33 00 - Submittal Procedures: Submittal procedures.
- B. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- C. Product Data, Submit the following:
  - 1. All electrical, piping, and ductwork requirements, including sizes, connection locations, and connection method recommendations.
  - 2. Each component of the unit shall be identified and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.
  - 3. All performance data, including capacities and airside and waterside pressure drops, for components.
  - 4. Fan curves shall be provided for fans with the design operating points indicated. Data shall be corrected to actual operating conditions, temperatures, and altitudes.
  - 5. For units utilizing multiple fans in a fan section, a fan curve shall be provided showing the performance of the entire bank of fans at design conditions. In addition, a fan curve shall be provided showing the performance of each individual fan in the bank of fans at design conditions. Also a fan curve shall be provided showing the performance of the bank of fans, if one fan is down. The percent redundancy of the bank of fans with one fan down shall be noted on the fan curve or in the tabulated fan data.
  - 6. A filter schedule must be provided for each air handling unit supplied by the air handling unit manufacturer. Schedule shall detail unit tag, unit size, corresponding filter section location within the AHU, filter arrangement (e.g. angled/flat), filter depth, filter type (e.g. pleated media), MERV rating, and filter quantity and size.
  - 7. A schedule detailing necessary trap height shall be provided for each air handling unit. Schedule shall detail unit tag, unit size, appropriate trap schematic with recommended trap dimensions, and unit supplied base rail height. Contractor shall be responsible for additional trap height required for trapping and insulation beyond the unit supplied base rail height by adequate housekeeping pad.
  - 8. A coil valve coordination schedule shall be provided for each air handling unit supplied by the air handling unit manufacturer. Schedule shall detail unit tag, coil type and corresponding section location within the AHU, valve style (e.g. global, ball), valve type (e.g. electronic 2-way/3-way), valve position (e.g. normally open/closed), size, flow coefficient (CV), and close-off pressure.
  - 9. An electrical MCA - MOP schedule shall be provided for each electrical circuit to which field-power must be supplied. Schedule to detail unit tag, circuit description, voltage/phase/hertz, Minimum Circuit Ampacity (MCA), and calculated Maximum Overcurrent Protection (MOP).
  - 10. Sound data shall be provided using AHRI 260 test methods. Unit discharge, inlet, and radiated sound power levels in dB shall be provided for 63, 125, 250, 500, 1000, 2000, 4000 and 8000Hz.
- D. Manufacturer's Installation Instructions: Submit.
- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- F. The AHU manufacturer shall list any exceptions to the specification.

#### **1.05 CLOSEOUT SUBMITTALS**

- A. Section 01 70 00 - Execution and Closeout Requirements: Closeout procedures.
- B. Operation and Maintenance Data: Submit instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

#### **1.06 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience.

1. Unit shall be manufactured to conform to UL 1995 and shall be listed by either UL/CUL or ETL. Units shall be provided with listing agency label affixed to the unit. In the event the unit is not UL/CUL or ETL approved, the contractor shall, at his/her expense, provide for a field inspection by a UL/CUL or ETL representative to verify conformance. If necessary, contractor shall perform modifications to the unit to comply with UL/CUL or ETL as directed by the representative, at no additional expense to the owner.
  2. Air handling units with multiple direct drive plenum fans, or direct drive plenum fans incorporated with ECM style motors are outside the scope of AHRI 430. These fans however are rated in accordance with AHRI 430.
  3. Certify air handling units in accordance with AHRI Standard 430. Units shall be provided with certification label affixed to the unit. If air handling units are not certified or fans are not rated in accordance with AHRI Standard 430 contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the contractor.
  4. Certify air handling coils in accordance with AHRI Standard 410. Units shall be provided with certification label affixed to the unit. If air handling coils are not certified in accordance with AHRI Standard 410, contractor shall be responsible for expenses associated with testing of coils after installation to verify performance of coil(s). Any costs incurred to adjust coils to meet scheduled capacities shall be the sole responsibility of the contractor.
- B. Installer: Company specializing in performing Work of this section with minimum three years experience.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.
- B. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- C. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Cost associated with non-conformance to shop drawings shall be the responsibility of the manufacturer. Each section shall have lifting lugs for field rigging, lifting and final placement of AHU section(s). AHU's less than 100-inches wide shall allow for forklift transport and maneuverability on the jobsite.
- D. Deliver units to jobsite with fan motor(s), sheave(s), and belt(s) completely assembled and mounted in units.
- E. Unit shall be shipped in a clear shrink-wrap or stretch-wrap to protect unit from in-transit rain and debris per ASHRAE 62.1 recommendations.
- F. Installing contractor shall be responsible for storing AHU in a clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

#### **1.08 WARRANTY**

- A. Section 01 70 00 - Execution and Closeout Requirements: Product warranties and product bonds.
- B. AHU manufacturer shall provide, at no additional cost, a standard parts and labor warranty that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

#### **1.09 EXTRA MATERIALS**

- A. Section 01 70 00 - Execution and Closeout Requirements: Spare parts and maintenance products.
- B. Furnish one set of fan belts for each unit.

- C. Furnish one set of filters for each unit.

## **PART 2 PRODUCTS**

### **2.01 ACCEPTABLE MANUFACTURERS**

- A. Refer to Equipment Schedules.
- B. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to consulting engineer prior to bid date. Acceptance of deviation(s) from specifications shall be in the form of written approval from the consulting engineer. Mechanical Contractor is responsible for expenses that occur due to exceptions made.
- C. Approved Manufacturers:
  - 1. Aeon
  - 2. Trane Performance Climate Changer
  - 3. York Solution XT High Performance
  - 4. Daikin McQuay Vision Custom

### **2.02 GENERAL**

- A. Unit layout and configuration shall be as defined in project plans and schedule.
- B. Manufacturer to provide a full perimeter integral base frame for either ceiling suspension of units or to support and raise all sections of the unit for proper trapping. Base frame will either be bolted construction or welded construction. Refer to schedule for base height and construction type. Contractor will be responsible for providing a housekeeping pad when unit base frame is not of sufficient height to properly trap unit. Unit base frames not constructed of galvanized steel shall be chemically cleaned and coated with both a rust-inhibiting primer and finished coat of rust-inhibiting enamel. Unit base height to be included in total height required for proper trap height.

### **2.03 UNIT CASING**

- A. Unit manufacturer shall ship unit in segments as specified by the contractor for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished to meet ASTM B117 250-hour salt-spray test. The removal of access panels or access doors shall not affect the structural integrity of the unit. All removable panels shall be gasketed. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.
- B. Casing performance - Casing air leakage shall not exceed leak class 6 (CL = 6) per ASHRAE 111 at specified casing pressure, where maximum casing leakage (cfm/100 ft<sup>2</sup> of casing surface area) = CL X P<sup>0.65</sup>.
- C. Air leakage shall be determined at 1.00 times maximum casing static pressure up to 8 inches w.g. Specified air leakage shall be accomplished without the use of caulk. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.
- D. Under 55F supply air temperature and design conditions on the exterior of the unit of 81F dry bulb and 73F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing to the Engineer and Owner, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying units in the field should external condensate form on them. In lieu of AHU manufacturer providing a written guarantee, the installing contractor must provide additional external insulation on AHU to prevent condensation.
- E. Unit casing (wall/floor/roof panels and doors) shall be able to withstand up to 1.5 times design static pressure, or 8-inch w.g., whichever is less, and shall not exceed 0.0042 per inch of panel span (L/240).

- F. Floor panels shall be double-wall construction and designed to support a 300-lb load during maintenance activities and shall deflect no more than 0.0042 per inch of panel span.
- G. Unit casing panels shall be 2-inch double-wall construction, with solid galvanized exterior and solid galvanized interior, to facilitate cleaning of unit interior.
- H. Unit casing panels (roof, walls, floor) and doors shall be provided with a minimum thermal resistance (R-value) of 13 Hr\*Ft<sup>2</sup>\*°F/BTU.
- I. Unit casing panels (roof, walls, floor) and external structural frame members shall be completely insulated filling the entire panel cavity in all directions so that no voids exist. Panel insulation shall comply with NFPA 90A.
- J. Casing panel inner liners must not extend to the exterior of the unit or contact the exterior frame. A mid-span, no-through-metal, internal thermal break shall be provided for all unit casing panels.
- K. Access panels and/or access doors shall be provided in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.
- L. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of interior surfaces.
- M. Traction enhancements shall be applied to the unit floor to improve the walking surface in those unit sections where the floor is fully accessible, and not impeded by internal structural or functional features.

## **2.04 ACCESS DOORS**

- A. Access doors shall be 2-inch double-wall construction. Interior and exterior shall be of the same construction as the interior and exterior wall panels.
- B. All doors shall be provided with a thermal break construction of door panel and door frame.
- C. Gasketing shall be provided around the full perimeter of the doors to prevent air leakage.
- D. Door hardware shall be surface-mounted to prevent through-cabinet penetrations that could likely weaken the casing leakage and thermal performance.
- E. Handle hardware shall be designed to prevent unintended closure.
- F. Access doors shall be hinged and removable without the use of specialized tools.
- G. Hinges shall be interchangeable with the door handle hardware to allow for alternating door swing in the field to minimize access interference due to unforeseen job site obstructions. Hinges shall be constructed of galvanized steel or stainless steel.
- H. Door handle hardware shall be adjustable and visually indicate locking position of door latch external to the section.
- I. All doors shall be a 60-inch high when sufficient unit height is available, or the maximum height allowed by the unit height.
- J. A single door handle shall be provided for each door linking multiple latching points necessary to maintain the specified air leakage integrity of the unit.
- K. An shatterproof window shall be provided in access doors where indicated on the plans. Window shall either be single pane, or thermal dual pane, as defined on schedule. Window shall be capable of withstanding unit operating pressures and shall be safe for viewing UV-C lamps.
- L. Test ports shall be supplied in access doors as defined in the unit schedule to facilitate the field commissioning by the test and balance contractor. Test ports shall not compromise the ASHRAE leakage class of the unit.

## **2.05 PRIMARY DRAIN PANS**

- A. All cooling coil sections shall be provided with an insulated, double-wall, galvanized drain pan.
- B. The drain pan shall be designed in accordance with ASHRAE 62.1 being of sufficient size to collect all condensation produced from the coil and sloped in two planes, pitched toward drain connections, promoting positive drainage to eliminate stagnant water conditions when

unit is installed level and trapped per manufacturer's requirements. See section 2.07, paragraph F through H for specifications on intermediate drain pans between cooling coils.

- C. The outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.
- D. All drain pan threaded connections shall be visible external to the unit. Threaded connections under the unit floor shall not be accepted.
- E. Drain connections shall be of the same material as the primary drain pan and shall extend a minimum 2-1/2-inch beyond the base to ensure adequate room for field piping of condensate traps.
- F. The installing contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.
- G. Coil support members inside the drain pan shall be of the same material as the drain pan and coil casing.
- H. If drain pans are required for heating coils, access sections, or mixing sections they will be indicated in the plans.

## 2.06 FANS

- A. Fan sections shall have a minimum of one hinged and latched access door located on the drive side of the unit to allow inspection and maintenance of the fan, motor, and drive components. Construct door(s) per Section 2.04.
- B. Provide fans of type and class as specified on the schedule. Fan shafts shall be solid steel, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans that are selected with inverter balancing shall first be dynamically balanced at design RPM. The fans then will be checked in the factory from 25% to 100% of design RPM to insure they are operating within vibration tolerance specifications, and that there are no resonant frequency issues throughout this operating range. Inverter balancing that requires lockout frequencies inputted into a variable frequency drive in order to bypass resonant frequencies shall not be acceptable. If supplied in this manner by the unit manufacturer, the contractor will be responsible for rebalancing in the field after unit installation. Fans selected with inverter balancing shall have a maintenance free, circumferential conductive micro fiber shaft grounding ring installed on the fan motor to discharge shaft currents to ground.
- C. Fans, direct drive plenum fans with integral frame motors, shall be mounted on isolation bases. Internally-mounted motor shall be on the same isolation base. Fan and motor shall be internally isolated with spring isolators. A flexible connection shall be installed between fan and unit casing to ensure complete isolation. Flexible connection shall comply with NFPA 90A and UL 181 requirements. If fans and motors are not internally isolated, then the entire unit shall be externally isolated from the building, including supply and return duct work, piping, and electrical connections. External isolation shall be furnished by the installing contractor in order to avoid transmission of noise and vibration through the ductwork and building structure.
- D. Direct drive plenum fans provided with ECM motors shall be balanced to a G6.3 per AMCA 204. No vibration isolation base required for these type fans. Motors for these fan types shall include an integral PID controller that will accept a 0-10VDC input signal for variable speed control.
- E. Fan airflow measurement systems shall be provided to measure fan airflow directly or to measure differential pressure that can be used to calculate airflow. The accuracy of the devices shall be no worse than +/- 5 percent when operating within stable fan operating conditions. Devices shall not affect the submitted fan performance and acoustical levels. Devices that obstruct the fan inlet or outlet shall not be acceptable. Devices shall be connected to transducers with selectable 4-20 mA or 2-10 VDC output. Signal shall be proportional to air velocity.



- F. Each direct drive fan in a multiple-fan array shall be provided with integral back flow prevention: a backdraft damper that prohibits recirculation of air in the event a fan or multiple fans become disabled. Dampers are tested and rated based on AMCA Standard 500. Dampers to be heavy duty type capable of a maximum back pressure that exceeds the design total static pressure with minimal leakage. The dampers should have a minimal total effect on airflow performance both pressure drop when open and system effect on the fan. The damper blades and frame shall be extruded aluminum with blade edge seals locked into the blade edge. Adhesive type seals are unacceptable. AHU manufacturer responsible for providing proper spacing upstream of dampers to ensure full, uniform airflow through upstream components. For units where the damper(s) are supplied at the jobsite, the installing contractor shall contract a certified TAB contractor to verify uniform airflow through upstream components.
- G. MOTORS AND DRIVES
1. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change. Fan sections without factory-installed motors shall have motors field installed by the contractor. The contractor shall be responsible for all costs associated with installation of motor and drive, alignment of sheaves and belts, run testing of the motor, and balancing of the assembly.
  2. Motors shall meet or exceed all NEMA Standards Publication MG 1 - 2006 requirements and comply with NEMA Premium efficiency levels when applicable. Motors shall comply with applicable requirements of NEC and shall be UL Listed.
  3. Fan Motors shall be heavy duty, open drip-proof operable at 460 volts, 60Hz, 3-phase. If applicable, motor efficiency shall meet or exceed NEMA Premium efficiencies.
  4. Belt driven fans shall use 4-pole, 1800 rpm, motors, NEMA B design, with Class B insulation, capable to operate continuously at 104 deg F (40 deg C) without tripping overloads.
  5. Direct driven fans utilizing integral frame motors shall use 2-pole (3600 rpm), 4-pole (1800 rpm) or 6-pole (1200 rpm) motors, NEMA Design B, with Class B insulation capable to operate continuously at 104 deg F (40 deg C) without tripping overloads.
  6. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.

## 2.07 COILS

- A. Coils section header end panel shall be removable to allow for removal and replacement of coils without impacting the structural integrity of the unit.
- B. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.
- C. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
- D. Construct cooling coil casings and coil supports of stainless steel. Heating coils shall be constructed of galvanized steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.
- E. All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.
- F. When two or more cooling coils are stacked in the unit, an intermediate drain pan shall be installed between each coil. The intermediate drain pan shall be designed being of sufficient size to collect all condensation produced from the coil and sloped to promote positive drainage to eliminate stagnant water conditions. The intermediate drain pan shall

- be constructed of the same material as the sections primary drain pan.
- G. The intermediate drain pan shall begin at the leading face of the water-producing device and be of sufficient length extending downstream to prevent condensate from passing through the air stream of the lower coil.
  - H. Intermediate drain pan shall include downspouts to direct condensate to the primary drain pan. The intermediate drain pan outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.
  - I. Coil shall have a flexible epoxy polymer e-coat uniformly applied to all coil surface areas without material bridging between fins. Coating process shall ensure complete coil encapsulation and a uniform dry film thickness from 0.8 to 1.2 mil on all surface areas including fin edges. Corrosion durability shall be confirmed through testing to no less than 5,000 hours salt spray per ASTM B117.
  - J. Hydronic Coils
    1. Supply and return header connections shall be clearly labeled on unit exterior such that direction of coil water-flow is counter to direction of unit air-flow.
    2. Coils shall be proof-tested to 300 psig and leak-tested to 200 psig air pressure under water.
    3. Headers shall be constructed of round copper pipe or cast iron.
    4. Tubes shall be 1/2-inch .024 copper, with aluminum fins.
    5. Hydronic coils shall be supplied with factory installed drain and vent piping to the unit exterior.
  - K. Refrigerant Cooling Coils
    1. Refrigerant suction and liquid connections shall be clearly labeled on unit exterior.
    2. Coils shall be proof tested to 450 psig and leak tested to 300 psig air pressure under water. After testing, insides of tubes shall be air dried, charged with dry nitrogen or dry air, and sealed to prevent contamination.
    3. Refrigerant suction and liquid headers shall be constructed of copper tubing. Suction and liquid connections shall penetrate unit casings to allow for sweat connections to refrigerant lines.
    4. Tubes shall be 1/2 inch O.D., minimum .016 inch thick copper. Fins shall be aluminum.
    5. Coils shall have equalizing type vertical distributors sized in conjunction with capacities of coils.

## 2.08 FILTERS

- A. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter section shall have side access filter guides and access door(s) extending the full height of the casing to facilitate filter removal. Construct doors in accordance with Section 2.04. Provide fixed filter blockoffs as required to prevent air bypass around filters. Blockoffs shall not need to be removed during filter replacement. Filters to be of size, and quantity needed to maximize filter face area of each particular unit size.
- B. Filter type, MERV rating, and arrangement shall be provided as defined in project plans and schedule
- C. Manufacturer shall provide one set of startup filters.
- D. Each filter section shall be provided with a factory-installed, flush-mounted Dwyer dial-type differential pressure gauge piped to both sides of the filter to indicate status. Gauge shall maintain a +/- 5 percent accuracy within operating temperature limits of -20°F to 120°F. Filter sections consisting of pre- and post-filters shall have a gauge for each.

## 2.09 DAMPERS

- A. All dampers shall be internally mounted. Dampers shall be premium ultra low leak and located as indicated on the schedule and plans. Blade arrangement (parallel or opposed) shall be provided as indicated on the schedule and drawings. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 3 CFM/square foot at one inch water gauge complying with ASHRAE 90.1 maximum damper leakage and shall be AMCA licensed for Class 1A. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D.

Manufacturer shall submit brand and model of damper(s) being furnished, if not Ruskin CD60.

- B. Airflow measuring stations shall be provided and located in the outside air path as indicated on the schedule and plans to measure airflow. Airflow measuring stations shall be tested per AMCA Standard 611 and licensed to bear the AMCA Ratings Seal for airflow measurement performance. Integral control damper blades shall be provided as galvanized steel and housed in a galvanized steel frame. Leakage rate shall not exceed 4 CFM/square foot at one inch water gauge complying with ASHRAE 90.1 maximum damper leakage.
1. The airflow measurement station shall measure up to 100 percent of the total outside air and/or return air. The airflow measurement station shall be capable of measuring down to 300 fpm. The airflow measuring device shall adjust for temperature variations. Output shall be provided from the station as a 2-10 VDC signal. Signal shall be proportional to air velocity. The accuracy of the measuring station shall be no greater than +/- 5 percent. Airflow measuring stations shall be mounted on the AHU interior.

## **2.10 ACCESS SECTIONS**

- A. Access sections shall be provided where indicated in the schedule and plans to allow additional access for inspection, cleaning, and maintenance of unit components. The unit shall be installed for proper access. Procedure for proper access, inspection and cleaning of the unit shall be provided in the AHU manufacturer's maintenance manual. Access section doors shall be constructed per Section 2.04.

## **2.11 AIR MIXER/BLENDER SECTION**

- A. Air mixers (blenders) shall be provided and located as indicated on the schedule and drawings. Mixers shall incorporate fixed blades, with no moving parts. Mixer panels shall be sized and installed in the unit with adequate distances upstream and downstream, based on the manufacturer's cataloged performance, to ensure a minimum mixing effectiveness of 70% at 25% outside air, at one mixer diameter downstream of the mixer.

## **PART 3 EXECUTION**

### **3.01 SHIPPING**

- A. Paper copies of the IOM shall also be shipped with each AHU.
- B. The AHU manufacturer shall identify all shipments with the order number. Enough information shall be provided with each shipment to enable the Mechanical Contractor to confirm the receipt of units when they are received. For parts too small to mark individually, the AHU manufacturer shall place them in containers.
- C. To protect equipment during shipment and delivery, all indoor units shall be completely stretch or shrink wrapped. Wrap shall be a minimum of 7 mil plastic. Pipe ends and pipe connection holes in the casing shall be capped or plugged prior to shipment.
- D. After loading the equipment for shipment, the AHU manufacturer shall contact the shipping contact on the order and provide the name of the carrier, description of equipment, order number, shipping point, and date of shipment.

### **3.02 ON-SITE STORAGE**

- A. If equipment is to be stored for a period of time prior to installation, the Mechanical Contractor shall remove all stretch or shrink wrap from units upon receipt to prevent unit corrosion and shall either place the units in a controlled indoor environment or shall cover the units with canvas tarps and place them in a well-drained area. Covering units with plastic tarps shall not be acceptable.

### **3.03 FIELD EXAMINATION**

- A. The Mechanical Contractor shall verify that the mechanical room and/or roof are ready to receive work and the opening dimensions are as indicated on the shop drawings and contract documents.
- B. The Mechanical Contractor shall verify that the proper power supply is available prior to starting of the fans.

### **3.04 INSTALLATION**

- A. Install in accordance with ARI 430.

- B. The Mechanical Contractor shall be responsible to coordinate ALL of his installation requirements with the Owner and the Owner's selected Mechanical Contractor to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or welded joints, and all other installation and assembly requirements.
- C. The AHU manufacturer shall provide all screws and gaskets for joining of sections in the field.
- D. The Mechanical Contractor shall level all unit sections in accordance with the unit manufacturer's instructions. The Mechanical Contractor shall provide and install all necessary permanent shim material to ensure individual sections and entire assembled units are level.
- E. Install flexible connections between unit and inlet and discharge ductwork. Install metal bands of connectors parallel with minimum 1 inch flex between ductwork and fan while running. Refer to Section 23 33 00.
- F. Install assembled units with vibration isolators. Install isolated fans with resilient mountings and flexible electrical leads. Install restraining snubbers as required. Adjust snubbers to prevent tension in flexible connectors when fan is operating. Refer to Section 23 05 48.
- G. Install floor mounted units on concrete housekeeping pads at least 3-1/2 inches high and 6 inches wider than unit. Refer to Section 03 30 00.
- H. Provide sheaves required for final air balance.
- I. Insulate coil headers located outside airflow as specified for piping. Refer to Section 23 07 00.
- J. Connect humidifiers to water supply. Install gate valve on water supply piping. Install 3/4 inch hose bibb accessible from interior. Pipe drain and overflow to nearest floor drain.
- K. Install condensate piping with trap and route from drain pan to nearest floor drain. Refer to Section 23 21 13.
- L. The Mechanical Contractor shall verify that the following items have been completed prior to scheduling the AHU manufacturer's final inspection and start up:
  - 1. All spring-isolated components have had their shipping restraints removed and the components have been leveled.
  - 2. On all field-joined units, that all interconnections have been completed, i.e., electrical and control wiring, piping, casing joints, bolting, welding, etc.
  - 3. All water and steam piping connections have been completed and hydrostatically tested and all water flow rates have been set in accordance with the capacities scheduled on the Drawings.
  - 4. All ductwork connections have been completed and all ductwork has been pressure tested for its intended service.
  - 5. All power wiring, including motor starters and disconnects, serving the unit has been completed.
  - 6. All automatic temperature and safety controls have been completed.
  - 7. All dampers are fully operational.
  - 8. All shipping materials have been removed.
  - 9. All (clean) filter media has been installed in the units.

### **3.05 INSTALLATION HOT WATER HEATING COIL**

- A. Make connections to coils with unions or flanges.
- B. Connect water supply to leaving airside of coil (counter flow arrangement).
- C. Locate water supply at bottom of supply header and return water connection at top.
- D. Install water coils to allow draining and install drain connection at low points.
- E. Install the following piping accessories on hot water piping connections. Refer to Section 23 21 16 and Section 23 21 13.
  - 1. On supply:
    - a. Thermometer well and thermometer.

- b. Well for control system temperature sensor.
  - c. Shutoff valve.
  - d. Strainer.
  - e. Pressure gage.
- 2. On return:
  - a. Thermometer well and thermometer.
  - b. Well for control system temperature sensor.
  - c. Pressure gage.
  - d. Shutoff valve.
  - e. Control valve.
  - f. Flow control valve.
- F. Install automatic air vents at high points complete with shutoff valve. Refer to Section 23 21 13.

### **3.06 FINAL INSPECTION AND START UP SERVICE**

- A. Section 01 40 00 - Quality Requirements: Requirements for manufacturer's field services.
- B. Section 01 70 00 - Execution and Closeout Requirements: Requirements for cleaning.
- C. After the Mechanical Contractor has provided all water and mechanical piping connections, ductwork connections, and field control wiring, and Electrical Contractor has provided all the field power wiring, the Mechanical Contractor shall inspect the installation. The Mechanical Contractor shall then perform startup of the equipment.
- D. The Automatic Temperature Control (Building Direct Digital Control) Contractor shall be scheduled to be at the job site at the time of the equipment start up.
- E. The Mechanical Contractor, shall perform the following tests and services and submit a report outlining the results:
  - 1. Record date, time, and person(s) performing service.
  - 2. Lubricate all moving parts.
  - 3. Check all motor and starter power lugs and tighten as required.
  - 4. Verify all electrical power connections.
  - 5. Vacuum clean coils and inside of unit cabinet.
  - 6. Install new throwaway filters in units at Substantial Completion
  - 7. Conduct a start up inspection per the AHU manufacturer's recommendations.
  - 8. Record fan motor voltage and amperage readings.
  - 9. Check fan rotation and spin wheel to verify that rotation is free and does not rub or bind.
  - 10. Check fan for excessive vibration.
  - 11. Remove all foreign loose material in ductwork leading to and from the fan and in the fan itself.
  - 12. Disengage all shipping fasteners on vibration isolation equipment.
  - 13. Check safety guards to insure they are properly secured.
  - 14. Secure all access doors to the fan, the unit and the ductwork.
  - 15. Switch electrical supply "on" and allow fan to reach full speed.
  - 16. Physically check each fan at start up and shut down to insure no abnormal or problem conditions exist.
  - 17. Check entering and leaving air temperatures (dry bulb and wet bulb) and simultaneously record entering and leaving chilled water temperatures and flow, steam pressures and flow, and outside air temperature.

**END OF SECTION**

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## SECTION 23 73 13 - AIR HANDLING UNITS

### PART 1 - GENERAL

#### 1.1 DESCRIPTION

- A. Provide labor, materials, equipment and services as required for the complete installation as shown on the Contract Documents.
- B. SUBMITTALS
- C. Submit unit performance including capacity, nominal and operating performance.
- D. Submit Mechanical Specifications for unit and accessories describing construction, components and options.
- E. Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations. Indicate unit shipping split locations, and split dimensions, installation and operating weights including dimensions.
- F. Provide fan curves with specified operating point clearly plotted.
- G. Submit data on electrical requirements. Include safety and start-up instructions.
- H. Submit sound data certified to ARI 260.

#### 1.2 DELIVERY STORAGE AND HANDLING

- A. Units may be shipped fully assembled or disassembled to the minimum module size in accordance with shipping or jobsite requirements.
- B. The units must be rigged and lifted in strict accordance with the manufacturer's recommendations.
- C. All unit openings must be sealed to prevent the entrance of construction dust.
- D. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

- A. The units shall consist of the AHU modules as shown on the plans.
- B. Air handling units to fit intended use and location as called for. Capacity, size and arrangement, static pressure, brake horsepower, component parts and accessories as called for and as necessary to obtain required results and allow for proper maintenance. Ratings based on standard Test Code for Centrifugal Fans, adopted jointly by AMCA and ASHRAE. Each size fan to be supplied shall be tested in the manufacturer's laboratory under simulated installation conditions. Ratings based on test, not on interpolated or extrapolated calculation. Guaranteed full capacity delivery through duct systems finally installed and under conditions listed. Guaranteed sound power level ratings not exceeding those of design equipment or as scheduled.
- C. Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.

- D. ARI Certification: Air-handling units and their components shall be factory tested according to the applicable ARI Standard and shall be listed and labeled by ARI.
- E. More than one manufacturer is listed as make, Contractor must be certain that equipment submitted fits properly into indicated space conditions, same as design equipment.
- F. Motors shall conform to the requirements of Specification Section 230513 - Motors.
- G. Drives:
  - 1. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change. Fan sections without factory-installed motors shall have motors field installed by the contractor. The contractor shall be responsible for all costs associated with installation of motor and drive, alignment of sheaves and belts, run testing of the motor, and balancing of the assembly.
  - 2. Equipment manufacturer furnish V-belt drives as recommended by drive manufacturer, unless otherwise indicated.
    - a. 200 % of motor rating, when motor is 10 HP and larger and /or subject to frequent starting, 150% of motor horsepower on motors less than 10 horsepower.
    - b. Motors 5 HP and Larger: Minimum of two (2) belts, matched belt sets for multiple belt drives.
    - c. Cast iron or cast steel pulleys, test holes in belt guards for speed checks. Provide shaft guards where shafts extend beyond belt guard.
  - 3. Motor pulleys:
    - a. Fixed sheave-type only.
    - b. 5 HP and Smaller: "A" section, 2.6 in. minimum pitch diameter.
    - c. 7-1/2 HP to 20 HP: "B" section, 4/6 in. minimum pitch diameter.
    - d. 25 HP and Larger: "C" section, 7.0 in minimum pitch diameter.
    - e. Drive ratio not over 4:1.

## **2.2 AIR HANDLING UNITS**

- A. Unit Base:
  - 1. Indoor Units: Provide factory-installed external support kit on the base of the unit. External support kit shall be used for ceiling suspension, external isolation, or with housekeeping pad. The external support kit for a floor mounted unit shall be 6 in. (minimum) height factory base rail. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned and coated with both a rust-inhibiting primer and finished coat of rust-inhibiting enamel.
- B. Casing:
  - 1. Indoor Units:
    - a. Unit shall be constructed of a complete structural frame with removable panels. Unit manufacturer shall ship separate segments so unit can be broken down for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished to meet ASTM B 117 250-hour salt-spray test. The removal of side panels shall not affect the structural integrity of the unit. All removable panels shall be gasketed to minimize air leakage. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.



- b. Indoor Units: Construct casing sections capable of operating from -4 in. wg to +6 in.wg.
- c. Access panels and/or access doors shall be available on both sides of the unit in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance. If panels are not removable, then manufacturer shall provide access sections with doors between all internal components to ensure access and cleanability of the air handler.
- d. Access doors shall be double wall construction to prevent damage to insulation during routine maintenance.
- e. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of all interior surfaces.
- f. Door hardware shall be surface mounted to minimize penetrations in the door casing that could lead to air leakage paths.
- g. All joints between exterior panels and structural frames, as well as joints between module frames, shall be properly sealed and gasketed to provide an air seal.
- h. Insulation shall be encased in double-wall casing between exterior and interior solid panel such that no insulation can erode to the airstream. Provide perforated panels as shown on the plans. Foil facing on insulation is not an acceptable alternate to double wall construction. Insulation shall have a minimum R-Value of 8 and shall be UL listed. The installation shall comply with NFPA 90A and B requirements.

C. Fan Section(s):

- 1. Provide supply and return fan section(s) as shown on the plans.
- 2. Fan types shall be double width, double inlet centrifugal fans as indicated. Fans shall be designed and suitable for class of service indicated in the unit schedule. Fan shaft to be properly sized and protectively coated with lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. Key fan wheels to fan shaft to prevent slipping.
- 3. Provide self-aligning, grease lubricated pillow-block ball bearings selected for L-50 200,000, L-50 400,000 - for plug fans hour average life per ANSI/AFBMA 9. Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive-side bearing support.
- 4. Provide supply and return fan sections with AF single width, single inlet centrifugal plug fans designed and suitable for class of service indicated on unit schedule. Fan shaft to be properly sized and protectively coated with lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. Key fan wheels to fan shaft to prevent slipping. Provide galvanized expanded metal access door guards to prevent unauthorized entry into fan sections when access doors are opened. Design access door guards for removal from outside of unit. On plug fan sections with vertical down discharge, a safety grate shall cover the entire discharge opening to prevent service personnel from falling into supply air ductwork.
- 5. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with 1 in. spring isolators. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A.

6. Fan sections shall have full height, double wall, hinged doors on both sides for inspection and maintenance of internal components.
  7. Belts shall be enclosed as required by OSHA standard 29 CFR 1910 to protect worker from accidental contact with the belts and sheaves.
- D. Filter Section:
1. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter section shall have filter guides and access doors extending the full height of the casing to facilitate filter removal. Provide filter block-offs as required to prevent air bypass around filters. Filters shall be removable from both sides of filter sections.
  2. Filter type, efficiency, and arrangement shall be provided as defined in project plans and schedule. Filters shall be removable from both sides of filter section(s).
  3. Provide 2 in. angled pre-filter sections with pleated filters.
  4. Manufacturer shall provide one set of startup filters and an additional set of operational filters.
- E. Coils:
1. Heating Coil: Steam.
  - 2.
  3. Supply-Air Refrigerant Coil:
    - a. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
    - b. Coil Split: Interlaced.
    - c. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.
  4. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drainpan under the coil.
  5. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
  6. Construct coil casings of galvanized steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.
  7. All coils shall be completely cleaned prior to installation into the air-handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.
  8. On stacked cooling coils, intermediate drain pans shall be installed between the coils. Intermediate drain pans shall have drop tubes to guide condensate to the main drain pan, thus preventing flooding of lower coils that would result in moisture carryover.
  9. Steam Coils: Distribution header type.
    - a. Tubes: Copper.
    - b. Fins: **Aluminum**
    - c. Frames: **Galvanized** steel.
  10. IAQ Drain Pans:
  11. Insulation shall be encased between exterior and interior walls. Units with cooling coils shall have drain pans under complete cooling coil section that extend beyond the air-

leaving side of the coil to ensure capture of all condensate in section. Cooling coil drain pans shall be sloped in 2 planes, pitched toward drain connections to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's requirements.

12. Units with heating coils shall have a drain pan under complete heating coil section sloped in 2 planes and pitched toward drain connections to ensure proper drainage during cleaning and to capture water in the event of a coil failure.
13. All drain pan connections supplied by unit manufacturer including, piping, and piping connections extending from stainless steel drain pans shall be constructed of stainless steel. The contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.
14. Flat drain pans shall be acceptable in sections that may have incidental, but not continuous contact with moisture. Flat drain pans shall be accessible for cleaning.

F. Dampers

1. All dampers shall be internally mounted. Dampers shall be premium ultra low leak and located as scheduled. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 5 CFM/square foot at one-inch water gauge and 9 CFM/square foot at 4 in. water gauge. All leakage testing and pressure ratings shall be based on AMCA Publication 500. Manufacturer shall submit brand and model of damper(s) being furnished.
2. Provide dampers to modulate the volume of outside air, return air, exhaust air as shown. Damper blades shall be galvanized steel, housed in a galvanized steel frame and mechanically fastened to an axle rod rotating on bearings. Blade seals are required to assure tight closure. All dampers shall be rated for a maximum leakage rate of less than 1 percent of nominal CFM at one-inch w.g. Configure the dampers as shown on the plans:
  - a. OA/RA Mixing Module.
  - b. Return fan economizer.

G. Access Sections:

1. Access for inspection and cleaning of the unit drain pan, coils and fans sections shall be provided. The unit shall be installed for proper access. Procedure for proper access, inspection and cleaning of the unit shall be included in the maintenance manual. Access section shall have double wall, hinged, removable access doors on both sides of sections.

H. Design Equipment:

1. Indoor Style Units: Trane.
2. Makes: Trane, Air Enterprises.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Provide equipment in accordance with manufacturer's recommendations and compatible with intent of the respective system performance requirements.
- B. Provide vibration isolators in accordance with manufacturer's recommendations, and as called for. Provide necessary steel supporting framework for equipment requiring same. Braced against swaying.
- C. Change pulley sizes as many times as necessary, as part of Contract, to make systems deliver specified quantities of air.

- D. Provide factory support rail system as noted on drawings.
- E. Install piping adjacent to machine to allow service and maintenance. Do not block access doors or coil pull-space with piping.
- F. Pan Drains:
  - 1. Connect condensate drain pans with full-size piping.
  - 2. Construct trap with offset dimension and seal depth per manufacturer's recommendations. Install cleanouts at changes in direction.
  - 3. Indoor Units: Extend to nearest equipment or floor drain.
- G. Start-Test-Check:
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
  - 2. Verify that shipping, blocking, and bracing are removed.
  - 3. Verify that unit is secure on mountings and supporting devices and that connection to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - 4. Leak Test: After installation, fill water and steam coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
  - 5. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
  - 6. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
  - 7. Verify that specified filters are installed. Check for leakage around filters.
  - 8. Verify that cooling coil drain pans have a positive slope to drain.
  - 9. Verify that the cooling coil condensate drain trap maintains an air seal.
  - 10. Clean air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
  - 11. After completing system installation and testing, adjusting, and balancing modular indoor air handling and air-distribution systems, clean filter housings and install new filters.

END OF SECTION 23 73 13

**SECTION 237414****– ROOFTOP AIR HANDLING UNITS WITH ENERGY RECOVERY****PART 1 GENERAL****1.01 SUMMARY**

- A. This Section includes central station air-handling units (rooftop units) with the following components and accessories:
  - 1. Supply and return fans.
  - 2. Filtration.
  - 3. Direct expansion: RTU-1, RTU- 2.
  - 4. Energy recovery wheel heat exchanger: RTU-1, RTU-2.
  - 5. Roof curbs.

**1.02 DEFINITIONS**

- A. DDC: Direct-digital control.
- B. RTU: Rooftop unit. As used in this Section, this abbreviation means outdoor, central-station air-handling units.
- C. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

**1.03 ACTION SUBMITTALS**

- A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Wiring Diagrams: Power, signal, and control wiring.

**1.04 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Structural members to which RTUs will be attached.
  - 2. Roof openings
  - 3. Roof curbs and flashing.
- B. Field quality-control test reports.
- C. Warranty: Special warranty specified in this Section.

**1.05 CLOSEOUT SUBMITTALS**

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

**1.06 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: Two sets of filters for each unit.

**1.07 QUALITY ASSURANCE**

- A. ARI Compliance:
  - 1. Comply with ARI 203/110 and ARI 303/110 for testing and rating energy efficiencies for RTUs.
  - 2. Comply with ARI 270 for testing and rating sound performance for RTUs.
- B. ASHRAE Compliance:
  - 1. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

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- C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.
- E. UL Compliance: Comply with UL 1995.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

**1.08 WARRANTY**

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within one year.

**PART 2 PRODUCTS****2.01 ACCEPTABLE MANUFACTURERS**

- A. The following manufacturers are approved for use. No substitutions will be permitted.
  - 1. Aeon (Basis of Design)
  - 2. Xetex, Inc.
  - 3. Carrier
  - 4. Trane
  - 5. Daikin
  - 6. Approved equal.

**2.02 UNIT CONSTRUCTION**

- A. Units scheduled with Direct expansion:
  - 1. refrigerant cooling coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 3" beyond unit casing for ease of installation. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.
    - a. Sweat type copper suction headers shall be provided.
    - b. Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
    - c. Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins on 1 1/2-inch centers, brazed at joints.
    - d. Sweat type copper suction connections located at the bottom of the suction headers for gravity oil drainage. Coils shall be uniformly circuited in a counterflow manner for either single circuit, row, face, interlaced, or interlaced face split capacity reduction as shown on unit schedule. Pressure type liquid distributors used. Coils shall be tested with 315 pounds air pressure under warm water, and suitable for 250 psig working pressure.
    - e. Coil casing shall be a formed channel frame of galvanized steel.
- B. Cabinet Construction
  - 1. Welded Structural Steel Base Frame and Floor:
    - a. Unit shall have an all-welded base frame constructed from structural steel. The frame shall include formed supports constructed from welded structural steel under blowers and other components.
    - b. The base frame shall incorporate a minimum of four (4) integral lifting lugs for every separate unit section.

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- c. A 16 gauge galvanized steel interior floor shall be installed on the base frame. The floor shall be insulated and a 22 gauge galvanized steel sub-floor shall be installed under the insulation.
  - d. Floor insulation shall be 2" thick and consist of a load-bearing, rigid, closed-cell polyiso foam core laminated to a black glass reinforced mat facer. Insulation blowing agents shall be HCFC-free and qualify under the Federal Procurement Regulation for Recycled Material. Additionally, insulation shall meet the following criteria:
    - 1) Insulation shall have an LTTR R-Value of 12.1 (where the LTTR is based on a 15 year time-weighted average in accordance with CAN/ULC-S770).
    - 2) Insulation shall have a compressive strength of 20 psi under ASTM D 1621, a density of 2 pcf under ASTM D 1622, a dimensional stability of less than 2% under ASTM D 2126, a moisture vapor transmission of less than 1 Perm under ASTM E 96, and a water absorption of less than 1% by volume under ASTM C 209. Insulation shall have a service temperature of -100 °F to 250 °F.
    - 3) Insulation shall be compliant with the following specifications: ASTM C1289, Type II, Class 1; UL Classified; FM Class 1 Approved; and CAN/ULC-S704. Additionally, the manufacturer's facility shall be ISO 9002 Registered.
  - e. All seams in the base frame shall be sealed and the frame shall be coated with a rust inhibiting paint. The perimeter of the frame shall be insulated.
2. Drain Pans:
- a. Drain pans shall be provided in all cooling coil, humidifier, and heat exchanger sections where condensate might be present.
  - b. Drain pans shall be double sloped, have all welded seams, MPT connections, and be constructed from 18 gauge G90 galvanized steel. Drain pans with a bitumastic coating are not acceptable because of their poor durability.
  - c. Flat Plate Heat Exchanger section shall have two separate, full width, double sloped drain pans, one in the supply air plenum and one in the exhaust air plenum. Each drain pan shall be 3" deep minimum with its own MPT drain. The heat exchanger shall be removable from the unit without requiring that the drain pans be removed, deconstructed, split, or damaged in any way. Exchanger sections with one drain pan or two single-sloped drain pans are not acceptable. Configurations that require the drain pans to be removed, deconstructed, split, or damaged in any way in order to remove the exchanger are not acceptable.
3. Hinged Access Doors:
- a. Access to all exchanger surfaces, blowers, motors, filters, and other components requiring regular maintenance shall be provided through access doors.
  - b. Access doors shall have double-wall construction with 18 gauge (minimum) galvanized steel inner and outer walls and 3# density hardboard fiberglass insulation. Access door construction shall be otherwise consistent with the unit panel and frame.
  - c. Access doors shall be held closed by a minimum of two roller cam latches. Door hinges shall be galvanized steel. Doors shall be removable from the unit frame.
  - d. Access door frames shall be made from galvanized steel. Continuous hollow rubber gasket shall be applied to all access openings to provide water and airtight seals.
  - e. Doors shall come equipped with hook-and-keeper holders to keep doors open against the side of the unit. Holders shall be zinc-plated and incorporate spring-loaded keepers to prevent unintentional door release.
4. Wall Construction:
- a. Cabinet frame exterior shall be of formed 18 gauge (minimum) galvanized steel. Panels (fixed and access) to be of 18 gauge galvanized steel.
  - b. Frame and panels to be double-walled construction with two inch thick mineral wool insulation. Insulation shall be 4# density, non-combustible, semi-rigid mineral wool insulation boards that are water repellent, designed for high temperature applications where flexibility is required, and meet the following

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criteria:

- c. Insulation shall have a thermal resistance R factor of 8.4.
- d. Insulation shall comply with ASTM C 612, Type IVA and have a melting point of no less than 2150 °F.. Under ASTM E 136 and CAN4 S114 it shall be Non-Combustible. Under ASTM E 84 and CAN/ULC S102 it shall have a maximum Flame Spread of zero (0).
- e. Insulation shall have linear shrinkage of less than 1% at 1200 °F under ASTM C 356.
- f. Insulation shall have a moisture sorption of no more than 0.03% under ASTM C 1104
- g. Insulation shall be free of CFC and HCFC materials and be made from natural and recycled materials.
- h. Insulation shall be UL Classified.
- 5. Rooftop Construction Requirements:
  - a. Weatherized outdoor construction shall include sloped roof panels with rain gutters that overhang the sidewalls to shed water away from access panels, capped roof seams, outside air shut-off damper, exhaust air backdraft damper, and intake and exhaust weather hoods with bird-screens. Secondary roof panels that could trap moisture are not allowed.
- 6. Unit Finish:
  - a. Unit exterior finish shall be Industrial Enamel painted Galvanealed steel.
  - b. Unit interior finish shall be G90 Galvanized steel.
- 7. Energy recovery wheel:
  - a. Wheel shall be constructed of corrugated synthetic fibrous media, with a desiccant intimately bound and uniformly and permanently dispersed throughout the matrix structure of the media. Rotors with desiccants coated bonded, or synthesized onto the media are not acceptable due to delaminating or erosion of the desiccant material. Media shall be synthetic to provide corrosion resistance and resistance against attack from laboratory chemicals present in pharmaceutical, hospital, etc. environments as well as attack from external outdoor air conditions. Coated aluminum is not acceptable. Face flatness of the wheel shall be maximized in order to minimize wear on inner seal surfaces and to minimize cross leakage. Rotor shall be constructed of alternating layers of flat and corrugated media. Wheel layers should be uniform in construction forming uniform aperture sizes for airflow. Wheel construction shall be fluted or formed honeycomb geometry so as to eliminate internal wheel bypass. Wheel layers that can be separated or spread apart by airflow are unacceptable due to the possibility of channeling and performance degradation. The minimum acceptable performance shall be as specified in the unit schedule. Desiccant Material: The desiccant material shall be a molecular sieve, and specifically a 4A or smaller molecular sieve to minimize cross contamination. Wheel Media Support System: The wheel frames shall consist of evenly spaced steel spokes, galvanized steel outer band and rigid center hub. The wheel construction should allow for post fabrication wheel alignment. Wheel Seals: The wheel seals shall be full contact nylon brush seals or equivalent. Seals should be easily adjustable. Wheel cassette: Cassettes shall be fabricated of heavy duty reinforced galvanized steel or welded structural box tubing. Cassettes shall have a built in adjustable purge section minimizing cross contamination of supply air as shown on unit schedule. Bearings shall be inboard, zero maintenance, permanently sealed roller bearings, or alternatively, external flanged or pillow block bearings. Drive systems shall consist of fractional horsepower AC drive motors with multi-link drive belts. Face and bypass dampers shall be furnished as shown on unit schedule and drawings. Certification: The wheel shall be AHRI certified by the energy recovery wheel supplier to AHRI Standard 1060 and must bear the AHRI certification stamp. Private independent testing performed "in accordance with" various standards is not a substitute for AHRI certification and shall not be accepted. The wheel shall be listed or recognized by UL or equivalent.



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8. Economizer:
    - a. Section shall be provided with top outside air opening and end return air opening and top exhaust air opening with or without parallel low leak airfoil damper blades. Dampers shall be hollow core galvanized steel airfoil blades, fully gasketed and have continuous vinyl seals between damper blades in a galvanized steel frame. Dampers shall have stainless steel jamb seals along end of dampers. Linkage and ABS plastic end caps shall be provided when return and outside air dampers sized for full airflow. Return and outside air dampers of different sizes or very large dampers and exhaust dampers must be driven separately. Damper Leakage: Leakage rate shall be less than two tenths of one percent leakage at 2 inches static pressure differential. Leakage rate tested in accordance with AMCA Standard 500.
  9. Blowers, Motors, and Mounts: The following blowers, motors, and mounts shall be provided.
    - a. Direct-drive, airfoil plenum fans.
    - b. Motors shall be premium efficient, ODP, T-frame, 1750 rpm nominal with a minimum service factor of 1.15 mounted on an adjustable base.
    - c. Motor and blower are to be mounted on common frame, isolated from the unit case with RIS isolators and discharge gasket duct connection.
    - d. Motors, blowers, and frames shall be coated with rust inhibiting paint.
    - e. Fans with RIS isolators shall have a hollow rubber gasket around the fan discharge to provide an airtight seal against the unit case to allow for easy removal and replacement of the fan without screws or permanent fasteners.
  10. 2" MERV 8 (30/30) Filters
    - a. Outside and Return air filters shall be medium-efficiency ASHRAE pleated panels consisting of cotton and synthetic media, media support grid and enclosing frame with integral channel for side-access application.
    - b. The filter shall have a Minimum Efficiency Reporting Value of MERV 8 when evaluated under the guidelines of ASHRAE Standard 52.2-2007. It shall also have a MERV-A of 8 when tested per Appendix J of the same standard.
    - c. Initial resistance to airflow shall not exceed 0.31" w.g. at an airflow of 500 fpm.
    - d. A welded wire grid, spot-welded on one-inch centers and treated for corrosion resistance, shall be bonded to the downstream side of the media to maintain the radial pleat and prevent media oscillation.
    - e. An enclosing frame of no less than 28-point high wet-strength beverage board shall provide a rigid and durable enclosure. The frame shall be bonded to the media to prevent air bypass and include integral diagonal support members on the air entering and air exiting side to maintain uniform pleat spacing in varying airflows. The top and bottom of the enclosing frame shall include integral reinforced channels for housing installation.
    - f. The filter shall be classified by Underwriters Laboratories as UL Class 2.
    - g. Filters shall be mounted within unit in galvanized holding frames upstream of exchanger and accessible through access panels or doors.
  11. Bypass
    - a. Provide return air bypass for recirculation of return air in unoccupied modes.
  12. Dampers
    - a. Dampers shall have heavy duty extruded aluminum frames and 4" extruded aluminum air-foil blades mounted on brass shafts and supported and inter-connected by nylon gears.
    - b. The side casings shall enclose the gears with ABS plastic covers that also serve as seals in the closed position.
    - c. Outside air dampers shall be mounted on the inlet of the unit and operated by a modulating direct-coupled actuator with an end switch to be interlocked with the supply air motor relay.
    - d. Return air shut-off dampers shall be mounted on the return air inlet and operated by a modulating direct-coupled actuator with an end switch to be interlocked with the exhaust air motor relay.

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- e. Recirculation air dampers shall be mounted between the return air and the supply air streams and operated by a modulating direct-coupled actuator.
- f. Exhaust air backdraft damper to be parallel blade.
- 13. Roof Curb
  - a. Roof curb kit of 18-inch height shall provide support for the air handler on the building roof and provide a weather protected area for terminating and securing the roof membrane. The roof curb kit shall be manufactured by the air handler unit manufacturer.
- 14. Electrical
  - a. Electrical controls shall include: variable frequency drives or motor starters with overloads, fused branch circuit breakers, control transformer for low voltage controls, service switch, and terminal points/blocks all contained in a NEMA 3R, unit-mounted control panel.
  - b. A single main disconnect switch for single point power connection shall be provided. The disconnect switch shall be mounted through the access panel so that power will have to be shut-off before the access door can be opened.
  - c. The motor power and branch circuits shall be protected by circuit breakers so replaceable fuses will not be necessary.
  - d. All provided wiring and controls shall be factory tested before shipment.
  - e. The unit wiring diagram shall be provided in the panel.

**PART 3 EXECUTION****3.01 EXAMINATION**

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

**3.02 INSTALLATION**

- A. Roof Curb: Coordinate installation of roof curb with General Contractor.
- B. Unit Support: Install unit level on curb.

**3.03 CONNECTIONS**

- A. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
  - 1. Install ducts to termination at top of roof curb.
  - 2. Connect supply ducts to RTUs with flexible duct connectors.
  - 3. Install return-air duct continuously through roof structure.

**3.04 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
  - 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. Report results in writing.
- C. Tests and Inspections:
  - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
  - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

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4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.

**3.05 STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions and do the following:
  1. Inspect for visible damage to unit casing.
  2. Verify that labels are clearly visible.
  3. Verify that clearances have been provided for servicing.
  4. Verify that controls are connected and operable.
  5. Verify that filters are installed.
  6. Remove packing from vibration isolators.
  7. Verify lubrication on fan and motor bearings.
  8. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
  9. Start unit according to manufacturer's written instructions.
    - a. Start refrigeration system.
    - b. Do not operate below recommended low-ambient temperature.
    - c. Complete startup sheets and attach copy with Contractor's startup report.
  10. Inspect and record performance of interlocks and protective devices; verify sequences.
  11. Operate unit for an initial period as recommended or required by manufacturer.
  12. Calibrate thermostats.
  13. Adjust and inspect high-temperature limits.
  14. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
  15. Inspect controls for correct sequencing of heating, mixing dampers and emergency shutdown.
  16. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
    - a. Supply-air volume.
    - b. Return-air volume.
    - c. Relief-air volume.
    - d. Outdoor-air intake volume.
  17. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

**3.06 CLEANING AND 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 site during other-than-normal occupancy hours for this purpose.
- B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

**3.07 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

**END OF SECTION**

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SECTION 238100  
DECENTRALIZED UNITARY HVAC EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

- A. This section includes self-contained air conditioner unit ventilators and accessories as indicated on drawings and schedules, and by requirements of this section.

1.02 QUALITY ASSURANCE

- A. AHRI Compliance: Test and rate Self Contained Air Conditioner unit ventilator in accordance with AHRI Standard 390 "Single Packaged Vertical Air Conditioners and Heat Pumps".
- B. NFPA 70 – National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2010, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. Applicable requirements in ANSI/ASHRAE/IES 90.1-2013, Section 6 - "Heating, Ventilating, and Air- Conditioning."
- E. Listed on <https://www.regulations.doe.gov/certification-data/>. Complies with Energy Policy and Conservation Act (42 USC 6311-6317).
- F. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum ten years documented experience.
- G. The unit shall be constructed in accordance with ANSI standards, and a label shall be affixed to the unit listing the product code under which it is registered.

1.03 WARRANTY

- A. Standard Unit Warranty:
  - 1. For units equipped with Modine Controls System - All Components (Parts Only) Warranty: Two years from date of first beneficial use by buyer or any other user, within two years from date of resale by buyer in any unchanged condition, or within 30 months from date of shipment from seller, whichever occurs first.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Furnish and install a self-contained vertical floor standing air conditioning unit ventilator, DX Cooling Only. Constructed in accordance with UL 1995 standards with a label affixed to the unit listing the product code under which it is registered. Unit performance shall be rated in accordance with AHRI 390. Unit shall be constructed following ISO: 9001 quality control program procedures and be fully assembled, charged, wired, and tested prior to

shipment.

## 2.02 MANUFACTURERS

- A. Basis-of-Design Product: The design for Single Packaged Vertical Air-Conditioners and Heat Pumps is based on Modine ClassMate Model.

## 2.03 CABINET

- A. Insulation: 1-inch thick, acoustic Hushcloth Polyester/Polyurethane foam with density of 2-pounds per cubic foot containing no fibrous materials.
1. Fire-Hazard Classification: Insulation shall have a fire rating of UL94HF-1.
  2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.
- B. Cabinet Construction: Constructed from aluminized steel with 20-gauge panels, degreased and coated with electrostatically applied baked-on polyester powder paint.
- C. Cabinet Interior: Interior right- and left-hand sides shall employ 20 gauge galvanized steel full double wall construction.
- D. Cabinet Finish: The unit color shall be Beige (Hammertone Finish)
1. Paint finish shall be easily cleanable and hard wearing to give maximum protection.
- E. Service and Maintenance Access: All service and maintenance access shall be possible through the front of the unit only.
- F. Return air openings shall be integrated into the cabinet sides.
- G. Access door is factory installed on the front of the unit. Face of door shall be absent of return air openings to allow for easy cleaning. Door shall be fully insulated to provide for superior noise deadening at front of unit. Door shall employ heavy duty 1/4" zinc plated steel plunger hinges with a spring-loaded 1/4" zinc plated steel pin to allow for easy removal, if required. Door is secured with two (2) key locks. Door swing designed to turn into itself allowing side of the unit to be installed directly against a wall in the corner of a room.
- H. Condensate Connection: Factory installed condensate connection stub provided for connection to the field installed building condensate drain.

## 2.04 REFRIGERATION SYSTEM

- A. Compressor: Two stage hermetic scroll compressor mounted on four (4) 125# all neoprene rubber 35-45 durometer vibration isolators for quiet operation. Compressor contains an internal unloading mechanism to provide capacity control and enable part load efficiencies to be increased.
1. An internal overload protector included to protect compressor against excessive motor temperatures and currents.
  2. Compressor is equipped with a crankcase heater to guard against liquid flood-back conditions and the elimination of oil foaming upon start up.
  3. Factory set high and low-pressure switches, automatic reset high pressure cutout, and automatic reset low-pressure cutout.
- B. Refrigeration Circuit (Cooling Only): Refrigeration system utilizes HFC-R410A and contains a factory fitted thermal expansion device and filter drier. Fitted with factory set automatic reset high-pressure and low-pressure cut-out switches and a sight glass included

for system observation.

- C. Indoor Coil: Patented micro-channel CFTM evaporator coil designed for maximum heat transfer with minimum footprint and pressure drop. Quick draining evaporator coil designed, tested and fabricated by unit ventilator manufacturer for optimal airflow and heat transfer specific to the unit. Coil is fitted to non- corrosive stainless steel drain trays.
- D. Outdoor Coil: Enhanced, high efficiency, cross rifled coil designed, tested and fabricated by unit ventilator manufacturer for optimal airflow and heat transfer specific to the unit.

## 2.05 FANS AND MOTORS

- A. The indoor fan assembly consists of one blower inside teardrop housing assembly engineered specifically for optimal airflow with low noise and minimal power consumption. Blower is powered by electronically commutated motor (ECM). The DC motor features brushless, permanently lubricated ball bearing construction for maintenance free operation. A wide range of programmable speeds and torque characteristics is possible for ultra-high efficiency and low audible noise. The ECM provides constant airflow by automatically adjusting the speed if the external static pressure changes. Electrical and control wiring to fan assembly includes quick disconnect plug local to assembly.
- B. Outdoor (Condenser) Fan Assembly: The outdoor fan assembly consists of one backward curved plug fan with centrifugal blower wheel powered by an electronically commutated motor (ECM). The DC motor features brushless, permanently lubricated ball bearing construction for maintenance free operation. A wide range of programmable speeds and torque characteristics are possible for ultra-high efficiency and low audible noise. Fan design capable of overcoming external static pressures brought on by rear extensions backs and duct work connected to the fan discharge opening. Fan is sized such that powered exhaust shall be integral to the unit to prevent over pressurization of the space when the unit is introducing outside air. Capable of exhausting 100% equivalent of the fresh air intake of the unit. Electrical and control wiring to fan assembly includes quick disconnect plug local to assembly.

## 2.06 FILTER

- A. Filter: 2" thick and utilize 14.3 pleats per foot. Electrostatically enhanced pleated filter shall be constructed from 100% Synthetic media. Minimum Efficiency Reporting Value of MERV 11 per ASHRAE standard 52.2. 99% Arrestance and 35-40% Dust Spot Efficiency based on the ASHRAE 52.1 - 1992 test method.

## 2.07 CONTROL PANEL

- A. Control Panel: Located at top of the unit behind the front door for direct, centrally located access to controller, controller transformer (24V), and all necessary contactors, relays, and circuit breakers.
- B. Wiring: Individually numbered terminal blocks and wires are to match job-specific wiring diagrams. All electrical wires in the control panel will run in an enclosed trough. Wiring outside the control panel to be contained in a protective sleeve. All controls and wiring is factory installed in a clean, organized arrangement.
- C. Plug and Socket Wiring: Supply and Exhaust Fan decks, compressor, damper assembly, and energy wheel assembly (if applicable) wiring includes plugs local to the assembly allowing for quick wiring disconnect when the component requires removal for service.

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2.08 ENERGY RECOVERY VENTILATOR WITH ECONOMIZER DAMPER

- A. Energy recovery ventilation (ERV) provided within the unit through an enthalpy transfer wheel mounted in an insulated cassette frame complete with seals, drive motor, and belt. The rotary wheel is coated with silica gel desiccant and is sized to handle a maximum of 500 cfm of outside air. The entire assembly shall be a UL tested component. Performance shall be certified in accordance with the ASHRAE Standard 84 method of test and AHRI Rating Standard of 1060.
- B. ERV Fans: ERV section employs dual electronically commutated ventilation fans to ensure precise control of airflow through energy wheel and provide optimal wheel frost protection as required.
- C. Outside Air Damper: Separate outside air damper and actuator provided for protection from outdoor elements when unit is not in use.
- D. Complete energy recovery ventilator installed on rails to allow the entire assembly to be slid out of the unit for service. Electrical and control wiring to damper assembly includes quick disconnect plug local to assembly.
- E. Full Economizer Mode: Includes the addition of an economizer damper with actuator and return air damper with actuator. This option enables full economizer functionality by closing off return air allowing up to 100% volume of outside air during free cooling applications.
- F. ERV Defrost Cycle: During occupied mode, if the outdoor air temperature falls below 15°F, the microprocessor controller will close the outdoor air damper and
  1. de-energize outside air ventilation fan while the wheel and exhaust air ventilation fan continue to run to properly defrost wheel.

## 2.09 CONTROLS

- A. Modine Control System: The unit is fitted with a programmable microprocessor controller provided by the unit manufacturer mounted outside the air stream in the control panel. The controller is designed specifically for operating the unit in its most energy efficient manner using pre-engineered control strategies. The microprocessor determines mode of operation based on the factory installed return air and supply air temperature sensors.
- B. Factory installed controls shall enable the unit to operate in the following modes:
  1. Free Cooling – using outside air in favorable conditions
  2. Stage One Mechanical Cooling: 67% capacity compressor, low speed supply fan
  3. Stage Two Mechanical Cooling: Controller adjusts compressor capacity and supply fan speed based on load conditions through a sequence that is proprietary to Modine Controls
  4. Stage Three Mechanical Cooling: 100% capacity compressor, high speed supply fan
  5. Heating: Hot water heat, high speed supply fan
- C. The microprocessor controller shall also modify the minimum damper position to compensate for mode of operation and fan speed.
- D. Free Cooling Sequence: If the return air temperature is higher than the occupied set point and if the ambient air temperature is low enough to satisfy the cooling load in the occupied space, the microprocessor controller will de-energize the energy recovery ventilator. Outdoor air ventilation fan is 100% energized and economizer damper and return air damper will automatically modulate between 0-100% allowing up to 100% free cooling to maintain



conditioned space temperature. The free cooling mode of operation leads to much reduced running time for the compressor leading to cost and equipment savings.

- E. Time Clock Card: The Modine Control System microprocessor includes a time clock card for units where time functions, night and weekend setback, etc. are not transmitted from a building management system or remote central time clock. The time clock shall have a full 7-day schedule and calendar function incorporated. The 7-day schedule shall have two adjustable occupied/unoccupied periods per day. The calendar function shall allow 20 calendar periods (start date  
1. / stop date = 1 period).

## 2.10 HOT WATER HEATING

- A. Hot Water Coil (unit mounted): Unit is equipped with a one row hot water heating coil integral to the unit mounted in the reheat position relative to the evaporator coil. The coil is manufactured from refrigeration quality copper tubing mechanically bonded onto aluminum fins. Coil is fitted with both an air bleed and a drain plug.

## 2.11 ADDITIONAL FACTORY INSTALLED OPTIONS

- A. Disconnect Switch: Located on the control panel, a amp power disconnect switch sized for the full load amperage of the unit. Allows the unit to be disconnected from the power supply prior to any maintenance. In the off position the switch can be locked out.

## 2.12 FIELD INSTALLED ACCESSORIES

- A. Top Inlet/Outlet Rear Extension: Where site conditions do not permit the use of the standard locations for outside air intake and exhaust air discharge, an insulated top inlet/outlet air rear extension is supplied for site installation between the back of the unit and the outside wall by the mechanical contractor. The top inlet/outlet air rear extension is 15" deep and incorporates channels that move supply and exhaust air openings to the top of the unit.
- B. Rear Filler Panels: When an outside air rear extension is used in conjunction with a plenum, rear filler panels are used to fill the gap between the rear of the plenum and the wall. Rear filler panels are painted to match the unit and shall be shipped separately for field mounting.
- C. Plenum: 16" discharge plenum mounted on top of the unit allowing for supply air to discharge through the front. Plenums with front discharge supplied with aluminum grills with a clear anodized finish. Lined with acoustic foam to minimize noise levels. Finished and painted to match the unit.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. General: Examine areas and conditions under which self-contained air conditioners are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer.

### 3.02 INSTALLATION

- A. General: Install self-contained air conditioners in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations

indicated, and maintain manufacturer's recommended clearances.

- B. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
  - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-16 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Ductwork: Refer to Division-15 section "Ductwork". Connect supply and return ducts to units with flexible duct connections. Provide transitions to exactly match unit duct connection size.
- D. Drain Piping: Connect self-contained air conditioner's condensate drain to nearest indirect waste connection, or as indicated.

### 3.03 FIELD QUALITY CONTROL

- A. See section 01-4000 – Quality Requirements, for additional requirements.

### 3.04 SYSTEM STARTUP

- A. Start-up units in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

END OF SECTION

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## SECTION 238126.13 SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

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

#### 1.02 RELATED REQUIREMENTS

- A. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections and installation and wiring of thermostats and other controls components.

#### 1.03 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment 2008, Including All Addenda.
- B. AHRI 520 - Performance Rating of Positive Displacement Condensing Units 2004.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants 2019, with Errata (2020).
- D. ASHRAE Std 23.1 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Pressures of the Refrigerant 2019.
- E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- F. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems 2018.
- G. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical Current Edition, Including All Revisions.

### PART 2 PRODUCTS

#### 2.01 SYSTEM DESIGN

- A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
  - 1. Heating: None.
  - 2. Cooling: Outdoor electric condensing unit with evaporator coils in multiple ductless indoor units ("mini-split").
  - 3. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- B. Performance Requirements: See Drawings for additional requirements.
- C. Electrical Characteristics:
  - 1.  kW.
  - 2.  volts, single phase, 60 Hz.
  - 3.  amperes maximum fuse size.
  - 4. Disconnect Switch: Factory mount disconnect switch on equipment under provisions of Section 260583.

#### 2.02 INDOOR AIR HANDLING UNITS FOR DUCTLESS SYSTEMS

- A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.
  - 1. Location: .
  - 2. Wall-Mounted Units:
    - a. Cooling Output: 18000 Btuh.
- B. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted

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distributor or thermostatic expansion valve.

1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
2. Manufacturer: System manufacturer.

### **2.03 OUTDOOR UNITS**

- A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
  1. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.
  2. Refrigerant: R-410A.
  3. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23.1 and UL 207.
- B. Air Cooled Condenser: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
- C. Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).
  1. Provide thermostatic expansion valves.
- D. Operating Controls:
  1. Control by room thermostat to maintain room temperature setting.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

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

### **3.02 INSTALLATION**

- A. Install in accordance with NFPA 90A and NFPA 90B.
- B. Install refrigeration systems in accordance with ASHRAE Std 15.

**END OF SECTION**

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## SECTION 238200 CONVECTION HEATING AND COOLING UNITS

### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Finned tube radiation.
- B. Cabinet unit heaters.
- C. Fan-coil units.
- D. Unit ventilators.
- E. Air coils.

#### 1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment-CPL.
- B. Section 230716 - HVAC Equipment Insulation-CPL.
- C. Section 230719 - HVAC Piping Insulation-CPL.
- D. Section 232113 - Hydronic Piping.
- E. Section 232114 - Hydronic Specialties.
- F. Section 232300 - Refrigerant Piping.
- G. Section 233100 - HVAC Ducts and Casings.
- H. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.  
Installation of room thermostats. Electrical supply to units.

#### 1.03 REFERENCE STANDARDS

- A. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Current Edition.
- B. AHRI 350 - Sound Performance Rating of Non-Ducted Indoor Air-Conditioning and Heat Pump Equipment 2015.
- C. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils 2001, with Addendum (2011).
- D. AHRI 440 - Performance Rating of Room Fan-Coils 2008.
- E. AHRI 840 - Unit Ventilators 1998.
- F. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications Most Recent Edition Cited by Referring Code or Reference Standard.
- G. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- I. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2005 (Revised 2009).

#### 1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide typical catalog of information including arrangements.
- C. Shop Drawings:

#### 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

### PART 2 PRODUCTS

#### 2.01 HYDRONIC FINNED TUBE RADIATION

- A. Manufacturers:

1. Modine Manufacturing Company: [www.modineHVAC.com/#sle](http://www.modineHVAC.com/#sle).
  2. Substitutions: See Section 016000 - Product Requirements.
- B. Required Directory Listing: AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at [www.ahrinet.org](http://www.ahrinet.org).
- C. Element Hangers: Quiet operating, ball bearing cradle type providing unrestricted longitudinal movement, on enclosure brackets.
- D. Enclosures: 18 gauge, 0.0478 inch sheet steel up to 18 inches in height, 16 gauge, 0.0598 inch sheet steel over 18 inches in height or aluminum as detailed, with easily jointed components for wall to wall installation.
- E. Finish: Factory applied baked primer coat.
- F. Damper: Where not thermostatically controlled, provide knob-operated internal damper at enclosure air outlet.
- G. Access Doors: For otherwise inaccessible valves, provide factory-made permanently hinged access doors, 6 by 7 inch minimum size, integral with cabinet.

## 2.02 HYDRONIC CABINET UNIT HEATERS

- A. Manufacturers:
1. Modine Manufacturing Company; [\_\_\_\_]: [www.modineHVAC.com/#sle](http://www.modineHVAC.com/#sle).
  2. Sterling Hydronics a Mestek Company; [\_\_\_\_]: [www.sterlingheat.com/#sle](http://www.sterlingheat.com/#sle).
  3. Trane, a brand of Ingersoll Rand; [\_\_\_\_]: [www.trane.com/#sle](http://www.trane.com/#sle).
  4. Substitutions: See Section 016000 - Product Requirements.
- B. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
- C. Coils:
1. Evenly spaced aluminum fins mechanically bonded to copper tubes.
- D. Cabinet: Minimum 16 gauge, 0.0598 inch thick sheet steel front panel with exposed corners and edges rounded, easily removed panels, glass fiber insulation, integral air outlet, and inlet grilles.
- E. Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.
- F. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.
- G. Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted.
- H. Control: Factory wired, solid state, infinite speed control, located in cabinet.
- I. Filter: Easily removed, 1 inch thick glass fiber throw-away type, located to filter air before coil.
- J. Electrical Characteristics:

## 2.03 FAN-COIL UNITS

- A. Manufacturers:
1. Horizontal Concealed:
- B. Performance Data and Safety Requirements:
1. Unit capacities certified in accordance with AHRI 440.
  2. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
  3. Insulation to comply with NFPA 90A requirements for flame spread and smoke generation.
  4. Equipment wiring to comply with requirements of NFPA 70.

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- C. Required Directory Listings: AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI).
- D. Coils:
  - 1. Evenly spaced aluminum fins mechanically bonded to copper tubes.
  - 2. Water Coil: Suitable for working temperatures not less than 200 degrees F.
  - 3. Provide drain pan under cooling coil easily removable for cleaning.
- E. Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.
- F. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.
- G. Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted.
- H. Controls:
  - 1. Provide units with control valves furnished by the fan coil unit manufacturer.
- I. Filter: Easily removed 1 inch thick glass fiber throw-away type, located to filter air before coil.
- J. Electrical Characteristics:

## **2.04 UNIT VENTILATORS**

- A. Manufacturers:
- B. Performance Data and Safety Requirements:
  - 1. Unit capacities certified and tested in accordance with AHRI 840 and AHRI 350.
  - 2. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
- C. Required Directory Listings: AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI).
- D. Hydronic Coils:
  - 1. Copper tubes mechanically expanded or bonded into evenly spaced aluminum fins.
  - 2. Factory pressure tested, hydrostatically, to not less than 350 psi.
  - 3. Provide insulated drain pan under chilled water coils, to prevent sweating, with field convertible left or right hand drain connections.
- E. Cabinet: 14 gauge, 0.0747 inch sheet steel on solid base pan with exposed edges rounded. Provide removable front panels with quick-acting, key-operated cam locks. Provide removable die-cast or fabricated steel discharge grilles. For units having cooling coils, insulate internal parts and surfaces exposed to conditioned air stream with moisture resistant insulation.
- F. Cabinet Accessories: Matching steel construction, reinforced, for use with unit ventilators or finned radiation, with steel alignment pins, adjustable kick plates with leveling bolts, shelves and sliding doors with locks as indicated, sinks, bubbler faucets and bowls, corner, end, and wall filler sections as required.
- G. Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.
- H. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven, arranged to draw air through coil.
- I. Wall Louvers: Anodized aluminum wall intake box and louvers removable from frame with 1/2 inch square mesh galvanized screen in back of louver.
- J. Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted.
- K. Controls:
  - 1. Provide units with control valves furnished by the unit ventilator manufacturer.
  - 2. Provide ASHRAE Cycle I as defined in ASHRAE (HVACA) Handbook - HVAC Applications.

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- L. Filter: Easily removed 1 inch thick glass fiber throw-away type, located to filter air before coil.
- M. Mixing Dampers: Multi-blade with compressible seal, capable of varying proportion of mixed air from 100 percent room air to 100 percent outside air.
- N. Electrical Characteristics:

## **2.05 AIR COILS**

- A. Manufacturers:
  - 1. Water Coils:
- B. Water Coils:
  - 1. Coils rated and tested in accordance with AHRI 410.
  - 2. Tubes: Material to consist of seamless copper or brass, mechanically expanded or tension wound to fins; appropriate tube joining methods based on tube material.
  - 3. Fins: Material to consist of aluminum or copper, continuous plate type with full fin collars, individual helical finned tube type wound under tension, or [\_\_\_\_\_].
  - 4. Casing: Heavy gauge galvanized steel with mounting holes, including intermediate tube supports if required by coil design and length.
  - 5. Headers (Manifolds): Construct of seamless copper pipe, cast iron, nonferrous, or [\_\_\_\_\_] material with tube connection appropriate to header material provided.
  - 6. Acceptable Factory Testing Methods:

## **2.06 HOSE KITS AND VALVES**

- A. Manufacturers:
- B. Hoses:
  - 1. Provide hoses for all units for connection to main water supply and return headers.
  - 2. Length: 2 feet.
  - 3. Material: Braided stainless steel rated to minimum 400 psi at 265 degrees F.
- C. Automatic Balancing Valves:
  - 1. Brass body for shutoff and hydronic balancing.
  - 2. Manufacturers:

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that surfaces are suitable for installation.
- B. Verify that field measurements are as indicated on drawings.

### **3.02 INSTALLATION**

- A. Install in accordance with manufacturer's recommendations.
- B. Do not damage equipment or finishes.
- C. Finned Tube Radiation:
- D. Cabinet Unit Heaters:
  - 1. Install as indicated.
  - 2. Coordinate to ensure correct recess size for recessed units.
- E. Fan-Coil Units:
  - 1. Install as indicated.
  - 2. Coordinate to ensure correct recess size for recessed units.
- F. Unit Ventilators:
  - 1. Locate as indicated, level and shim units, and anchor to structure.
  - 2. Coordinate exact location of wall louvers.
- G. Units with Hydronic Coils:
  - 1. Provide with shut-off valve on supply piping and tamper-proof, balancing valve with memory stop on return piping.
- H. Air Coils:



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1. Install in ducts and casings in accordance with SMACNA (DCS).
2. Hydronic (Drainable) Coils:

### **3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.

### **3.04 CLEANING**

### **3.05 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals, for closeout submittals.

### **3.06 PROTECTION**

- A. Provide finished cabinet units with protective covers during the balance of construction.

**END OF SECTION**

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## SECTION 238216 - HYDRONIC AIR COILS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes hydronic heating air coils.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
  - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

#### 1.4 CLOSEOUT SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 DESCRIPTION

- A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

#### 2.2 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the project requirements provide coils by one of the following manufacturers.
  - 1. Daikin Applied.
  - 2. Super Radiator.
  - 3. Trane.
  - 4. Carrier.
  - 5. York.

#### 2.3 GENERAL DESCRIPTION

- A. Furnish as shown on plans and as described in the specification, Daikin Applied Water Heating Coils.
- B. Coils to have extended surface, staggered tube, and plate fin design.

#### 2.4 HEADERS

- A. Made of seamless copper tubing to assure compatibility with primary surface.
- B. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
- C. Vent and drain plugs shall be provided on the coil header.

## **2.5 CONNECTIONS**

- A. Coil connection should be compatible with the piping to the coil to minimize chance of "galvanic action/electrolysis".
- B. Connections shall be a diameter adequate for specified gpm flow.
  - 1. The connections are located to permit right hand mounting of the coil and assure equal pressure through all the circuits.
- C. Connection and material type.
  - 1. Connection material to be carbon steel pipe. Connection type to be threaded.
- D. Coils are circuited to provide maximum mean effective temperature difference for heat transfer rates.
- E. Coils, greater than 2 rows, must be arranged for counter flow.

## **2.6 TESTING AND PRESSURE RATINGS**

- A. Completed coils are tested at a minimum of 315 PSIG air pressure while submerged in warm water.
- B. Hydronic tests alone are not acceptable.
- C. Standard coil construction is rated for 250 PSIG working pressure at 300 degrees F.

## **2.7 CAPACITY**

- A. Coil capacity shall be as outline on the project schedule and confirmed with computer generated output.
- B. Application.
  - 1. Heating.
- C. Fluid Type.
  - 1. Water.

## **2.8 PRIMARY SURFACE**

- A. Tubes to be 5/8" O.D., staggered in direction of airflow, and must be on 1 ½" tube centers.
- B. Wall thickness to be .020" nominal copper and water pressure drop of coil selection adjusted to wall thickness specified.
- C. Tubes to be mechanically expanded in to fin collars to provide a continuous primary to secondary compression bond over entire coil length, assuring maximum heat transfer.
- D. Coil Tube Type.
  - 1. Standard smooth bore.

## **2.9 SECONDARY SURFACE**

- A. Plate style fins shall be corrugated for high capacity and structural strength.
  - 1. Fin thickness shall be .0075" aluminum.
- B. The fins to have collars to determine fin spacing per inch and support the heat transfer bond to primary surface. Tubing should not be visible between the fins.
  - 1. Fin Style to be a New Ripple fin type.

## **2.10 COIL TYPE & SERPENTINE**

- A. 5WH - Half Serpentine.
- B. Coils available from 12" to 54" fin height on 1.5" tube centers and on 3" increments.
- C. All water heating coils with standard .020" nominal copper tubing available from 12" to 216" fin length in two decimal point increments. For other tube material types the maximum tube length is 180".

## **2.11 CASINGS**

- A. Casing Style
  - 1. Contractor Coil with flanged casing.
- B. Casing Material.
  - 1. Galvanized Steel.

## **2.12 PROTECTIVE COATINGS**

- A. Daikin's electro-fin coating where scheduled.

## **2.13 PACKAGING**

- A. Coil(s) to be fully crated in a wood enclosure with protective cardboard covering the finned area.

# **PART 3 - EXECUTION**

## **3.1 EXAMINATION**

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

## **3.2 INSTALLATION**

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Straighten bent fins on air coils.
- D. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

## **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping.

END OF SECTION 238216

## SECTION 238219 - BLOWER COIL UNITS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
1. Ducted fan coil units and accessories.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  2. Include diagrams for power, signal, and control wiring.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Suspended ceiling components.
  2. Structural members to which fan coil units will be attached.
  3. Method of attaching hangers to building structure.
  4. Size and location of initial access modules for acoustical tile.
  5. Items penetrating finished ceiling, including the following:
    - a. Lighting fixtures.
    - b. Air outlets and inlets.
    - c. Speakers.
    - d. Sprinklers.
    - e. Access panels.
  6. Perimeter moldings.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.
1. In addition to general project requirements, include the following:
    - a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

## **1.5 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. Fan Coil Unit Filters: Furnish two spare filters for each filter installed.

## **1.6 QUALITY ASSURANCE**

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

## **1.7 COORDINATION**

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

## **1.8 WARRANTY**

- A. Special Warranty: Manufacturer agrees to repair or replace components of fan coil units that fail in materials or workmanship within one year of substantial completion.

# **PART 2 - PRODUCTS**

## **2.1 MANUFACTURERS**

- A. Subject to compliance with project requirements, provide products by one of the following manufacturers.
  - 1. Daikin Applied
  - 2. Trane – Basis of design
  - 3. ETI
  - 4. Greenheck
  - 5. Approved equal

## **2.2 FAN COIL TYPE AND ARRANGEMENT**

- A. The fan coil shall be furnished as a draw-through cooling coil with a heating coil in preheat position.

## **2.3 GENERAL CONSTRUCTION**

- A. The units shall include a chassis, coil(s), fan deck with blower(s)/blower housing and motor(s). Steel parts exposed to moisture shall be galvanized and insulated to prevent condensation. The complete fan assembly shall be easily removable for service and maintenance. A quick-connect motor electric plug shall be provided.
- B. Plenum
  - 1. Unit shall be supplied with return plenum complete with filter frame and filter. The plenum shall be fabricated of 18 gauge galvanized steel. The inside plenum surface shall be insulated with 1/2" matt-faced fiberglass insulation. Plenum insulation shall meet



minimum K value of 0.24 (BTU-in)/(hr-ft<sup>2</sup>-F) and rated for maximum air velocity of 5000 fpm. Fiberglass insulation conforms to:

- a. ASTM C1071 (including C665)
- b. UL 181 for erosion
- c. 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and NFPA 90A

## **2.4 SUPPLY FAN**

- A. Supply fans shall be a DWDI forward-curved type. Fan assemblies including fan, motor and sheaves shall be dynamically balanced by the manufacturer on all three planes at all bearing supports. Manufacturer must ensure maximum fan RPM is below the first critical speed.
- B. The complete fan assembly, including motor and main drain pan shall be easily removable.
- C. Units shall be certified in accordance with the Room Fan Coil Unit certification program that is based on ARI Standard 440.
- D. An ECM blower motor shall be provided on all units. Factory motor wiring shall be set for optimum fan performance. The unit shall be shipped at one fixed setting. The ECM motor shall utilize a permanent magnet rotor, which is connected to the shaft through resilient rings to absorb high frequency torque ripple. ECM motor shall be programmed for constant CFM or constant torque.
- E. ECM blower motor shall be 3 speeds, single phase with means for proportional field adjustment of each speed.

## **2.5 ELECTRICAL**

- A. Motor wires shall include a quick-disconnect motor plug.

## **2.6 COOLING AND HEATING**

- A. Steam Heating Coil
  1. Heating performance shall be as specified on the unit schedule.
  2. Coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
  3. Coils shall be provided with headers of seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Coil connections shall be copper sweat connections with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain connections shall be furnished on the coil connection, external to the cabinet. Vent connections shall be provided at the highest point to ensure proper venting. Drain connections shall be provided at the lowest point.

## **2.7 FILTERS**

- A. Filters shall be 1" (25 mm) throwaway. They shall be concealed from sight and easily removable.

## **2.8 CONTROLS**

- A. Unit shall be supplied with a DDC interface board.

- B. DDC Interface board shall have three 24-volt relays with line-voltage contactors to operate the fan motor speeds.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Install fan coil units level and plumb.
- B. Install fan coil units to comply with NFPA 90A.
- C. Suspend fan coil units from structure with elastomeric hangers.
- D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation.
- E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

#### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  - 1. Install piping adjacent to machine to allow service and maintenance.
  - 2. Connect piping to fan coil unit factory hydronic piping package.
- B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors. Comply with safety requirements in UL 1995 for duct connections.

#### **3.4 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

#### **3.5 ADJUSTING**

- A. Adjust initial temperature set points.

- B. 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.

**3.6 DEMONSTRATION**

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

END OF SECTION 238219

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## SECTION 238223 - UNIT VENTILATORS

### 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 unit ventilators and accessories with the following heating and cooling features:

1. [Hydronic] [Steam] heating coil.
2. [Hydronic] [Direct-expansion refrigerant] cooling coil.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product
1. Include rated capacities, operating characteristics, and furnished specialties and accessories for each unit type and configuration.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail anchorages and attachments to structure and to supported equipment.
4. Include diagrams for power, signal, and control wiring.

#### 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, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Size and location of access panels in hard ceilings to provide access to concealed units.
6. Items penetrating finished ceiling, including the following:
  - a. Lighting fixtures.
  - b. Air outlets and inlets.
  - c. Speakers.
  - d. Sprinklers.
  - e. Access panels.
7. Perimeter moldings.
8. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

9. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
10. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For unit ventilators to include in emergency, operation, and maintenance manuals.
  1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
    - a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

### **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. Unit Ventilator Filters: Furnish 2 spare filters for each filter installed.

### **1.7 QUALITY ASSURANCE**

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

### **1.8 COORDINATION**

- A. Coordinate layout and installation of unit ventilators and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake.

### **1.9 WARRANTY**

- A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
  1. Failures include, but are not limited to, the following:
    - a. Compressor failure.
    - b. Condenser coil leak.
  2. Warranty Period: Five years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 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. Factory-packaged and -tested units rated according to AHRI 840, ASHRAE 33, and UL 1995.

### 2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Carrier Corporation.
  - 2. McQuay International.
  - 3. Trane.

### 2.3 MANUFACTURED UNITS

- A. Description: Unit ventilators consisting of finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in draw-through configuration, and hydronic cooling coil.

### 2.4 CABINETS

- A. Insulation: Minimum 1/2-inch-thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
  - 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
  - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner, formed as required by ASHRAE 62.1. Heating-only units shall also be provided with drain pans for future installation of a cooling coil.
- C. Cabinet end pockets shall be a minimum of 12 inches wide to facilitate piping and service. If the standard end pocket is less than 12 inches wide an extended cabinet unit shall be provided.
- D. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners and key-operated control and valve access doors.
  - 1. Steel components exposed to moisture shall be hot-dip galvanized after fabrication.
  - 2. Ceiling-mounted units:
    - a. Ceiling units shall be constructed with two hinged bottom panels for ease of maintenance. Access to filters, controls and piping shall be easily available through the two bottom panels. Retainer chains shall be factory installed to prevent sudden release of bottom panels
- E. Cabinet Finish: Electrostatically painted with an oven-baked thermosetting urethane powder finish, color as selected by Architect.
- F. Indoor-Supply-Air Grille: Steel linear bar welded in-place as an integral part of the unit structure.
- G. Return-Air Inlet: Front toe space.
- H. End Panels: Matching material and finish of unit ventilator.

- I. Outdoor-Air Wall Box (Floor-mounted units): Minimum 0.1265-inch-thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
  - 1. Louver Configuration: Vertical, rain-resistant louver.
  - 2. Louver Material: Aluminum.
  - 3. Bird Screen: 1/2-inch mesh screen on interior side of louver.
  - 4. Decorative Grille: On outside of intake.
  - 5. Finish: Anodized aluminum.
- J. Floor-mounted units shall have an integral pipe tunnel for convenient installation of through-piping.

## 2.5 COILS

- A. Test and rate unit ventilator coils according to ASHRAE 33.
- B. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
- C. Steam Coils: Copper distributing tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 75 psig.
- D. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.

## 2.6 INDOOR FAN

- A. Fan and Motor Board: Removable.
  - 1. Fan: Forward curved, double width, double inlet, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls, with offset aerodynamic blades.
  - 2. Fan Shaft and Bearings: 1-1/4" dia. hollow-steel shaft with permanently lubricated, resiliently mounted bearings.
  - 3. Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment." Motor speed shall be controlled by factory mounted multi-tap transformer through a High-Medium-Low-Off switch. Motors shall be 115/60/1 NEMA permanent split capacitor (PSC), plug-in type designed specifically for unit ventilator operation. Motors shall be located out of the airstream and have an internal thermal overload device (auto reset). Fan motors and controls shall have each hot line protected by factory installed cartridge type fuse(s). Motors shall have sleeve type bearings and require oiling no more than once annually. Units shall have shaft bearing located out of the air stream. Bearings in the airstream are not acceptable.
  - 4. Wiring Termination: Connect motor to chassis wiring with plug connection.
  - 5. The fan and motor assembly shall be rated at low or medium speed to meet the design criteria.
  - 6. For Ceiling-mounted units, provide high-static fan motor.



## 2.7 FILTERS

- A. Filter shall be one-piece design located to provide filtration of the outdoor air/return air mixture to assure even dust loading and balanced airflow in lieu of separate filters for outdoor air and return, and shall be factory furnished initially installed in all units.

## 2.8 DAMPERS

- A. Outside and Room Air Dampers: The room air damper shall be constructed of aluminum using metal-forming techniques to resist twisting and shall be counterbalanced against backpressure. Outdoor air damper shall be two-piece double-wall construction with 1/2 " thick, 1.5 lbs. density fiberglass insulation encapsulated between welded 20 ga. galvanized steel blades for rigidity and to inhibit corrosion, and have additional insulation on the exterior surfaces of the damper blade and on the ends of the outdoor air chamber. **Provide with factory-mounted electric actuator.**
- B. Dampers shall be fitted with mohair seals along all sealing edges. Dampers shall use turned-metal principle on long closing ends with no metal-to-metal contact. No plastic or rubber gaskets shall be acceptable. Damper bearings shall be made of nylon or other material which does not require lubrication.
- C. Face and Bypass Dampers: Galvanized-steel damper blades with edge and end seals and nylon bearings; **with factory-mounted electric actuator.**
- D. Comply with ASHRAE/IES 90.1.

## 2.9 ACCESSORIES

- A. Exhaust Shutter: **[Barometric] [Motorized, modulating] type designed to limit room pressure to maximum 0.10-inch wg with [steel] [aluminum] [fabric] damper blades, including edge and end seals, in galvanized-steel frame with [outdoor] [and] [interior] wall grille.**
- B. Subbase: Sheet metal floor-mounting base with leveling screws and black enamel finish.
- C. Insulated false back with gasket seals on wall and outdoor-air plenum.
  - 1. Insulation: Minimum 1/2-inch-thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
    - a. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
    - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Return-air plenum, **6 inches** thick, designed to take return air from top inlet grilles in cabinets on both sides of unit ventilator with gasket seals on wall and outdoor-air plenum extension.
- E. Duct flanges for supply-, return-, and outdoor-air connections.
- F. Radiation Grille: **[Steel] [Aluminum], [linear-bar] [stamped] grille with finish to match discharge-air grille.**
- G. Energy Recovery Wheel:
  - 1. Casing: **Steel with manufacturer's standard paint coating and with the following:**
    - a. **Integral purge section.**
    - b. **Casing seals on periphery of rotor, on duct divider, and on purge section.**
    - c. **Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.**

2. Rotor: Corrugated-aluminum, segmented wheel strengthened with radial spokes, and having nontoxic, noncorrosive silica-gel desiccant coating. Construct media for passing maximum 800-micrometer solids and maximum 0.04 percent cross contamination by volume of exhaust air. Drive rotor with belt around outside of rotor.
3. Defrost Coils: Electric defrost coil in the exhaust airstream.
4. Drive: Fractional horsepower motor and gear reducer, with speed changed by adjustable variable frequency controller.
5. Inlet and Discharge Fans: Forward curved, centrifugal; resiliently mounted with flexible duct connections.
  - a. Motor and Drive: Permanently lubricated, direct driven. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
6. Filters: 1-inch-thick, disposable type, mounted in galvanized-steel frame upstream of energy recovery wheel in both supply and exhaust airstreams.
7. Electrical: Single electrical connection from attached unit ventilator.

## 2.10 INTEGRAL COOLING CHASSIS

- A. Description: Assembly mounted within unit ventilator, factory assembled and tested; consisting of compressors, condenser coils, fans, motors, and refrigerant receivers; removable for maintenance, with plug and receptacle connections for control and power wiring. Construct, test, and rate condensing units according to AHRI 210/240 and ASHRAE 15.
- B. Casing: Galvanized steel with removable panels for access to controls and refrigerant piping.
- C. Exterior Louver: Extruded aluminum.
- D. Compressor: Hermetic, [scroll] [reciprocating] type; internally isolated for vibration with factory-installed safety devices as follows:
  1. Antirecycle timer.
  2. High-pressure cutout.
  3. Low-pressure cutout or loss-of-charge switch.
  4. Internal thermal-overload protection.
  5. Current- and voltage-sensitive safety devices.
- E. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
- F. Refrigerant Piping Materials:
  1. Drawn-Temper Copper Tube: [ASTM B 88, Type L].
  2. Annealed-Temper Copper Tube: [ASTM B 88, Type L] [ASTM B 88, Type K].
  3. Wrought-Copper Fittings: ASME B16.22.
- G. Refrigerant: [R-22] [R-407C] [R-410A].
- H. Refrigerant: R-407C or R-410A.
- I. Low ambient controls to permit operation down to 45 deg F.
- J. Crankcase heater.
- K. Charging and service fittings.
- L. Filter dryer.

- M. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat.
- N. HGBP, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
- O. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
- P. Direct-Driven Condenser Fan: Forward curved, double width, centrifugal; thermoplastic or painted-steel wheels and galvanized-steel fan scrolls.
  - 1. Motor: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

## 2.11 BASIC UNIT CONTROLS

- A. Control devices and operational sequences are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."
- B. Basic Unit Controls:
  - 1. Control voltage transformer.
  - 2. [Wall-mounting] [Unit-mounted] thermostat with the following features.
    - a. Heat-cool-off switch.
    - b. Fan on-auto switch.
    - c. Fan-speed switch.
    - d. [Manual] [Automatic] changeover.
    - e. Adjustable deadband.
    - f. [Concealed] [Exposed] set point.
    - g. [Concealed] [Exposed] indication.
    - h. [Degree F] [Degree C] indication.
  - 3. [Wall-mounting] [Unit-mounted] humidistat.
    - a. [Concealed] [Exposed] set point.
    - b. [Concealed] [Exposed] indication.
  - 4. [Wall-mounting] [Unit-mounted] temperature sensor.
  - 5. Unoccupied-period-override push button.
  - 6. Data entry and access port.
    - a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    - b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
- C. [DDC ]Terminal Controller:
  - 1. Safety Controls Operation: Freezestat shall stop fan and close outdoor-air damper if air less than 38 deg F enters coils.
  - 2. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
  - 3. Unoccupied-Period-Override Operation: [Two] <Insert number> hours.
  - 4. Dual-Temperature Coil Operation:
    - a. Occupied Periods: When chilled water is available, [open] [modulate] control valve if room temperature exceeds thermostat set point. When hot water is available, [open] [modulate] control valve if room temperature falls below thermostat set point.

- b. Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, **[open] [modulate]** control valve if room temperature falls below thermostat setback temperature.
- 5. Hydronic Cooling-Coil Operation:
  - a. Occupied Periods: **[Open] [Modulate]** control valve to provide cooling if room temperature exceeds thermostat set point.
  - b. Unoccupied Periods: Close control valve.
- 6. Refrigerant-Coil Operation:
  - a. Occupied Periods: Start compressor to maintain room temperature.
  - b. Unoccupied Periods: **[Stop compressor cooling] [Cycle compressor for heating to maintain setback temperature]**.
- 7. **[Supplemental]** Heating-Coil Operation:
  - a. Occupied Periods: **[Open control valve] [Modulate control valve] [Energize electric-resistance coil]** to provide heating if room temperature falls below thermostat set point.
  - b. Unoccupied Periods: Start fan and **[open control valve] [modulate control valve] [energize electric-resistance coil]** if room temperature falls below setback temperature.
  - c. Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below **[25 deg F] <Insert temperature>**.
- 8. Reheat-Coil Operation:
  - a. Humidity Control for Occupied Periods: Humidistat **[opens control valve] [modulates control valve] [energizes electric-resistance coil]** to provide heating. As room temperature rises above set point, cooling-coil valve **[opens] [modulates]** to maintain room temperature.
  - b. Humidity Control for Unoccupied Periods: **[Close control valve] [De-energize]**.
- 9. Outdoor-Air Damper Operation: Open to **[25] <Insert number>** percent fixed minimum intake during occupied periods, and close during unoccupied periods.
- 10. Outdoor-Air Damper Operation: Open to **[25] <Insert number>** percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II during occupied periods, and close during unoccupied periods. Microprocessor controller shall permit air-side economizer operation when outdoor air is less than **[60 deg F] <Insert temperature>**.
- 11. Carbon Dioxide Sensor Operation: During occupied periods, reset minimum outdoor-air ratio down to minimum **[10] <Insert number>** percent to maintain maximum **[800-ppm] <Insert value>** concentration.
- 12. Face-and-Bypass Damper Operation: Position damper to face of coils until room temperature equals thermostat set point; bypass after room-temperature set point is achieved.
- 13. Cooling Lockout: During economizer cycle operation, block out cooling.
- 14. HGBP: Open HGBP solenoid valve to maintain minimum suction pressure at compressor.
- 15. Energy Recovery Wheel Operation:
  - a. Factory-mounted and -wired, starting relay and manual motor starter for field wiring.
  - b. Occupied period is established by **[remote signal] [room occupancy sensor]**.
  - c. Energy recovery wheel and inlet and discharge fans operate during occupied periods after room temperature set point has been achieved.

- d. Energy recovery wheel operates during occupied periods, but stops when unit ventilator controls call for cooling, and outdoor-air temperatures permit free air cooling.
  - e. Energy recovery wheel and fans stop during unoccupied periods.
- 16. Controller shall have volatile-memory backup.
- D. Building Automation System (BAS) Interface Requirements:
  - 1. Interface relay for scheduled operation.
  - 2. Interface relay to provide indication of fault at the central workstation.
  - 3. Provide [BACnet] [or] [LonWorks] interface for central BAS workstation for the following functions:
    - a. Adjust set points.
    - b. Unit ventilator start, stop, and operating status.
    - c. Data inquiry to include [outdoor-air damper position, ]supply- and room-air temperature[ and humidity].
    - d. Occupied and unoccupied schedules.
- E. Electrical Connection: Factory wire motors and controls for a single electrical connection.

## 2.12 METAL SHELVES AND CABINETS

- A. Include manufacturer's standard cabinets to match unit ventilators with required installation hardware as indicated:
  - 1. Open Shelving with Reinforced Shelves:
    - a. [Return-air plenum] [Radiation enclosure] and aluminum bar grille with finish to match unit ventilator grille.
    - b. Through-piping enclosure with solid top.
  - 2. Closed Shelving with Reinforced Shelves:
    - a. [Return-air plenum] [Radiation enclosure] and aluminum bar grille with finish to match unit ventilator grille.
    - b. Through-piping enclosure with solid top.
    - c. Two sliding doors with key-operated locks.
  - 3. Utility compartment with access panel with key-operated lock.
  - 4. Wall and corner filler sections, and end panels finished to match shelving.
- B. Painted Finish: Manufacturer's custom baked enamel, in color selected by Architect, applied to shelving before shipping.
- C. Cabinet Top: Plastic-laminate top in color and pattern selected by Architect from manufacturer's custom colors.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas, with Installer present, to receive unit ventilators for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit ventilator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install unit ventilators to comply with NFPA 90A.
- B. Suspend horizontal unit ventilators from structure with threaded steel rods and minimum 0.25-inch static deflection, elastomeric vibration isolation hanger. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- C. Comply with requirements in Section 236200 "Packaged Compressor and Condenser Units" for condensing units matched to refrigerant cooling coil packaged in unit ventilators.

### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  - 1. Install piping adjacent to machine to allow service and maintenance.
  - 2. Connect condensate drain to indirect waste.
- B. Install refrigerant piping as required by Section 232300 "Refrigerant Piping," and add refrigerant as required to compensate for length of piping.
- C. Connect supply-air and return-air ducts to unit ventilators with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
  - 4. Record temperatures entering and leaving energy recovery wheel when outdoor-air temperature is a minimum of 15 deg F higher, or 20 deg F lower, than room temperature.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

### 3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.

### 3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain unit ventilators.

**SECTION 260505  
SELECTIVE DEMOLITION FOR ELECTRICAL**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Electrical demolition.

**1.02 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.

**PART 2 PRODUCTS**

**2.01 MATERIALS AND EQUIPMENT**

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

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A. Verify that abandoned wiring and equipment serve only abandoned facilities.
- B. Beginning of demolition means installer accepts existing conditions.

**3.02 PREPARATION**

- A. Disconnect electrical systems in walls, floors, and ceilings to be removed.
- B. Coordinate utility service outages with utility company.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
  - 1. Obtain permission from Owner at least 72 hours before partially or completely disabling system.
- E. Existing PA System System: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
  - 1. Obtain permission from Owner at least 24 hours before partially or completely disabling system.

**3.03 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK**

- A. Perform work for removal and disposal of equipment and materials containing toxic substances regulated under the Federal Toxic Substances Control Act (TSCA) in accordance with applicable federal, state, and local regulations. Applicable equipment and materials include, but are not limited to:
  - 1. PCB-containing electrical equipment, including transformers, capacitors, and switches.
  - 2. PCB- and DEHP-containing lighting ballasts.
- B. Remove, relocate, and extend existing installations to accommodate new construction.
- C. Remove abandoned wiring to source of supply.
- D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.
- F. Disconnect and remove abandoned panelboards and distribution equipment.
- G. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

- H. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
- I. Repair adjacent construction and finishes damaged during demolition and extension work.
- J. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.

#### **3.04 CLEANING AND REPAIR**

- A. See Section 017419 - Construction Waste Management and Disposal for additional requirements.
- B. Clean and repair existing materials and equipment that remain or that are to be reused.
- C. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.
- D. Luminaires: Remove existing luminaires for cleaning. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts and broken electrical parts.

**END OF SECTION**



**SECTION 260513  
MEDIUM-VOLTAGE CABLES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Medium voltage cable.
- B. Cable accessories.

**1.02 RELATED REQUIREMENTS**

**1.03 REFERENCE STANDARDS**

- A. IEEE 48 - IEEE Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV 2020.
- B. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy 2021.
- C. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide for cable, terminations, and accessories.
- C. Obtain approval by Central Hudson Gas & Electric prior to submittal.
- D. Project Record Documents: Record actual sizes and locations of cables.
- E. Certificate of Compliance: Indicate approval of installation by CHG&E Utility..

**1.05 QUALITY ASSURANCE**

- A. Comply with NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience and with service facilities within 100 miles of Project.
- C. Installer Qualifications: Authorized installer of specified manufacturer with service facilities within 100 miles of Project.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

**PART 2 PRODUCTS**

**2.01 MEDIUM-VOLTAGE CABLE**

- A. Manufacturers:
  - 1. Okonite: [www.okonite.com/#sle](http://www.okonite.com/#sle).
  - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Medium Voltage Cable: NEMA WC 70 rubber insulated cable.
  - 1. Voltage: 15 kV, grounded.
  - 2. Conductor: #2 Copper, 7-wire compressed or concentric round stranding, with 15 mils conductor shield, 220 mils cross linked polyethylene insulation, 30 mils insulation shield and 10 #14 AWG copper concentric neutral applied spirally around the cable with a 55 mils jacket applied over the neutral conductor.

**2.02 CABLE ACCESSORIES**

- A. Manufacturers:
  - 1. 3M: [www.3m.com/#sle](http://www.3m.com/#sle).
  - 2. TE Connectivity; Raychem Products: [www.te.com/#sle](http://www.te.com/#sle).
- B. Cable Terminations: IEEE 48, Class 2 porcelain insulator cable terminator in kit form.

**PART 3 EXECUTION****3.01 EXAMINATION**

- A. Verify that conduit, duct, trench, or manholes are ready to receive cable.
- B. Verify that field measurements are as indicated.
- C. Verify routing and termination locations of cable bank prior to rough-in.
- D. Cable routing is shown in approximate locations unless dimensioned. Route as required to complete wiring system.

**3.02 PREPARATION**

- A. Use swab to clean conduits before pulling cables.

**3.03 INSTALLATION**

- A. Avoid abrasion and other damage to cables during installation.
- B. Use suitable lubricants and pulling equipment.
- C. Sustain cable pulling tensions and bending radii below recommended limits.
- D. Ground cable shield at each termination and splice.

**3.04 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect exposed cable sections for physical damage.
- C. Inspect cable for proper connections as indicated.
- D. Inspect shield grounding, cable supports, and terminations for proper installation.
- E. Inspect and test in accordance with NETA ATS, except Section 4.

**3.05 PROTECTION**

- A. Protect installed cables from entrance of moisture.

**END OF SECTION**

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**SECTION 260519**  
**LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Single conductor building wire.
- B. Underground feeder and branch-circuit cable.
- C. Service entrance cable.
- D. Metal-clad cable.
- E. Manufactured wiring systems.
- F. Wiring connectors.
- G. Electrical tape.
- H. Heat shrink tubing.
- I. Oxide inhibiting compound.
- J. Wire pulling lubricant.
- K. Cable ties.
- L. Firestop sleeves.

**1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 260526 - Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.

**1.03 REFERENCE STANDARDS**

- A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire 2013 (Reapproved 2018).
- B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft 2011 (Reapproved 2017).
- C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes 2010, with Editorial Revision (2020).
- D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation 2004 (Reapproved 2020).
- E. ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape 2017.
- F. ASTM D4388 - Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes 2013.
- G. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- H. NECA 120 - Standard for Installing Armored Cable (AC) and Metal-Clad Cable (MC) 2012.
- I. NECA 121 - Standard for Installing Nonmetallic-Sheathed Cable (Type NM-B) and Underground Feeder and Branch-Circuit Cable (Type UF) 2007.
- J. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy 2009.
- K. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- L. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- M. UL 44 - Thermoset-Insulated Wires and Cables Current Edition, Including All Revisions.

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- N. UL 83 - Thermoplastic-Insulated Wires and Cables Current Edition, Including All Revisions.
- O. UL 183 - Manufactured Wiring Systems Current Edition, Including All Revisions.
- P. UL 486A-486B - Wire Connectors Current Edition, Including All Revisions.
- Q. UL 486C - Splicing Wire Connectors Current Edition, Including All Revisions.
- R. UL 486D - Sealed Wire Connector Systems Current Edition, Including All Revisions.
- S. UL 493 - Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables Current Edition, Including All Revisions.
- T. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape Current Edition, Including All Revisions.
- U. UL 1569 - Metal-Clad Cables Current Edition, Including All Revisions.

#### **1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and available sizes, configurations, and stranding.
- C. Field Quality Control Test Reports.
- D. Project Record Documents: Record actual installed circuiting arrangements. Record actual routing for underground circuits.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  - 1. See Section 016000 - Product Requirements, for additional provisions.

#### **1.05 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

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

#### **1.07 FIELD CONDITIONS**

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

### **PART 2 PRODUCTS**

#### **2.01 CONDUCTOR AND CABLE APPLICATIONS**

- A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.
- B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.
  - 1. Exceptions:
    - a. Use manufactured wiring systems for branch circuits where concealed above accessible ceilings for lighting.
      - 1) Exception: Provide single conductor building wire in raceway for circuit homerun from distribution box to panelboard.
- C. Underground feeder and branch-circuit cable is permitted only as follows:
  - 1. Where not otherwise restricted, may be used:
  - 2. In addition to other applicable restrictions, may not be used:
    - a. Where exposed to view.
    - b. Where exposed to damage.

- D. Armored cable is not permitted.
- E. Metal-clad cable is permitted only as follows:
  - 1. Where not otherwise restricted, may be used:
    - a. Where concealed above accessible ceilings for final connections from junction boxes to luminaires.
      - 1) Maximum Length: 6 feet.
    - b. Where concealed in hollow stud walls and above accessible ceilings for branch circuits 30 Amp.
  - 2. In addition to other applicable restrictions, may not be used:
    - a. Where exposed to damage.
    - b. For damp, wet, or corrosive locations, unless provided with a PVC jacket listed as suitable for those locations.

## 2.02 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- D. Comply with NEMA WC 70.
- E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- G. Conductors for Grounding and Bonding: Also comply with Section 260526.
- H. Conductors and Cables Installed Exposed in Spaces Used for Environmental Air (only where specifically permitted): Plenum rated, listed and labeled as suitable for use in return air plenums.
- I. Conductor Material:
  - 1. Provide copper conductors only. Aluminum conductors are not acceptable for this project. Conductor sizes indicated are based on copper.
  - 2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
  - 3. Tinned Copper Conductors: Comply with ASTM B33.
- J. Minimum Conductor Size:
  - 1. Branch Circuits: 12 AWG.
    - a. Exceptions:
      - 1) 20 A, 120 V circuits longer than 100 feet: 10 AWG, for voltage drop.
      - 2) 20 A, 120 V circuits longer than 200 feet: 8 AWG, for voltage drop.
- K. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- L. Conductor Color Coding:
  - 1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
  - 2. Color Coding Method: Integrally colored insulation.
  - 3. Color Code:
    - a. 208Y/120 V, 3 Phase, 4 Wire System:
      - 1) Phase A: Black.
      - 2) Phase B: Red.
      - 3) Phase C: Blue.
      - 4) Neutral/Grounded: White.
    - b. Equipment Ground, All Systems: Green.

**2.03 SINGLE CONDUCTOR BUILDING WIRE**

- A. Manufacturers:
  - 1. Copper Building Wire:
    - a. Cerro Wire LLC: [www.cerrowire.com/#sle](http://www.cerrowire.com/#sle).
    - b. Encore Wire Corporation: [www.encorewire.com/#sle](http://www.encorewire.com/#sle).
    - c. General Cable Technologies Corporation; [ ]: [www.generalcable.com/#sle](http://www.generalcable.com/#sle).
    - d. Service Wire Co: [www.servicewire.com/#sle](http://www.servicewire.com/#sle).
    - e. Southwire Company: [www.southwire.com/#sle](http://www.southwire.com/#sle).
    - f. Substitutions: See Section 016000 - Product Requirements.
- B. Description: Single conductor insulated wire.
- C. Conductor Stranding:
  - 1. Feeders and Branch Circuits:
    - a. Size 10 AWG and Smaller: Solid.
    - b. Size 8 AWG and Larger: Stranded.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation:
  - 1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.

**2.04 UNDERGROUND FEEDER AND BRANCH-CIRCUIT CABLE**

- A. Manufacturers:
  - 1. Cerro Wire LLC: [www.cerrowire.com/#sle](http://www.cerrowire.com/#sle).
  - 2. Encore Wire Corporation: [www.encorewire.com/#sle](http://www.encorewire.com/#sle).
  - 3. Service Wire Co: [www.servicewire.com/#sle](http://www.servicewire.com/#sle).
  - 4. Southwire Company: [www.southwire.com/#sle](http://www.southwire.com/#sle).
- B. Description: NFPA 70, Type UF multiple-conductor cable listed and labeled as complying with UL 493, Type UF-B.
- C. Provide equipment grounding conductor unless otherwise indicated.
- D. Conductor Stranding:
  - 1. Size 10 AWG and Smaller: Solid.
  - 2. Size 8 AWG and Larger: Stranded.
- E. Insulation Voltage Rating: 600 V.

**2.05 SERVICE ENTRANCE CABLE**

- A. Manufacturers:
  - 1. Copper Service Entrance Cable:
    - a. Cerro Wire LLC: [www.cerrowire.com/#sle](http://www.cerrowire.com/#sle).
    - b. Encore Wire Corporation: [www.encorewire.com/#sle](http://www.encorewire.com/#sle).
    - c. Service Wire Co: [www.servicewire.com/#sle](http://www.servicewire.com/#sle).
    - d. Southwire Company: [www.southwire.com/#sle](http://www.southwire.com/#sle).
    - e. Substitutions: See Section 016000 - Product Requirements.
- B. Conductor Stranding: Stranded.
- C. Insulation Voltage Rating: 600 V.

**2.06 METAL-CLAD CABLE**

- A. Manufacturers:
  - 1. AFC Cable Systems Inc: [www.afcweb.com/#sle](http://www.afcweb.com/#sle).
  - 2. Encore Wire Corporation: [www.encorewire.com/#sle](http://www.encorewire.com/#sle).
  - 3. Service Wire Co: [www.servicewire.com/#sle](http://www.servicewire.com/#sle).
  - 4. Southwire Company: [www.southwire.com/#sle](http://www.southwire.com/#sle).
- B. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.
- C. Conductor Stranding:

1. Size 10 AWG and Smaller: Solid.
  2. Size 8 AWG and Larger: Stranded.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.
- F. Grounding: Full-size integral equipment grounding conductor.
- G. Armor: Steel, interlocked tape.
- H. Provide PVC jacket applied over cable armor where indicated or required for environment of installed location.

## 2.07 MANUFACTURED WIRING SYSTEMS

- A. Manufacturers:
1. AFC Cable Systems Inc: [www.afcweb.com/#sle](http://www.afcweb.com/#sle).
  2. D&P Custom Lights & Wiring Systems, Inc: [www.dandpcustomlights.com/#sle](http://www.dandpcustomlights.com/#sle).
  3. RELOC Wiring Solutions, a brand of Acuity Brands, Inc: [www.relocwiring.com/#sle](http://www.relocwiring.com/#sle).
  4. Wiremold, a brand of Legrand North America, Inc: [www.legrand.us/#sle](http://www.legrand.us/#sle).
- B. Description: Manufactured wiring assemblies complying with NFPA 70 Article 604, and listed and labeled as complying with UL 183.
- C. Provide components necessary to transition between manufactured wiring system and other wiring methods.
- D. Branch Circuit Cables:
1. Conductor Stranding (Size 10 AWG and Smaller): Solid.
  2. Insulation Voltage Rating: 600 V.
  3. Insulation: Type THHN.
  4. Grounding: Full-size integral equipment grounding conductor.
  5. Armor: Steel, interlocked tape.
- E. Connectors: Keyed and color-coded to prevent interconnection of different voltages.
- F. Fixture Leads: Type TFN insulation.

## 2.08 WIRING CONNECTORS

- A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.
- B. Connectors for Grounding and Bonding: Comply with Section 260526.
- C. Wiring Connectors for Splices and Taps:
1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
  2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.
- D. Wiring Connectors for Terminations:
1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
  2. Provide compression adapters for connecting conductors to equipment furnished with mechanical lugs when only compression connectors are specified.
  3. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
  4. Provide motor pigtail connectors for connecting motor leads in order to facilitate disconnection.
  5. Copper Conductors Size 8 AWG and Larger: Use mechanical connectors or compression connectors where connectors are required.
  6. Stranded Conductors Size 10 AWG and Smaller: Use crimped terminals for connections to terminal screws.

- E. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.
- F. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.
- G. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.
  - 1. Manufacturers:
    - a. 3M: [www.3m.com/#sle](http://www.3m.com/#sle).
    - b. Ideal Industries, Inc: [www.idealindustries.com/#sle](http://www.idealindustries.com/#sle).
    - c. NSI Industries LLC: [www.nsiindustries.com/#sle](http://www.nsiindustries.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
- H. Mechanical Connectors: Provide bolted type or set-screw type.
  - 1. Manufacturers:
    - a. Burndy LLC; [ ]: [www.burndy.com/#sle](http://www.burndy.com/#sle).
    - b. IlSCO: [www.ilSCO.com/#sle](http://www.ilSCO.com/#sle).
    - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
- I. Compression Connectors: Provide circumferential type or hex type crimp configuration.
  - 1. Manufacturers:
    - a. Burndy LLC; [ ]: [www.burndy.com/#sle](http://www.burndy.com/#sle).
    - b. IlSCO: [www.ilSCO.com/#sle](http://www.ilSCO.com/#sle).
    - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
- J. Crimped Terminals: Nylon-insulated, with insulation grip and terminal configuration suitable for connection to be made.
  - 1. Manufacturers:
    - a. Burndy LLC; [ ]: [www.burndy.com/#sle](http://www.burndy.com/#sle).
    - b. IlSCO: [www.ilSCO.com/#sle](http://www.ilSCO.com/#sle).
    - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.

## 2.09 ACCESSORIES

- A. Electrical Tape:
  - 1. Manufacturers:
    - a. 3M: [www.3m.com/#sle](http://www.3m.com/#sle).
    - b. Plymouth Rubber Europa: [www.plymouthrubber.com/#sle](http://www.plymouthrubber.com/#sle).
    - c. Substitutions: See Section 016000 - Product Requirements.
  - 2. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
  - 3. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.
  - 4. Rubber Splicing Electrical Tape: Ethylene Propylene Rubber (EPR) tape, complying with ASTM D4388; minimum thickness of 30 mil; suitable for continuous temperature environment up to 194 degrees F and short-term 266 degrees F overload service.
  - 5. Electrical Filler Tape: Rubber-based insulating moldable putty, minimum thickness of 125 mil; suitable for continuous temperature environment up to 176 degrees F.
  - 6. Moisture Sealing Electrical Tape: Insulating mastic compound laminated to flexible, all-weather vinyl backing; minimum thickness of 90 mil.
- B. Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.
  - 1. Manufacturers:



- a. 3M: [www.3m.com/#sle](http://www.3m.com/#sle).
  - b. Burndy LLC; [ ]: [www.burndy.com/#sle](http://www.burndy.com/#sle).
  - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
- C. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.
- 1. Manufacturers:
    - a. Burndy LLC; [ ]: [www.burndy.com/#sle](http://www.burndy.com/#sle).
    - b. Ideal Industries, Inc: [www.idealindustries.com/#sle](http://www.idealindustries.com/#sle).
    - c. IlSCO: [www.ilsco.com/#sle](http://www.ilsco.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
- D. Wire Pulling Lubricant: Listed; suitable for use with the conductors or cables to be installed and suitable for use at the installation temperature.
- 1. Manufacturers:
    - a. 3M: [www.3m.com/#sle](http://www.3m.com/#sle).
    - b. American Polywater Corporation: [www.polywater.com/#sle](http://www.polywater.com/#sle).
    - c. Ideal Industries, Inc: [www.idealindustries.com/#sle](http://www.idealindustries.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
- E. Cable Ties: Material and tensile strength rating suitable for application.
- 1. Manufacturers:
    - a. Burndy LLC; [ ]: [www.burndy.com/#sle](http://www.burndy.com/#sle).
- F. Sealing Systems for Roof Penetrations: Premanufactured components and accessories as required to preserve integrity of roofing system and maintain roof warranty; suitable for cables and roofing system to be installed; designed to accommodate existing penetrations where applicable.
- 1. Products:
    - a. Menzies Metal Products; Electrical Roof Stack and Cap: [www.menzies-metal.com/#sle](http://www.menzies-metal.com/#sle).
    - b. Menzies Metal Products; Electrical Retro Box: [www.menzies-metal.com/#sle](http://www.menzies-metal.com/#sle).
    - c. Substitutions: See Section 016000 - Product Requirements.
- G. Firestop Sleeves: Listed; provide as required to preserve fire resistance rating of building elements.
- 1. Products:
    - a. HoldRite, a brand of Reliance Worldwide Corporation; HydroFlame Pro Series/HydroFlame Custom Built: [www.holdrite.com/#sle](http://www.holdrite.com/#sle).
    - b. Substitutions: See Section 016000 - Product Requirements.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that interior of building has been protected from weather.
- B. Verify that work likely to damage wire and cable has been completed.
- C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.
- D. Verify that field measurements are as indicated.
- E. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 PREPARATION**

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

### **3.03 INSTALLATION**

- A. Circuiting Requirements:
  - 1. Unless dimensioned, circuit routing indicated is diagrammatic.
  - 2. When circuit destination is indicated without specific routing, determine exact routing required.
  - 3. Arrange circuiting to minimize splices.

4. Include circuit lengths required to install connected devices within 10 ft of location indicated.
  5. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
  6. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is not permitted.
  7. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.
- B. Install products in accordance with manufacturer's instructions.
- C. Perform work in accordance with NECA 1 (general workmanship).
- D. Install underground feeder and branch-circuit cable (Type UF-B) in accordance with NECA 121.
- E. Install metal-clad cable (Type MC) in accordance with NECA 120.
- F. Installation in Raceway:
1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
  2. Pull all conductors and cables together into raceway at same time.
  3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
  4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
- G. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- H. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
1. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conductors and cables to lay on ceiling tiles.
  2. Installation in Vertical Raceways: Provide supports where vertical rise exceeds permissible limits.
- I. Terminate cables using suitable fittings.
1. Metal-Clad Cable (Type MC):
    - a. Use listed fittings.
    - b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.
- J. Install conductors with a minimum of 12 inches of slack at each outlet.
- K. Where conductors are installed in enclosures for future termination by others, provide a minimum of 5 feet of slack.
- L. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.
- M. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
- N. Make wiring connections using specified wiring connectors.
1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
  2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
  3. Do not remove conductor strands to facilitate insertion into connector.

4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
  5. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
  6. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- O. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
1. Dry Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
    - a. For taped connections, first apply adequate amount of rubber splicing electrical tape or electrical filler tape, followed by outer covering of vinyl insulating electrical tape.
  2. Damp Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
    - a. For connections with insulating covers, apply outer covering of moisture sealing electrical tape.
    - b. For taped connections, follow same procedure as for dry locations but apply outer covering of moisture sealing electrical tape.
  3. Wet Locations: Use heat shrink tubing.
- P. Insulate ends of spare conductors using vinyl insulating electrical tape.
- Q. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.
- R. Identify conductors and cables in accordance with Section 260553.
- S. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- T. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

### 3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is required for all conductors. The resistance test for parallel conductors listed as optional is not required.
- D. Correct deficiencies and replace damaged or defective conductors and cables.

### END OF SECTION

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<b>NEWBURGH ECSD</b>	<b>Phase 5: 2019 Capital Improvement Project</b>
13740.20	Grounding and Bonding for Electrical Systems
	260526 - 1

## **SECTION 260526 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground bars.
- E. Ground rod electrodes.
- F. Pre-fabricated signal reference grids.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 260519 - Low-Voltage Electrical Power Conductors and Cables: Additional requirements for conductors for grounding and bonding, including conductor color coding.
- B. Section 260553 - Identification for Electrical Systems: Identification products and requirements.

#### **1.03 REFERENCE STANDARDS**

- A. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System 2012.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NEMA GR 1 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings 2017.
- D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. UL 467 - Grounding and Bonding Equipment Current Edition, Including All Revisions.

#### **1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for grounding and bonding system components.
- C. Field quality control test reports.

#### **1.05 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

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

### **PART 2 PRODUCTS**

#### **2.01 GROUNDING AND BONDING REQUIREMENTS**

- A. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
- C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- D. Grounding System Resistance:
  - 1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by Architect. Precipitation within the previous 48 hours does not

- constitute normally dry conditions.
2. Grounding Electrode System: Not greater than 5 ohms to ground, when tested according to IEEE 81 using "fall-of-potential" method.
  3. Between Grounding Electrode System and Major Electrical Equipment Frames, System Neutral, and Derived Neutral Points: Not greater than 0.5 ohms, when tested using "point-to-point" methods.
- E. Grounding Electrode System:
1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
    - a. Provide continuous grounding electrode conductors without splice or joint.
    - b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
  2. Metal Underground Water Pipe(s):
    - a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
    - b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
    - c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
  3. Metal In-Ground Support Structure:
    - a. Provide connection to metal in-ground support structure that is in direct contact with earth in accordance with NFPA 70.
  4. Concrete-Encased Electrode:
    - a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of either steel reinforcing bars or bare copper conductor not smaller than 4 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
  5. Ground Rod Electrode(s):
    - a. Provide single electrode unless otherwise indicated or required.
    - b. Space electrodes not less than 10 feet from each other and any other ground electrode.
    - c. Where location is not indicated, locate electrode(s) at least 5 feet outside building perimeter foundation as near as possible to electrical service entrance; where possible, locate in softscape (uncovered) area.
  6. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
  7. Ground Riser: Provide common grounding electrode conductor not less than 3/0 AWG for tap connections to multiple separately derived systems as permitted in NFPA 70.
- F. Service-Supplied System Grounding:
1. For each service disconnect, provide grounding electrode conductor to connect neutral (grounded) service conductor to grounding electrode system. Unless otherwise indicated, make connection at neutral (grounded) bus in service disconnect enclosure.
  2. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.
- G. Bonding and Equipment Grounding:
1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.

2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
  3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
  4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
  5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
  6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
  7. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
    - a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
    - b. Metal gas piping.
  8. Provide bonding for metal building frame.
- H. Communications Systems Grounding and Bonding:
1. Provide bonding jumper in raceway from intersystem bonding termination to each communications room or backboard and provide ground bar for termination.
    - a. Bonding Jumper Size: 6 AWG, unless otherwise indicated or required.
    - b. Raceway Size: 3/4 inch trade size unless otherwise indicated or required.
    - c. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
    - d. Ground Bar Mounting Height: 96 inches above finished floor unless otherwise indicated.
- I. Signal Reference Grids:
1. Provide signal reference grid on subfloor under access floors where indicated.
  2. Construct grid using field-welded sections of pre-fabricated signal reference grids.
  3. Unless otherwise indicated, make bonding connections to signal reference grid using exothermic welded connections.
  4. Make bonding connections as short as possible, with no sharp folds or bends.
  5. Unless otherwise indicated, provide separate bonding connections from signal reference grid to each item to be bonded. Do not daisy chain items together to facilitate single point connection to signal reference grid.
  6. Provide 6 AWG bonding jumper to connect every sixth access floor pedestal in each direction to signal reference grid. Make connections to floor pedestals using exothermic welded connections.
  7. Provide 6 AWG bonding jumper to connect each steel column within and at the perimeter of room to signal reference grid. Make connections to steel columns using exothermic welded connections.
  8. Provide 6 AWG bonding jumper to connect each metal item such as conduits, pipes, ducts, etc. crossing the plane of, or within 6 feet (1.8 m) of, the signal reference grid. Make connections to conduits and pipes using listed ground clamps.
  9. Provide 6 AWG bonding jumper to connect signal reference grid to grounding point of separately derived systems serving equipment located on the signal reference grid.
  10. Provide low impedance risers to connect each equipment enclosure to signal reference grid. For each piece of equipment, provide two separate connections of different lengths connected to opposite sides of equipment and to different points on the signal reference grid. Make connections to equipment enclosures using mechanical connectors. Do not make connection to signal reference grid on the outermost grid conductor.

## 2.02 GROUNDING AND BONDING COMPONENTS

- A. General Requirements:
1. Provide products listed, classified, and labeled as suitable for the purpose intended.
  2. Provide products listed and labeled as complying with UL 467 where applicable.
- B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 260526:

1. Use insulated copper conductors unless otherwise indicated.
  - a. Exceptions:
    - 1) Use bare copper conductors where installed underground in direct contact with earth.
    - 2) Use bare copper conductors where directly encased in concrete (not in raceway).
- C. Connectors for Grounding and Bonding:
  1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
  2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
  3. Unless otherwise indicated, use mechanical connectors, compression connectors, or exothermic welded connections for accessible connections.
  4. Manufacturers - Mechanical and Compression Connectors:
    - a. Advanced Lightning Technology (ALT): [www.altfab.com/#sle](http://www.altfab.com/#sle).
    - b. Burndy LLC: [www.burndy.com/#sle](http://www.burndy.com/#sle).
    - c. Harger Lightning & Grounding: [www.harger.com/#sle](http://www.harger.com/#sle).
    - d. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - e. Substitutions: See Section 016000 - Product Requirements.
  5. Manufacturers - Exothermic Welded Connections:
    - a. Burndy LLC: [www.burndy.com/#sle](http://www.burndy.com/#sle).
    - b. Cadweld, a brand of Erico International Corporation: [www.erico.com/#sle](http://www.erico.com/#sle).
    - c. thermOweld, subsidiary of Continental Industries; division of Burndy LLC: [www.thermoweld.com/#sle](http://www.thermoweld.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
- D. Ground Bars:
  1. Description: Copper rectangular ground bars with mounting brackets and insulators.
  2. Size: As indicated.
  3. Holes for Connections: As indicated or as required for connections to be made.
  4. Manufacturers:
    - a. Advanced Lightning Technology (ALT); [ ]: [www.altfab.com/#sle](http://www.altfab.com/#sle).
    - b. Erico International Corporation; [ ]: [www.erico.com/#sle](http://www.erico.com/#sle).
    - c. Harger Lightning & Grounding; [ ]: [www.harger.com/#sle](http://www.harger.com/#sle).
    - d. thermOweld, subsidiary of Continental Industries; division of Burndy LLC; [ ]: [www.thermoweld.com/#sle](http://www.thermoweld.com/#sle).
    - e. Substitutions: See Section 016000 - Product Requirements.
- E. Ground Rod Electrodes:
  1. Comply with NEMA GR 1.
  2. Material: Copper-bonded (copper-clad) steel.
  3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.
  4. Where rod lengths of greater than 10 feet are indicated or otherwise required, sectionalized ground rods may be used.
  5. Manufacturers:
    - a. Advanced Lightning Technology (ALT): [www.altfab.com/#sle](http://www.altfab.com/#sle).
    - b. Erico International Corporation: [www.erico.com/#sle](http://www.erico.com/#sle).
    - c. Galvan Industries, Inc: [www.galvanelectrical.com/#sle](http://www.galvanelectrical.com/#sle).
    - d. Harger Lightning & Grounding: [www.harger.com/#sle](http://www.harger.com/#sle).
    - e. Substitutions: See Section 016000 - Product Requirements.
- F. Pre-Fabricated Signal Reference Grids:
  1. Description: Factory pre-fabricated grid manufactured from 2 inch wide, 26 gauge, flat copper strips spaced on 24 inch centers, factory-welded at each crossover.
  2. Low Impedance Risers: Factory fabricated 2 inch wide, 26 gauge, flat copper strips designed for connecting equipment enclosures to pre-fabricated signal reference grid.
  3. Manufacturers:
    - a. Advanced Lightning Technology (ALT): [www.altfab.com/#sle](http://www.altfab.com/#sle).



- b. Erico International Corporation: [www.erico.com/#sle](http://www.erico.com/#sle).
- c. Harger Lightning & Grounding: [www.harger.com/#sle](http://www.harger.com/#sle).
- d. thermOweld, subsidiary of Continental Industries; division of Burndy LLC:  
[www.thermoweld.com/#sle](http://www.thermoweld.com/#sle).
- e. Substitutions: See Section 016000 - Product Requirements.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

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

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70 or provide ground plates.
  - 1. Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.
  - 2. Indoor Installations: Unless otherwise indicated, install with 4 inches of top of rod exposed.
- D. Make grounding and bonding connections using specified connectors.
  - 1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
  - 2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
  - 3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
  - 4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
  - 5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- E. Identify grounding and bonding system components in accordance with Section 260553.

### **3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.13.
- D. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- E. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.
- F. Submit detailed reports indicating inspection and testing results and corrective actions taken.

**END OF SECTION**

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## **SECTION 260529 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

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

#### **1.02 RELATED REQUIREMENTS**

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 055000 - Metal Fabrications : Materials and requirements for fabricated metal supports.
- C. Section 260533.13 - Conduit for Electrical Systems: Additional support and attachment requirements for conduits.
- D. Section 260533.16 - Boxes for Electrical Systems: Additional support and attachment requirements for boxes.
- E. Section 265100 - Interior Lighting: Additional support and attachment requirements for interior luminaires.
- F. Section 265600 - Exterior Lighting: Additional support and attachment requirements for exterior luminaires.

#### **1.03 REFERENCE STANDARDS**

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware 2016a.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel 2019.
- D. MFMA-4 - Metal Framing Standards Publication 2004.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- F. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
  - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
  - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
  - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
  - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, non-penetrating rooftop supports, and post-installed concrete and masonry anchors.

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- C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with NFPA 70.
- B. Comply with applicable building code.
- C. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

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

### **PART 2 PRODUCTS**

#### **2.01 SUPPORT AND ATTACHMENT COMPONENTS**

- A. General Requirements:
  1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
  2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
  3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of [\_\_\_\_]. Include consideration for vibration, equipment operation, and shock loads where applicable.
  4. Do not use products for applications other than as permitted by NFPA 70 and product listing.
  5. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
  6. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
    - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
    - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
    - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
    - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Materials for Metal Fabricated Supports: Comply with Section 055000.
- C. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
  1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
  2. Conduit Clamps: Bolted type unless otherwise indicated.
  3. Manufacturers:
    - a. Cooper Crouse-Hinds, a division of Eaton Corporation: [www.cooperindustries.com/#sle](http://www.cooperindustries.com/#sle).
    - b. Erico International Corporation: [www.erico.com/#sle](http://www.erico.com/#sle).
    - c. HoldRite, a brand of Reliance Worldwide Corporation: [www.holdrite.com/#sle](http://www.holdrite.com/#sle).
    - d. O-Z/Gedney, a brand of Emerson Electric Co: [www.emerson.com/#sle](http://www.emerson.com/#sle).
    - e. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - f. Substitutions: See Section 016000 - Product Requirements.
- D. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.
  1. Manufacturers:
    - a. Cooper Crouse-Hinds, a division of Eaton Corporation: [www.cooperindustries.com/#sle](http://www.cooperindustries.com/#sle).
    - b. Erico International Corporation: [www.erico.com/#sle](http://www.erico.com/#sle).
    - c. HoldRite, a brand of Reliance Worldwide Corporation: [www.holdrite.com/#sle](http://www.holdrite.com/#sle).

- d. O-Z/Gedney, a brand of Emerson Electric Co: [www.emerson.com/#sle](http://www.emerson.com/#sle).
  - e. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
  - f. Substitutions: See Section 016000 - Product Requirements.
- E. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
  - 1. Comply with MFMA-4.
  - 2. Channel Material:
    - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
    - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
  - 3. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch.
  - 4. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.
  - 5. Manufacturers:
    - a. Cooper B-Line, a division of Eaton Corporation: [www.cooperindustries.com/#sle](http://www.cooperindustries.com/#sle).
    - b. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - c. Unistrut, a brand of Atkore International Inc: [www.unistrut.com/#sle](http://www.unistrut.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
- F. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
  - 1. Minimum Size, Unless Otherwise Indicated or Required:
    - a. Equipment Supports: 1/2 inch diameter.
    - b. Single Conduit up to 1 inch (27 mm) trade size: 1/4 inch diameter.
    - c. Single Conduit larger than 1 inch (27 mm) trade size: 3/8 inch diameter.
    - d. Trapeze Support for Multiple Conduits: 3/8 inch diameter.
    - e. Outlet Boxes: 1/4 inch diameter.
    - f. Luminaires: 1/4 inch diameter.
- G. Non-Penetrating Rooftop Supports for Low-Slope Roofs: Steel pedestals with thermoplastic or rubber bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified.
  - 1. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
  - 2. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.
  - 3. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.
  - 4. Manufacturers:
    - a. Cooper B-Line, a division of Eaton Corporation: [www.cooperindustries.com/#sle](http://www.cooperindustries.com/#sle).
    - b. Erico International Corporation: [www.erico.com/#sle](http://www.erico.com/#sle).
    - c. PHP Systems/Design: [www.phpsd.com/#sle](http://www.phpsd.com/#sle).
    - d. Unistrut, a brand of Atkore International Inc: [www.unistrut.com/#sle](http://www.unistrut.com/#sle).
- H. Anchors and Fasteners:
  - 1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
  - 2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
  - 3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
  - 4. Hollow Masonry: Use toggle bolts.
  - 5. Hollow Stud Walls: Use toggle bolts.
  - 6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
  - 7. Sheet Metal: Use sheet metal screws.
  - 8. Wood: Use wood screws.
  - 9. Plastic and lead anchors are not permitted.
  - 10. Powder-actuated fasteners are not permitted.
  - 11. Hammer-driven anchors and fasteners are not permitted.
  - 12. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
    - a. Comply with MFMA-4.

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- b. Channel Material: Use galvanized steel.
- c. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch minimum base metal thickness.
- d. Manufacturer: Same as manufacturer of metal channel (strut) framing system.
- 13. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) for compliance with applicable building code.
- 14. Manufacturers - Mechanical Anchors:
  - a. Hilti, Inc: [www.us.hilti.com/#sle](http://www.us.hilti.com/#sle).
  - b. ITW Red Head, a division of Illinois Tool Works, Inc: [www.itwredhead.com/#sle](http://www.itwredhead.com/#sle).
  - c. Powers Fasteners, Inc: [www.powers.com/#sle](http://www.powers.com/#sle).
  - d. Simpson Strong-Tie Company Inc: [www.strongtie.com/#sle](http://www.strongtie.com/#sle).
  - e. Substitutions: See Section 016000 - Product Requirements.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

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

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- D. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- E. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- F. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- G. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- H. Equipment Support and Attachment:
  - 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
  - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
  - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
  - 4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 3 inch high concrete pad constructed in accordance with Section 033000.
  - 5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- I. Conduit Support and Attachment: Also comply with Section 260533.13.
- J. Box Support and Attachment: Also comply with Section 260533.16.
- K. Interior Luminaire Support and Attachment: Also comply with Section 265100.
- L. Exterior Luminaire Support and Attachment: Also comply with Section 265600.
- M. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
- N. Secure fasteners according to manufacturer's recommended torque settings.
- O. Remove temporary supports.

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### **3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

**END OF SECTION**

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**SECTION 260533.13**  
**CONDUIT FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Galvanized steel rigid metal conduit (RMC).
- B. Intermediate metal conduit (IMC).
- C. Flexible metal conduit (FMC).
- D. Liquidtight flexible metal conduit (LFMC).
- E. Electrical metallic tubing (EMT).
- F. Rigid polyvinyl chloride (PVC) conduit.
- G. Liquidtight flexible nonmetallic conduit (LFNC).
- H. Conduit fittings.
- I. Accessories.

**1.02 RELATED REQUIREMENTS**

- A. Section 033000 - Cast-in-Place Concrete: Concrete encasement of conduits.
- B. Section 078400 - Firestopping.
- C. Section 260526 - Grounding and Bonding for Electrical Systems.
  - 1. Includes additional requirements for fittings for grounding and bonding.
- D. Section 260529 - Hangers and Supports for Electrical Systems.
- E. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 262100 - Low-Voltage Electrical Service Entrance: Additional requirements for electrical service conduits.
- G. Section 271000 - Structured Cabling: Additional requirements for communications systems conduits.
- H. Section 312316 - Excavation.
- I. Section 312323 - Fill: Bedding and backfilling.

**1.03 REFERENCE STANDARDS**

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC) 2015.
- B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S) 2015.
- C. ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit (EIMC) 2018.
- D. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- E. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT) 2013.
- F. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC) 2017.
- G. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable 2014.
- H. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit 2020.
- I. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing 2016.
- J. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- K. UL 1 - Flexible Metal Conduit Current Edition, Including All Revisions.
- L. UL 6 - Electrical Rigid Metal Conduit-Steel Current Edition, Including All Revisions.
- M. UL 360 - Liquid-Tight Flexible Steel Conduit Current Edition, Including All Revisions.

- N. UL 514B - Conduit, Tubing, and Cable Fittings Current Edition, Including All Revisions.
- O. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings Current Edition, Including All Revisions.
- P. UL 797 - Electrical Metallic Tubing-Steel Current Edition, Including All Revisions.
- Q. UL 1242 - Electrical Intermediate Metal Conduit-Steel Current Edition, Including All Revisions.
- R. UL 1660 - Liquid-Tight Flexible Nonmetallic Conduit Current Edition, Including All Revisions.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

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

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conduits and fittings.
- C. Project Record Documents: Record actual routing for conduits installed underground, conduits embedded within concrete slabs, and conduits 2 inch (53 mm) trade size and larger.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

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

### **PART 2 PRODUCTS**

#### **2.01 CONDUIT APPLICATIONS**

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70 and product listing.
- B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
  - 1. Under Slab on Grade: Use rigid PVC conduit.
  - 2. Exterior, Direct-Buried: Use galvanized steel rigid metal conduit or rigid PVC conduit.
  - 3. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from underground.
- D. Embedded Within Concrete:
  - 1. Within Slab on Grade: Use galvanized steel rigid metal conduit.

2. Within Slab Above Ground: Use galvanized steel rigid metal conduit.
3. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from concrete.
- E. Concealed Within Hollow Stud Walls: Use electrical metallic tubing (EMT).
- F. Concealed Above Accessible Ceilings: Use electrical metallic tubing (EMT).
- G. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit.
- H. Exposed, Interior, Not Subject to Physical Damage: Use intermediate metal conduit (IMC) or electrical metallic tubing (EMT).
- I. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit.
  1. Locations subject to physical damage include, but are not limited to:
    - a. Where exposed below 8 feet, except within electrical and communication rooms or closets.
- J. Exposed, Exterior: Use galvanized steel rigid metal conduit.
- K. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use galvanized steel rigid metal conduit.
- L. Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit.
  1. Maximum Length: 6 feet.
- M. Connections to Vibrating Equipment:
  1. Dry Locations: Use flexible metal conduit.
  2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
  3. Maximum Length: 6 feet unless otherwise indicated.
  4. Vibrating equipment includes, but is not limited to:
- N. Fished in Existing Walls, Where Necessary: Use flexible metal conduit.

## 2.02 CONDUIT REQUIREMENTS

- A. Electrical Service Conduits: Also comply with Section 262100.
- B. Communications Systems Conduits: Also comply with Section 271000.
- C. Fittings for Grounding and Bonding: Also comply with Section 260526.
- D. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.
- E. Provide products listed, classified, and labeled as suitable for the purpose intended.
- F. Minimum Conduit Size, Unless Otherwise Indicated:
  1. Branch Circuit Homeruns: 3/4 inch (21 mm) trade size.
  2. Underground, Interior: 3/4 inch (21 mm) trade size.
  3. Underground, Exterior: 1 inch (27 mm) trade size.
- G. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

## 2.03 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- A. Manufacturers:
  1. Allied Tube & Conduit, a division of Atkore International: [www.alliedeg.com/#sle](http://www.alliedeg.com/#sle).
  2. Nucor Tubular Products: [www.nucortubular.com/#sle](http://www.nucortubular.com/#sle).
  3. Western Tube, a division of Zekelman Industries: [www.westerntube.com/#sle](http://www.westerntube.com/#sle).
  4. Wheatland Tube, a division of Zekelman Industries: [www.wheatland.com/#sle](http://www.wheatland.com/#sle).
  5. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- C. Fittings:
  1. Manufacturers:
    - a. Bridgeport Fittings Inc: [www.bptfittings.com/#sle](http://www.bptfittings.com/#sle).
    - b. O-Z/Gedney, a brand of Emerson Electric Co: [www.emerson.com/#sle](http://www.emerson.com/#sle).
    - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.

2. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
3. Material: Use steel or malleable iron.
4. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

#### **2.04 INTERMEDIATE METAL CONDUIT (IMC)**

- A. Manufacturers:
  1. Allied Tube & Conduit, a division of Atkore International: [www.alliedeg.com/#sle](http://www.alliedeg.com/#sle).
  2. Nucor Tubular Products: [www.nucortubular.com/#sle](http://www.nucortubular.com/#sle).
  3. Western Tube, a division of Zekelman Industries: [www.westerntube.com/#sle](http://www.westerntube.com/#sle).
  4. Wheatland Tube, a division of Zekelman Industries: [www.wheatland.com/#sle](http://www.wheatland.com/#sle).
  5. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- C. Fittings:
  1. Manufacturers:
    - a. Bridgeport Fittings Inc: [www.bptfittings.com/#sle](http://www.bptfittings.com/#sle).
    - b. O-Z/Gedney, a brand of Emerson Electric Co: [www.emerson.com/#sle](http://www.emerson.com/#sle).
    - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
  2. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  3. Material: Use steel or malleable iron.
  4. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

#### **2.05 FLEXIBLE METAL CONDUIT (FMC)**

- A. Manufacturers:
  1. AFC Cable Systems, Inc: [www.afcweb.com/#sle](http://www.afcweb.com/#sle).
  2. Electri-Flex Company: [www.electriflex.com/#sle](http://www.electriflex.com/#sle).
  3. International Metal Hose: [www.metalhose.com/#sle](http://www.metalhose.com/#sle).
  4. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type FMC standard wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.
- C. Fittings:
  1. Manufacturers:
    - a. Bridgeport Fittings Inc: [www.bptfittings.com/#sle](http://www.bptfittings.com/#sle).
    - b. O-Z/Gedney, a brand of Emerson Electric Co: [www.emerson.com/#sle](http://www.emerson.com/#sle).
    - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
  2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  3. Material: Use steel or malleable iron.

#### **2.06 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)**

- A. Manufacturers:
  1. AFC Cable Systems, Inc: [www.afcweb.com/#sle](http://www.afcweb.com/#sle).
  2. Electri-Flex Company: [www.electriflex.com/#sle](http://www.electriflex.com/#sle).
  3. International Metal Hose: [www.metalhose.com/#sle](http://www.metalhose.com/#sle).
- B. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.
- C. Fittings:
  1. Manufacturers:
    - a. Bridgeport Fittings Inc: [www.bptfittings.com/#sle](http://www.bptfittings.com/#sle).
    - b. O-Z/Gedney, a brand of Emerson Electric Co: [www.emerson.com/#sle](http://www.emerson.com/#sle).
    - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).

- d. Substitutions: See Section 016000 - Product Requirements.
- 2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
- 3. Material: Use steel or malleable iron.

## **2.07 ELECTRICAL METALLIC TUBING (EMT)**

- A. Manufacturers:
  - 1. Allied Tube & Conduit, a division of Atkore International: [www.alliedeg.com/#sle](http://www.alliedeg.com/#sle).
  - 2. Nucor Tubular Products: [www.nucortubular/#sle](http://www.nucortubular/#sle).
  - 3. Western Tube, a division of Zekelman Industries: [www.westerntube.com/#sle](http://www.westerntube.com/#sle).
  - 4. Wheatland Tube, a division of Zekelman Industries: [www.wheatland.com/#sle](http://www.wheatland.com/#sle).
  - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- C. Fittings:
  - 1. Manufacturers:
    - a. Bridgeport Fittings Inc: [www.bptfittings.com/#sle](http://www.bptfittings.com/#sle).
    - b. O-Z/Gedney, a brand of Emerson Electric Co: [www.emerson.com/#sle](http://www.emerson.com/#sle).
    - c. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
  - 2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 3. Material: Use steel or malleable iron.
  - 4. Connectors and Couplings: Use compression (gland) type.
    - a. Do not use indenter type connectors and couplings.
    - b. Do not use set-screw type connectors and couplings.

## **2.08 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT**

- A. Manufacturers:
  - 1. Cantex Inc: [www.cantexinc.com/#sle](http://www.cantexinc.com/#sle).
  - 2. Carlon, a brand of Thomas & Betts Corporation: [www.carlon.com/#sle](http://www.carlon.com/#sle).
  - 3. JM Eagle: [www.jmeagle.com/#sle](http://www.jmeagle.com/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.
- C. Fittings:
  - 1. Manufacturer: Same as manufacturer of conduit to be connected.
  - 2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

## **2.09 LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC)**

- A. Manufacturers:
  - 1. AFC Cable Systems, Inc: [www.afcweb.com/#sle](http://www.afcweb.com/#sle).
  - 2. Electri-Flex Company: [www.electriflex.com/#sle](http://www.electriflex.com/#sle).
  - 3. International Metal Hose: [www.metalhose.com/#sle](http://www.metalhose.com/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type LFNC liquidtight flexible nonmetallic conduit listed and labeled as complying with UL 1660.
- C. Fittings:
  - 1. Manufacturer: Same as manufacturer of conduit to be connected.
  - 2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B; suitable for the type of conduit to be connected.

## **2.10 ACCESSORIES**

- A. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.
- B. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- C. Epoxy Adhesive for RTRC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- D. Pull Strings: Use nylon cord with average breaking strength of not less than 200 pound-force.
- E. Sealing Compound for Sealing Fittings: Listed for use with the particular fittings to be installed.
- F. Modular Seals for Conduit Penetrations: Rated for minimum of 40 psig; Suitable for the conduits to be installed.
- G. Sealing Systems for Roof Penetrations: Premanufactured components and accessories as required to preserve integrity of roofing system and maintain roof warranty; suitable for conduits and roofing system to be installed; designed to accommodate existing penetrations where applicable.
  - 1. Products:
    - a. Menzies Metal Products; Electrical Roof Stack and Cap: [www.menzies-metal.com/#sle](http://www.menzies-metal.com/#sle).
    - b. Menzies Metal Products; Electrical Retro Box: [www.menzies-metal.com/#sle](http://www.menzies-metal.com/#sle).
    - c. Substitutions: See Section 016000 - Product Requirements.
- H. Flashing Panels for Exterior Wall Penetrations: Premanufactured components and accessories as required to preserve integrity of building envelope; suitable for conduits and facade materials to be installed.
  - 1. Manufacturers:
    - a. Quickflash Weatherproofing Products, Inc: [www.quickflashproducts.com/#sle](http://www.quickflashproducts.com/#sle).
    - b. Substitutions: See Section 016000 - Product Requirements.
- I. Firestop Sleeves: Listed; provide as required to preserve fire resistance rating of building elements.
  - 1. Products:
    - a. HoldRite, a brand of Reliance Worldwide Corporation; HydroFlame Pro Series/HydroFlame Custom Built: [www.holdrite.com/#sle](http://www.holdrite.com/#sle).
    - b. Substitutions: See Section 016000 - Product Requirements.
- J. Duct Bank Spacers: Nonmetallic; designed for maintaining conduit/duct spacing for concrete encasement in open trench installation; suitable for the conduit/duct arrangement to be installed.
  - 1. Products:
    - a. Advance Products & Systems, LLC; Duct Bank Spacers: [www.apsonline.com/#sle](http://www.apsonline.com/#sle).
    - b. Substitutions: See Section 016000 - Product Requirements.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

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

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.
- D. Install intermediate metal conduit (IMC) in accordance with NECA 101.

- E. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
- F. Install liquidtight flexible nonmetallic conduit (LFNC) in accordance with NECA 111.
- G. Conduit Routing:
  - 1. Unless dimensioned, conduit routing indicated is diagrammatic.
  - 2. When conduit destination is indicated without specific routing, determine exact routing required.
  - 3. Conceal all conduits unless specifically indicated to be exposed.
  - 4. Conduits in the following areas may be exposed, unless otherwise indicated:
    - a. Electrical rooms.
    - b. Mechanical equipment rooms.
    - c. Within joists in areas with no ceiling.
  - 5. Unless otherwise approved, do not route conduits exposed:
    - a. Across floors.
    - b. Across roofs.
    - c. Across top of parapet walls.
    - d. Across building exterior surfaces.
  - 6. Conduits installed underground or embedded in concrete may be routed in the shortest possible manner unless otherwise indicated. Route all other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
  - 7. Arrange conduit to maintain adequate headroom, clearances, and access.
  - 8. Arrange conduit to provide no more than the equivalent of four 90 degree bends between pull points.
  - 9. Arrange conduit to provide no more than 150 feet between pull points.
  - 10. Route conduits above water and drain piping where possible.
  - 11. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
  - 12. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
  - 13. Maintain minimum clearance of 12 inches between conduits and hot surfaces. This includes, but is not limited to:
    - a. Heaters.
    - b. Hot water piping.
    - c. Flues.
  - 14. Group parallel conduits in the same area together on a common rack.
- H. Conduit Support:
  - 1. Secure and support conduits in accordance with NFPA 70 and Section 260529 using suitable supports and methods approved by the authority having jurisdiction.
  - 2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
  - 3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
  - 4. Use conduit strap to support single surface-mounted conduit.
    - a. Use clamp back spacer with conduit strap for damp and wet locations to provide space between conduit and mounting surface.
  - 5. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
  - 6. Use conduit clamp to support single conduit from beam clamp or threaded rod.
  - 7. Use non-penetrating rooftop supports to support conduits routed across rooftops (only where approved).
  - 8. Use of spring steel conduit clips for support of conduits is permitted only as follows:
    - a. Support of electrical metallic tubing (EMT) up to 1 inch (27 mm) trade size concealed above accessible ceilings and within hollow stud walls.
  - 9. Use of wire for support of conduits is not permitted.
- I. Connections and Terminations:

1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
  2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
  3. Use suitable adapters where required to transition from one type of conduit to another.
  4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
  5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
  6. Where spare conduits stub up through concrete floors and are not terminated in a box or enclosure, provide threaded couplings equipped with threaded plugs set flush with finished floor.
  7. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.
  8. Secure joints and connections to provide maximum mechanical strength and electrical continuity.
- J. Penetrations:
1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
  2. Make penetrations perpendicular to surfaces unless otherwise indicated.
  3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
  4. Conceal bends for conduit risers emerging above ground.
  5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.
  6. Provide suitable modular seal where conduits penetrate exterior wall below grade.
  7. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
  8. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.
  9. Provide metal escutcheon plates for conduit penetrations exposed to public view.
  10. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- K. Underground Installation:
1. Provide trenching and backfilling in accordance with Section 312316 and Section 312323.
  2. Minimum Cover, Unless Otherwise Indicated or Required:
    - a. Underground, Exterior: 24 inches.
    - b. Under Slab on Grade: 12 inches to bottom of slab.
  3. Provide underground warning tape in accordance with Section 260553 along entire conduit length for service entrance where not concrete-encased.
- L. Concrete Encasement: Where conduits not otherwise embedded within concrete are indicated to be concrete-encased, provide concrete in accordance with Section 033000 with minimum concrete cover of 3 inches on all sides unless otherwise indicated.
- M. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
  2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
  3. Where conduits are subject to earth movement by settlement or frost.
- N. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at



an accessible point near the penetration to prevent condensation. This includes, but is not limited to:

1. Where conduits pass from outdoors into conditioned interior spaces.
  2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.
- O. Provide pull string in all empty conduits and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.
- P. Provide grounding and bonding in accordance with Section 260526.
- Q. Identify conduits in accordance with Section 260553.

### **3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- C. Correct deficiencies and replace damaged or defective conduits.

### **3.04 CLEANING**

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

### **3.05 PROTECTION**

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

**END OF SECTION**

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**SECTION 260533.16**  
**BOXES FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
- C. Boxes and enclosures for integrated power, data, and audio/video.
- D. Floor boxes.
- E. Underground boxes/enclosures.
- F. Accessories.

**1.02 RELATED REQUIREMENTS**

- A. Section 033000 - Cast-in-Place Concrete.
- B. Section 083100 - Access Doors and Panels: Panels for maintaining access to concealed boxes.
- C. Section 260529 - Hangers and Supports for Electrical Systems.
- D. Section 260533.13 - Conduit for Electrical Systems:
  - 1. Conduit bodies and other fittings.
  - 2. Additional requirements for locating boxes to limit conduit length and/or number of bends between pulling points.
- E. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 262726 - Wiring Devices:
  - 1. Wall plates.
  - 2. Floor box service fittings.
  - 3. Additional requirements for locating boxes for wiring devices.
- G. Section 271000 - Structured Cabling: Additional requirements for communications systems outlet boxes.

**1.03 REFERENCE STANDARDS**

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2010.
- C. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable 2014.
- D. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports 2013.
- E. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports 2013.
- F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- G. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. SCTE 77 - Specification for Underground Enclosure Integrity 2017.
- I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- K. UL 508A - UL Standard for Safety Industrial Control Panels 2018.
- L. UL 514A - Metallic Outlet Boxes Current Edition, Including All Revisions.
- M. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers Current Edition, Including All Revisions.

#### 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
  - 4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
  - 5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
  - 6. Coordinate the work with other trades to preserve insulation integrity.
  - 7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
  - 8. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

#### 1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cabinets and enclosures, boxes for hazardous (classified) locations, floor boxes, and underground boxes/enclosures.
  - 1. Underground Boxes/Enclosures: Include reports for load testing in accordance with SCTE 77 certified by a professional engineer or an independent testing agency upon request.
- C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  - 1. See Section 016000 - Product Requirements, for additional provisions.
  - 2. Keys for Lockable Enclosures: Two of each different key.

#### 1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

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

### PART 2 PRODUCTS

#### 2.01 BOXES

- A. General Requirements:
  - 1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
  - 2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
  - 3. Provide products listed, classified, and labeled as suitable for the purpose intended.
  - 4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
  - 5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:

1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
3. Use cast iron boxes or cast aluminum boxes where exposed galvanized steel rigid metal conduit or exposed intermediate metal conduit (IMC) is used.
4. Use nonmetallic boxes where exposed rigid PVC conduit is used.
5. Use suitable concrete type boxes where flush-mounted in concrete.
6. Use suitable masonry type boxes where flush-mounted in masonry walls.
7. Use raised covers suitable for the type of wall construction and device configuration where required.
8. Use shallow boxes where required by the type of wall construction.
9. Do not use "through-wall" boxes designed for access from both sides of wall.
10. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
11. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
12. Nonmetallic Boxes: Comply with NEMA OS 2, and list and label as complying with UL 514C.
13. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
14. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
15. Minimum Box Size, Unless Otherwise Indicated:
  - a. Wiring Devices (Other Than Communications Systems Outlets): 4 inch square by 1-1/2 inch deep (100 by 38 mm) trade size.
  - b. Communications Systems Outlets: Comply with Section 271000.
  - c. Ceiling Outlets: 4 inch octagonal or square by 1-1/2 inch deep (100 by 38 mm) trade size.
16. Wall Plates: Comply with Section 262726.
17. Manufacturers:
  - a. Cooper Crouse-Hinds, a division of Eaton Corporation: [www.cooperindustries.com/#sle](http://www.cooperindustries.com/#sle).
  - b. Hubbell Incorporated; Bell Products: [www.hubbell-rtb.com/#sle](http://www.hubbell-rtb.com/#sle).
  - c. Hubbell Incorporated; RACO Products: [www.hubbell-rtb.com/#sle](http://www.hubbell-rtb.com/#sle).
  - d. O-Z/Gedney, a brand of Emerson Electric Co: [www.emerson.com/#sle](http://www.emerson.com/#sle).
  - e. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
  - f. Substitutions: See Section 016000 - Product Requirements.
- C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
  1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
  2. NEMA 250 Environment Type, Unless Otherwise Indicated:
    - a. Indoor Clean, Dry Locations: Type 1, painted steel.
  3. Junction and Pull Boxes Larger Than 100 cubic inches:
    - a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
    - b. Boxes 6 square feet and Larger: Provide hinged-cover enclosures.
  4. Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes:
    - a. Provide lockable hinged covers, all locks keyed alike unless otherwise indicated.
    - b. Terminal Blocks: Provide voltage/current ratings and terminal quantity suitable for purpose indicated, with 25 percent spare terminal capacity.
  5. Finish for Painted Steel Enclosures: Manufacturer's standard grey unless otherwise indicated.
  6. Manufacturers:
    - a. Cooper B-Line, a division of Eaton Corporation: [www.cooperindustries.com/#sle](http://www.cooperindustries.com/#sle).
    - b. Hoffman, a brand of Pentair Technical Products: [www.hoffmanonline.com/#sle](http://www.hoffmanonline.com/#sle).
    - c. Hubbell Incorporated; Wiegmann Products: [www.hubbell-wiegmann.com/#sle](http://www.hubbell-wiegmann.com/#sle).

- d. Substitutions: See Section 016000 - Product Requirements.
- D. Boxes and Enclosures for Integrated Power, Data, and Audio/Video: Size and configuration as indicated or as required with partitions to separate services; field-connected gangable boxes may be used.
  - 1. Manufacturers:
    - a. Hubbell Incorporated: [www.hubbell.com/#sle](http://www.hubbell.com/#sle).
    - b. Substitutions: See Section 016000 - Product Requirements.
- E. Floor Boxes:
  - 1. Description: Floor boxes compatible with floor box service fittings provided in accordance with Section 262726; with partitions to separate multiple services; furnished with all components, adapters, and trims required for complete installation.
  - 2. Use cast iron floor boxes within slab on grade.
  - 3. Metallic Floor Boxes: Fully adjustable (with integral means for leveling adjustment prior to and after concrete pour).
  - 4. Manufacturer: Same as manufacturer of floor box service fittings.
- F. Underground Boxes/Enclosures:
  - 1. Description: In-ground, solid bottom boxes furnished with flush, non-skid covers with legend indicating type of service and stainless steel tamper resistant cover bolts.
  - 2. Size: As indicated on drawings.
  - 3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 12 inches.
  - 4. Provide logo on cover to indicate type of service.
  - 5. Applications:
    - a. Sidewalks and Landscaped Areas Subject Only to Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77 Tier 8 load rating.
    - b. Parking Lots, in Areas Subject Only To Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77 Tier 15 load rating.
    - c. Do not use polymer concrete enclosures in areas subject to deliberate vehicular traffic.
  - 6. Polymer Concrete Underground Boxes/Enclosures: Comply with SCTE 77.
    - a. Manufacturers:
      - 1) Hubbell Incorporated; Quazite Products: [www.hubbellpowersystems.com/#sle](http://www.hubbellpowersystems.com/#sle).
      - 2) MacLean Highline: [www.macleanhigline.com/#sle](http://www.macleanhigline.com/#sle).
      - 3) Oldcastle Precast, Inc: [www.oldcastleprecast.com/#sle](http://www.oldcastleprecast.com/#sle).
      - 4) Substitutions: See Section 016000 - Product Requirements.
    - b. Combination fiberglass/polymer concrete boxes/enclosures are acceptable.
    - c. Product(s):
      - 1) MacLean Highline PHA Series: Straight wall, all-polymer concrete splice box/pull box; available Tier 8, Tier 15, and Tier 22 load ratings.
      - 2) MacLean Highline CHA Series: Fiberglass/polymer concrete splice box/pull box; available Tier 8 and Tier 15 load ratings.
      - 3) MacLean Highline CVA Series: Fiberglass/polymer concrete splice vault; available Tier 8, Tier 15, and Tier 22 load ratings.

## 2.02 ACCESSORIES

- A. Flashing Panels for Exterior Wall Penetrations: Premanufactured components and accessories as required to preserve integrity of building envelope; suitable for boxes and facade materials to be installed.
  - 1. Manufacturers:
    - a. Quickflash Weatherproofing Products, Inc: [www.quickflashproducts.com/#sle](http://www.quickflashproducts.com/#sle).
    - b. Substitutions: See Section 016000 - Product Requirements.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

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

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.
- E. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.
- F. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.
- G. Box Locations:
  - 1. Locate boxes to be accessible. Provide access panels in accordance with Section 083100 as required where approved by the Architect.
  - 2. Unless dimensioned, box locations indicated are approximate.
  - 3. Locate boxes as required for devices installed under other sections or by others.
    - a. Switches, Receptacles, and Other Wiring Devices: Comply with Section 262726.
    - b. Communications Systems Outlets: Comply with Section 271000.
  - 4. Locate boxes so that wall plates do not span different building finishes.
  - 5. Locate boxes so that wall plates do not cross masonry joints.
  - 6. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
  - 7. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
  - 8. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
    - a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
    - b. Do not install flush-mounted boxes with area larger than 16 square inches or such that the total aggregate area of openings exceeds 100 square inches for any 100 square feet of wall area.
  - 9. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 260533.13.
  - 10. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect:
    - a. Concealed above accessible suspended ceilings.
    - b. Within joists in areas with no ceiling.
    - c. Electrical rooms.
    - d. Mechanical equipment rooms.
- H. Box Supports:
  - 1. Secure and support boxes in accordance with NFPA 70 and Section 260529 using suitable supports and methods approved by the authority having jurisdiction.
  - 2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.

- 3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
- I. Install boxes plumb and level.
- J. Flush-Mounted Boxes:
  - 1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
  - 2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
  - 3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.
- K. Floor-Mounted Cabinets: Mount on properly sized 3 inch high concrete pad constructed in accordance with Section 033000.
- L. Install boxes as required to preserve insulation integrity.
- M. Metallic Floor Boxes: Install box level at the proper elevation to be flush with finished floor.
- N. Underground Boxes/Enclosures:
  - 1. Install enclosure on gravel base, minimum 6 inches deep.
  - 2. Flush-mount enclosures located in concrete or paved areas.
  - 3. Mount enclosures located in landscaped areas with top at 1 inch above finished grade.
  - 4. Provide cast-in-place concrete collar constructed in accordance with Section 033000, minimum 10 inches wide by 12 inches deep, around enclosures that are not located in concrete areas.
  - 5. Install additional bracing inside enclosures in accordance with manufacturer's instructions to minimize box sidewall deflections during backfilling. Backfill with cover bolted in place.
- O. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- P. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- Q. Close unused box openings.
- R. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- S. Provide grounding and bonding in accordance with Section 260526.
- T. Identify boxes in accordance with Section 260553.

### 3.03 CLEANING

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

### 3.04 PROTECTION

- A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

**END OF SECTION**



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## **SECTION 260533.23 SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Surface raceway systems.
- B. Wireways.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260529 - Hangers and Supports for Electrical Systems.
- C. Section 260533.13 - Conduit for Electrical Systems.
- D. Section 260533.16 - Boxes for Electrical Systems.
- E. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 262726 - Wiring Devices: Receptacles.

#### **1.03 REFERENCE STANDARDS**

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- D. UL 5 - Surface Metal Raceways and Fittings Current Edition, Including All Revisions.
- E. UL 111 - Outline of Investigation for Multioutlet Assemblies Current Edition, Including All Revisions.
- F. UL 870 - Wireways, Auxiliary Gutters, and Associated Fittings Current Edition, Including All Revisions.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the placement of raceways with millwork, furniture, equipment, etc. installed under other sections or by others.
  - 2. Coordinate rough-in locations of outlet boxes provided under Section 260533.16 and conduit provided under Section 260533.13 as required for installation of raceways provided under this section.
  - 3. Verify minimum sizes of raceways with the actual conductors and components to be installed.
  - 4. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install raceways until final surface finishes and painting are complete.
  - 2. Do not begin installation of conductors and cables until installation of raceways is complete between outlet, junction and splicing points.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets including dimensions, knockout sizes and locations, materials, fabrication details, finishes, service condition requirements, and accessories.
  - 1. Surface Raceway Systems: Include information on fill capacities for conductors and cables.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

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## 1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

## 1.07 DELIVERY, STORAGE, AND HANDLING

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

## PART 2 PRODUCTS

### 2.01 RACEWAY REQUIREMENTS

- A. Provide all components, fittings, supports, and accessories required for a complete raceway system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Do not use raceways for applications other than as permitted by NFPA 70 and product listing.

### 2.02 SURFACE RACEWAY SYSTEMS

- A. Manufacturers:
  - 1. Hubbell Incorporated: [www.hubbell.com/#sle](http://www.hubbell.com/#sle).
  - 2. MonoSystems, Inc: [www.monosystems.com/#sle](http://www.monosystems.com/#sle).
  - 3. Wiremold, a brand of Legrand North America, Inc: [www.legrand.us/#sle](http://www.legrand.us/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Surface Metal Raceways: Listed and labeled as complying with UL 5.
- C. Multioutlet Assemblies: Listed and labeled as complying with UL 111.
- D. Type [ ] - Surface Raceway System:
  - 1. Raceway Type: Single channel, painted steel.
  - 2. Size: [ ] by [ ] inches.
  - 3. Color: White.
  - 4. Accessory Device Boxes: Suitable for the devices to be installed; color to match raceway.
  - 5. Integrated Device Provisions:
    - a. Receptacles:
      - 1) Comply with Section 262726, except for finishes.
      - 2) Configuration: As indicated on the drawings.
      - 3) Color: Match raceway.
      - 4) Spacing: As indicated on the drawings.
    - b. Communications Outlets:
      - 1) Voice and Data Jacks: As specified in Section 271000.
  - 6. Products:
    - a. Hubbell Incorporated; [ ]: [www.hubbell.com/#sle](http://www.hubbell.com/#sle).
    - b. Substitutions: See Section 016000 - Product Requirements.

### 2.03 WIREWAYS

- A. Manufacturers:
  - 1. Cooper B-Line, a division of Cooper Industries: [www.cooperindustries.com/#sle](http://www.cooperindustries.com/#sle).
  - 2. Enduro Composites: [www.endurocomposites.com/#sle](http://www.endurocomposites.com/#sle).
  - 3. Hoffman, a brand of Pentair Technical Products: [www.hoffmanonline.com/#sle](http://www.hoffmanonline.com/#sle).
  - 4. Schneider Electric; Square D Products: [www.schneider-electric.us/#sle](http://www.schneider-electric.us/#sle).
  - 5. Substitutions: See Section 016000 - Product Requirements.

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- B. Description: Lay-in wireways and wiring troughs with removable covers; listed and labeled as complying with UL 870.
- C. Wireway Type, Unless Otherwise Indicated:
  - 1. Indoor Clean, Dry Locations: NEMA 250, Type 1, painted steel with screw-cover.
  - 2. Outdoor Locations: NEMA 250, Type 3R, painted steel with screw-cover; include provision for padlocking.
- D. Finish for Painted Steel Wireways: Manufacturer's standard grey unless otherwise indicated.
- E. Minimum Wireway Size: 4 by 4 inches unless otherwise indicated.
- F. Where wireway size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

#### **2.04 SOURCE QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes and conduit terminations are installed in proper locations and are properly sized in accordance with NFPA 70 to accommodate raceways.
- C. Verify that mounting surfaces are ready to receive raceways and that final surface finishes are complete, including painting.
- D. Verify that conditions are satisfactory for installation prior to starting work.

#### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install raceways plumb and level.
- D. Arrange wireways and associated raceway connections to comply with NFPA 70, including but not limited to requirements for deflected conductors and wireways used as pullboxes. Increase size of wireway where necessary.
- E. Secure and support raceways in accordance with Section 260529 at intervals complying with NFPA 70 and manufacturer's requirements.
- F. Close unused raceway openings.
- G. Provide grounding and bonding in accordance with Section 260526.
- H. Identify raceways in accordance with Section 260553.

#### **3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect raceways for damage and defects.
- C. Surface Raceway Systems with Integrated Devices: Test each wiring device to verify operation and proper polarity.
- D. Correct wiring deficiencies and replace damaged or defective raceways.

#### **3.04 CLEANING**

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

#### **3.05 PROTECTION**

- A. Protect installed raceways from subsequent construction operations.

### **END OF SECTION**

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## **SECTION 260553 IDENTIFICATION FOR ELECTRICAL SYSTEMS**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Electrical identification requirements.
- B. Identification nameplates and labels.
- C. Wire and cable markers.
- D. Voltage markers.
- E. Underground warning tape.
- F. Floor marking tape.
- G. Warning signs and labels.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 099113 - Exterior Painting.
- B. Section 099123 - Interior Painting.
- C. Section 260519 - Low-Voltage Electrical Power Conductors and Cables: Color coding for power conductors and cables 600 V and less; vinyl color coding electrical tape.
- D. Section 262726 - Wiring Devices - Lutron: Device and wallplate finishes; factory pre-marked wallplates.
- E. Section 271000 - Structured Cabling: Identification for communications cabling and devices.

#### **1.03 REFERENCE STANDARDS**

- A. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- B. UL 969 - Marking and Labeling Systems Current Edition, Including All Revisions.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.
- B. Sequencing:
  - 1. Do not conceal items to be identified, in locations such as above suspended ceilings, until identification products have been installed.
  - 2. Do not install identification products until final surface finishes and painting are complete.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.
- C. Shop Drawings: Provide schedule of items to be identified indicating proposed designations, materials, legends, and formats.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.

#### **1.07 FIELD CONDITIONS**

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

**PART 2 PRODUCTS****2.01 IDENTIFICATION REQUIREMENTS**

- A. Existing Work: Unless specifically excluded, identify existing elements to remain that are not already identified in accordance with specified requirements.
- B. Identification for Equipment:
  - 1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
    - a. Switchboards:
      - 1) Identify ampere rating.
      - 2) Identify voltage and phase.
      - 3) Identify power source and circuit number. Include location when not within sight of equipment.
      - 4) Use identification nameplate to identify main overcurrent protective device.
      - 5) Use identification nameplate to identify load(s) served for each branch device. Identify spares and spaces.
    - b. Panelboards:
      - 1) Identify ampere rating.
      - 2) Identify voltage and phase.
      - 3) Identify power source and circuit number. Include location when not within sight of equipment.
      - 4) Identify main overcurrent protective device. Use identification label for panelboards with a door. For power distribution panelboards without a door, use identification nameplate.
      - 5) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces using pencil.
      - 6) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Do not identify spares and spaces.
    - c. Enclosed switches, circuit breakers, and motor controllers:
      - 1) Identify voltage and phase.
      - 2) Identify power source and circuit number. Include location when not within sight of equipment.
      - 3) Identify load(s) served. Include location when not within sight of equipment.
    - d. Time Switches:
      - 1) Identify load(s) served and associated circuits controlled. Include location.
    - e. Electricity Meters:
      - 1) Identify load(s) metered.
  - 2. Service Equipment:
    - a. Use identification nameplate to identify each service disconnecting means.
  - 3. Use voltage marker to identify highest voltage present for each piece of electrical equipment.
  - 4. Use identification nameplate to identify disconnect location for equipment with remote disconnecting means.
  - 5. Use identification label on inside of door at each fused switch to identify required NEMA fuse class and size.
  - 6. Use identification label to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".
  - 7. Use field-painted floor markings, floor marking tape, or warning labels to identify required equipment working clearances where indicated or where required by the authority having jurisdiction.
    - a. Field-Painted Floor Markings: Alternating black and white stripes, 3 inches wide, painted in accordance with Section 099123 and 099113.
  - 8. Use warning signs to identify electrical hazards for entrances to all buildings, vaults, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 600 V nominal with the word message "DANGER; HIGH VOLTAGE; KEEP OUT".

- C. Identification for Conductors and Cables:
1. Color Coding for Power Conductors 600 V and Less: Comply with Section 260519.
  2. Identification for Communications Conductors and Cables: Comply with Section 271000.
  3. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.
  4. Use wire and cable markers to identify circuit number or other designation indicated for power, control, and instrumentation conductors and cables at the following locations:
    - a. At each source and load connection.
    - b. Within boxes when more than one circuit is present.
  5. Use wire and cable markers to identify connected grounding electrode system components for grounding electrode conductors.
  6. Use underground warning tape to identify direct buried cables.
- D. Identification for Raceways:
1. Use voltage markers to identify highest voltage present for accessible conduits at maximum intervals of 20 feet.
  2. Use voltage markers or color-coded bands to identify systems other than normal power system for accessible conduits at maximum intervals of 20 feet.
    - a. Color-Coded Bands: Use field-painting or vinyl color coding electrical tape to mark bands 3 inches wide.
      - 1) Color Code:
        - (a) Fire Alarm System: Red.
      - 2) Field-Painting: Comply with Section 099123 and 099113.
      - 3) Vinyl Color Coding Electrical Tape: Comply with Section 260519.
  3. Use identification labels or plastic marker tags to identify circuits enclosed for accessible conduits at wall penetrations, at floor penetrations, at roof penetrations, and at equipment terminations when source is not within sight.
  4. Use identification labels or plastic marker tags to identify spare conduits at each end. Identify purpose and termination location.
  5. Use underground warning tape to identify underground raceways.
  6. Use voltage markers to identify highest voltage present for wireways at maximum intervals of 20 feet.
- E. Identification for Boxes:
1. Use voltage markers to identify highest voltage present.
  2. Use identification labels to identify circuits enclosed.
    - a. For exposed boxes in public areas, use only identification labels.
- F. Identification for Devices:
1. Identification for Communications Devices: Comply with Section 271000.
  2. Wiring Device and Wallplate Finishes: Comply with Section 262726.
  3. Use identification label to identify fire alarm system devices.
  4. Use identification label or engraved wallplate to identify serving branch circuit for all receptacles.
    - a. For receptacles in public areas or in areas as directed by Architect, provide identification on inside surface of wallplate.
- G. Identification for Luminaires:
1. Use permanent red dot on luminaire frame to identify luminaires connected to emergency power system.

## 2.02 IDENTIFICATION NAMEPLATES AND LABELS

- A. Identification Nameplates:
1. Manufacturers:
    - a. Brimar Industries, Inc: [www.brimar.com/#sle](http://www.brimar.com/#sle).
    - b. Kolbi Pipe Marker Co: [www.kolbipipemarkers.com/#sle](http://www.kolbipipemarkers.com/#sle).

- c. Seton Identification Products: [www.seton.com/#sle](http://www.seton.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
  - 2. Materials:
    - a. Indoor Clean, Dry Locations: Use plastic nameplates.
    - b. Outdoor Locations: Use plastic, stainless steel, or aluminum nameplates suitable for exterior use.
  - 3. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
  - 4. Stainless Steel Nameplates: Minimum thickness of 1/32 inch; engraved or laser-etched text.
  - 5. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch; engraved or laser-etched text.
  - 6. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.
- B. Identification Labels:
  - 1. Manufacturers:
    - a. Brady Corporation: [www.bradyid.com/#sle](http://www.bradyid.com/#sle).
    - b. Brother International Corporation: [www.brother-usa.com/#sle](http://www.brother-usa.com/#sle).
    - c. Panduit Corp: [www.panduit.com/#sle](http://www.panduit.com/#sle).
    - d. Substitutions: See Section 016000 - Product Requirements.
  - 2. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
    - a. Use only for indoor locations.
  - 3. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.
- C. Format for Equipment Identification:
  - 1. Minimum Size: 1 inch by 2.5 inches.
  - 2. Legend:
    - a. Equipment designation or other approved description.
  - 3. Text: All capitalized unless otherwise indicated.
  - 4. Minimum Text Height:
    - a. Equipment Designation: 1/2 inch.
  - 5. Color:
    - a. Normal Power System: White text on black background.
    - b. Fire Alarm System: White text on red background.
- D. Format for General Information and Operating Instructions:
  - 1. Minimum Size: 1 inch by 2.5 inches.
  - 2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
  - 3. Text: All capitalized unless otherwise indicated.
  - 4. Minimum Text Height: 1/4 inch.
  - 5. Color: Black text on white background unless otherwise indicated.
    - a. Exceptions:
      - 1) Provide white text on red background for general information or operational instructions for fire alarm systems.
- E. Format for Caution and Warning Messages:
  - 1. Minimum Size: 2 inches by 4 inches.
  - 2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
  - 3. Text: All capitalized unless otherwise indicated.
  - 4. Minimum Text Height: 1/2 inch.
  - 5. Color: Black text on yellow background unless otherwise indicated.
- F. Format for Receptacle Identification:
  - 1. Minimum Size: 3/8 inch by 1.5 inches.



2. Legend: Power source and circuit number or other designation indicated.
  3. Text: All capitalized unless otherwise indicated.
  4. Minimum Text Height: 3/16 inch.
  5. Color: Black text on clear background.
- G. Format for Control Device Identification:
1. Minimum Size: 3/8 inch by 1.5 inches.
  2. Legend: Load controlled or other designation indicated.
  3. Text: All capitalized unless otherwise indicated.
  4. Minimum Text Height: 3/16 inch.
  5. Color: Black text on clear background.
- H. Format for Fire Alarm Device Identification:
1. Minimum Size: 3/8 inch by 1.5 inches.
  2. Legend: Designation indicated and device zone or address.
  3. Text: All capitalized unless otherwise indicated.
  4. Minimum Text Height: 3/16 inch.
  5. Color: Red text on white background.

### 2.03 WIRE AND CABLE MARKERS

- A. Manufacturers:
1. Brady Corporation: [www.bradyid.com/#sle](http://www.bradyid.com/#sle).
  2. HellermannTyton: [www.hellermannntyton.com/#sle](http://www.hellermannntyton.com/#sle).
  3. Panduit Corp: [www.panduit.com/#sle](http://www.panduit.com/#sle).
  4. Substitutions: See Section 016000 - Product Requirements.
- B. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.
- C. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.
- D. Legend: Power source and circuit number or other designation indicated.
- E. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.
- F. Minimum Text Height: 1/8 inch.
- G. Color: Black text on white background unless otherwise indicated.

### 2.04 VOLTAGE MARKERS

- A. Manufacturers:
1. Brady Corporation: [www.bradyid.com/#sle](http://www.bradyid.com/#sle).
  2. Brimar Industries, Inc: [www.brimar.com/#sle](http://www.brimar.com/#sle).
  3. Seton Identification Products: [www.seton.com/#sle](http://www.seton.com/#sle).
  4. Substitutions: See Section 016000 - Product Requirements.
- B. Markers for Conduits: Use factory pre-printed self-adhesive vinyl, self-adhesive vinyl cloth, or vinyl snap-around type markers.
- C. Markers for Boxes and Equipment Enclosures: Use factory pre-printed self-adhesive vinyl or self-adhesive vinyl cloth type markers.
- D. Minimum Size:
1. Markers for Equipment: 1 1/8 by 4 1/2 inches.
  2. Markers for Conduits: As recommended by manufacturer for conduit size to be identified.
  3. Markers for Pull Boxes: 1 1/8 by 4 1/2 inches.
  4. Markers for Junction Boxes: 1/2 by 2 1/4 inches.
- E. Legend:
1. Markers for Voltage Identification: Highest voltage present.
  2. Markers for System Identification:

F. Color: Black text on orange background unless otherwise indicated.

## **2.05 UNDERGROUND WARNING TAPE**

- A. Manufacturers:
  - 1. Brady Corporation; [\_\_\_\_]: [www.bradyid.com/#sle](http://www.bradyid.com/#sle).
  - 2. Brimar Industries, Inc: [www.brimar.com/#sle](http://www.brimar.com/#sle).
  - 3. Seton Identification Products; [\_\_\_\_]: [www.seton.com/#sle](http://www.seton.com/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Materials: Use non-detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.
- C. Non-detectable Type Tape: 6 inches wide, with minimum thickness of 4 mil.
- D. Legend: Type of service, continuously repeated over full length of tape.
- E. Color:

## **2.06 FLOOR MARKING TAPE**

- A. Manufacturers:
  - 1. Brady Corporation: [www.bradyid.com/#sle](http://www.bradyid.com/#sle).
  - 2. Brimar Industries, Inc: [www.brimar.com/#sle](http://www.brimar.com/#sle).
  - 3. Insite Solutions, LLC: [www.stop-painting.com/#sle](http://www.stop-painting.com/#sle).
  - 4. Seton Identification Products: [www.seton.com/#sle](http://www.seton.com/#sle).
  - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Floor Marking Tape for Equipment Working Clearance Identification: Self-adhesive vinyl or polyester tape with overlamine, 3 inches wide, with alternating black and white stripes.

## **2.07 WARNING SIGNS AND LABELS**

- A. Manufacturers:
  - 1. Brimar Industries, Inc: [www.brimar.com/#sle](http://www.brimar.com/#sle).
  - 2. Clarion Safety Systems, LLC; [\_\_\_\_]: [www.clarionsafety.com/#sle](http://www.clarionsafety.com/#sle).
  - 3. Insite Solutions, LLC; [\_\_\_\_]: [www.stop-painting.com/#sle](http://www.stop-painting.com/#sle).
  - 4. Seton Identification Products; [\_\_\_\_]: [www.seton.com/#sle](http://www.seton.com/#sle).
  - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.
- C. Warning Signs:
  - 1. Materials:
    - a. Indoor Dry, Clean Locations: Use factory pre-printed rigid plastic or self-adhesive vinyl signs.
    - b. Outdoor Locations: Use factory pre-printed rigid aluminum signs.
  - 2. Rigid Signs: Provide four mounting holes at corners for mechanical fasteners.
  - 3. Minimum Size: 7 by 10 inches unless otherwise indicated.
- D. Warning Labels:
  - 1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
    - a. Do not use labels designed to be completed using handwritten text.
  - 2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
  - 3. Minimum Size: 2 by 4 inches unless otherwise indicated.

## **PART 3 EXECUTION**

### **3.01 PREPARATION**

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

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.

- 
- B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
1. Surface-Mounted Equipment: Enclosure front.
  2. Flush-Mounted Equipment: Inside of equipment door.
  3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
  4. Elevated Equipment: Legible from the floor or working platform.
  5. Branch Devices: Adjacent to device.
  6. Interior Components: Legible from the point of access.
  7. Conduits: Legible from the floor.
  8. Boxes: Outside face of cover.
  9. Conductors and Cables: Legible from the point of access.
  10. Devices: Outside face of cover.
- C. Install identification products centered, level, and parallel with lines of item being identified.
- D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.
- E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.
- F. Install underground warning tape above buried lines with one tape per trench at 3 inches below finished grade.
- G. Secure rigid signs using stainless steel screws.
- H. Mark all handwritten text, where permitted, to be neat and legible.

### **3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

**END OF SECTION**

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## **SECTION 260583 WIRING CONNECTIONS**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Electrical connections to equipment.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 260519 - Low-Voltage Electrical Power Conductors and Cables.
- B. Section 260533.13 - Conduit for Electrical Systems.
- C. Section 260533.16 - Boxes for Electrical Systems.
- D. Section 262726 - Wiring Devices.
- E. Section 262816.16 - Enclosed Switches.

#### **1.03 REFERENCE STANDARDS**

- A. NEMA WD 1 - General Color Requirements for Wiring Devices 1999 (Reaffirmed 2015).
- B. NEMA WD 6 - Wiring Devices - Dimensional Specifications 2016.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
  - 2. Determine connection locations and requirements.
- B. Sequencing:
  - 1. Install rough-in of electrical connections before installation of equipment is required.
  - 2. Make electrical connections before required start-up of equipment.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide wiring device manufacturer's catalog information showing dimensions, configurations, and construction.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.

### **PART 2 PRODUCTS**

#### **2.01 MATERIALS**

- A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
  - 1. Colors: Comply with NEMA WD 1.
  - 2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
  - 3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.
- B. Disconnect Switches: As specified in Section 262816.16 and in individual equipment sections.
- C. Wiring Devices: As specified in Section 262726.
- D. Flexible Conduit: As specified in Section 260533.13.
- E. Wire and Cable: As specified in Section 260519.
- F. Boxes: As specified in Section 260533.16.

**2.02 EQUIPMENT CONNECTIONS**

- A. HVAC Motors:
  - 1. Electrical Connection: Flexible conduit.
  - 2. Electrical Connection: Cord and plug (NEMA 6-20R).

**PART 3 EXECUTION****3.01 EXAMINATION**

- A. Verify that equipment is ready for electrical connection, wiring, and energization.

**3.02 ELECTRICAL CONNECTIONS**

- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.
- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

**END OF SECTION**

## **SECTION 260923 LIGHTING CONTROL DEVICES**

### **PART 1 GENERAL**

#### **1.01 SUMMARY**

- A. Section Includes"
  - 1. Occupancy, Vacancy and Daylighting Sensor Control.
  - 2. Daylight Photocells.
  - 3. Outdoor Photoelectric Switch.
  - 4. Emergency Lighting Control (if applicable)
- B. Control Intent - Control Intent includes, but is not limited to:
  - 1. Defaults and pre-defined calibration settings for such items as daylighting, occupancy sensor times, sensitivity, fade rates, etc.Defaults and pre-defined calibration settings for such items as daylighting, occupancy sensor times, sensitivity, fade rates, etc.
  - 2. Wallstation pre-defined control sequences
  - 3. Daylight sensor and switching zones

### **PART 2 PRODUCTS**

#### **2.01 LIGHTING CONTROL DEVICES - GENERAL REQUIREMENTS**

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide all required conduit, wiring, connectors, hardware, components, accessories, etc. as required for a complete operating system.
  - 1. Products for Switching of Electronic Ballasts/Drivers: Tested and rated to be suitable for peak inrush currents specified in NEMA 410.

#### **2.02 MANUFACTURERS**

- A. Acceptable Manufacturer:
  - 1. Hubbell Controls
    - a. System Room Controller NX Series.
    - b. Or Approved Equivalent.
  - 2. Basis of design product: Hubbell Controls Room Controller or subject to compliance and prior approval with specified requirements of this section, one of the following:
    - a. Hubbell Controls Room Controller NX Series or equal.
- B. Substitutions:
  - 1. Delete items 1 through 2 if substitutions are not permitted.
  - 2. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by the design professional a minimum of 10 working days prior to the bid date and must be made available to all bidders. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.
  - 3. Any substitutions provided by the contractor shall be reviewed at the contractor's expense by the electrical engineer at a rate.
  - 4. By using pre-approved substitutions, the contractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring. The contractor shall provide complete engineered shop drawings (including power and control wiring) with deviations from the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

#### **2.03 WALL OR CEILING MOUNTED OCCUPANCY PERFORMANCE REQUIREMENTS**

- A. Sensing mechanism:
  - 1. [Dual Technology]:
    - a. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
    - b. Utilize an operating frequency of 32 kHz or 40 kHz that shall be crystal controlled to operate within plus or minus 0.005% tolerance.
    - c. Incorporate Doppler shift ultrasonic and passive infrared motion detection technologies. Products that react to noise or ambient sound shall not be

considered.

- B. Power Failure Memory:
  - 1. Controls incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and parameters saved in protected memory shall not be lost.
- C. Designed and tested to withstand discharges without impairment of performance when subjected to discharges of 15,000 volts per IEC 801-2.
- D. Products tested in identical manner, complaint to NEMA WD 7 -2011 Occupancy Motion Sensors Standards.
- E. Sensor shall have time delays from 8 to 30min.
- F. When specified, sensors shall automatically adjust time delay and sensitivity settings.
- G. All sensors shall provide an LED as a visual means of indication at all times to verify that motion is being detected during both testing and normal operation.
- H. All sensors shall have readily accessible, user adjustable settings for time delay and sensitivity. Settings shall be located on the sensor (not the control unit) and shall be recessed to limit tampering.
- I. Where specified, sensor shall have an internal additional isolated relay with Normally Open, Normally Closed, and Common outputs for use with HVAC control, Data Logging and other control options. Sensors utilizing separate components or specially modified units to achieve this function are not acceptable.

#### 2.04 CEILING MOUNTED SENSORS

- A. Product: NXOS-OMNIDT2.
- B. Turn-Off Delay: Field adjustable, with time delay settings up to 30 minutes.
- C. Provide all necessary mounting hardware and instructions.
- D. Sensors shall be Class 2 devices.
  - 1. Connect to Room Controller via Click & Go cable to eliminate wiring errors.
  - 2. NX Room Controller accessory is used to allow any standard Occupancy/ Vacancy Sensor to utilize Click & Go cable connections
  - 3. Two RJ45 connection ports for connection to Room Controller
  - 4. Occupancy Sensor and Daylight sensor shall be capable of a daisy chain connection to the Room Controller
- E. Device calibration and features
  - 1. Sensitivity – 0-100% in 10% increments.
  - 2. Test mode – Fifteen second time Time delay – 1-30, self-adjusts to 8 min based on room occupancydelay
  - 3. Test mode – Fifteen second time delay
  - 4. Detection technology – PIR, Ultrasonic or Dual Technology activation and/or re-activation.
  - 5. Walk-through mode
  - 6. Dual Technology Sensors utilizes two independent sensor detection circuits simultaneously to ensure optimum performance regardless of location or proximity to walls and structures.
  - 7. Dual Technology Sensors utilize Variable Drive Circuitry (VDC) in cases of over saturation from misapplication, which automatically adjusts the volumetric output without reducing detection capability. Systems that reduce detection coverage area shall not be acceptable.
  - 8. Automatically and continually self-adjust ultrasonic frequency to ignore specific frequency continuous noise from airflow to prevent detuning which can lead to inadvertent lights out. Sensors that require detuning shall not be acceptable.
  - 9. All load parameters including Automatic-On/Manual-ON, blink warning, and daylight enable/disable when daylight sensors are pre-defined with the Room Controller local network.
- F. Device Status LEDs including:
  - 1. PIR Detection.



2. Ultrasonic detection
- G. Occupancy sensor are pre-defined to specific loads within the room without wiring or special tools for maximum energy savings.
- H. Manual override of controlled loads.
- I. Multiple occupancy sensors may be installed in a room by simply daisy chaining them together to the Room Controller via Click & Go cable. No additional configuration will be required.
- J. Where specified, sensor packaging shall be 100% recycled [made entirely from post consumer waste (100% post consumer fiber content) as well as, 100% recyclable].
- K. Sensors shall be RoHS compliant.
- L. Dual-Technology Type for High Ceilings: 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. Ceiling sensor to be provided with isolated relay for integration with Building HVAC management system.
  3. Timer timeouts: Primary – 8 second test mode – 4, 8, 16 and 30 minutes timeout
    - a. Products:
  4. Daylight Range: 30 – 2500FC
  5. White finish
  6. Surface mount to J-box via stainless steel screws and locking nuts.
  7. Provide with 360 degree lens.
  8. Ceiling occupancy sensor. - Hubbell Model # WSP SM 24V or equal and associated Lens – Hubbell Model # WSP L360.
    - a. Substitutions: See Section 016000 - Product Requirements.

## 2.05 LOW VOLTAGE ROOM CONTROLLER DIGITAL WALLSTATIONS

- A. Low voltage momentary pushbutton switches in 2, 3, 4, 5 and 6 button configuration; available in white, ivory, grey and black; compatible with wall plates with decorator opening. Wallstations shall include the following features:
  1. Removable buttons for field replacement with engraved buttons and/or alternate color buttons [ENGRV-\*BTNL-\*],[ENGRV-\*BTNS-\*]. Button replacement may be completed without removing the switch from the wall.
  2. Intuitive button labeling to match application and load controls.
- B. Two RJ-45 ports for connection to the Room Controller local network.
- C. Multiple digital wallstations may be installed in a room by simply connecting them to the Room Controller local network. No additional configuration will be required to achieve multi-way switching.
- D. Room Controller digital wallstations are delivered with pre-defined functions including, raise, lower, A/V mode, Quiet Time, manual and scene control. No additional configuration is required to provide a fully functional system. Systems that require configuration or load binding and do not deliver maximum energy savings out of the box shall not be acceptable.
- E. Optional custom labeling is available for application or location specific wallstation button labels.
- F. Hubbell Controls Wall switch: 4 button – ON/Raise/Lower/Off switch position. Catalog numbers: NXSW – ORLO-WH. (White Finish).
  1. Substitutions: See Section 016000 - Product Requirements.
  2. Lutron Maestro Series; [www.lutron.com/#sle](http://www.lutron.com/#sle).

## 2.06 LOW VOLTAGE SINGLE BUTTON WALL SWITCH WITH PILOT LIGHT

- A. Low Voltage Single Button Wall switch with Pilot Light.
  1. Momentary button action.
  2. Single gang.
  3. 1 button with LED Pilot light

4. Zero Arc Point Switching.
5. 120-277Vac model.
6. Construction: High impact injection molded plastic.
7. Five-year limited warranty.
8. Low voltage device: 24Vdc.

B. Hubbell Controls: LVS M 1 PL WH (White Finish)

## **2.07 DUAL TECH WALL SWITCH SENSOR**

- A. Dual tech wall switch sensor
  1. Digital dual tech: (US) and (PIR) sensors.
  2. Single gang.
  3. IntelliDAPT self-adaptive tech – no manual adjustment required.
  4. Dual circuit has isolated relays.
  5. Occupancy (auto-on) and Vacancy (manual-on) operating modes
  6. 1000 square-foot, 180degree coverage area.
  7. RhinoTuff vandal resistant lens.
  8. 120/277VAC operation.
  9. No minimum load requirement.
  10. Zero Arc Point Switching.
  11. Five-year limited warranty.
  12. 120-277Vac model.
  13. Low voltage device:24vdc.
  14. Construction: High impact injection molded plastic
- B. Hubbell Controls: LHMTS 1 - G-WH (White Finish)
  1. Substitutions: See Section 016000 - Product Requirements.

## **2.08 DIMMING PIR WALL SWITCH SENSOR**

- A. Dimming PIR wall switch sensor
  1. Digital Passive (PIR) sensors.
  2. Single gang.
  3. IntelliDAPT self-adaptive tech – no manual adjustment required.
  4. One relay for single level switching.
  5. Occupancy (auto-on) and Vacancy (manual-on) operating modes.
  6. 1000 square-foot, 180degree coverage area.
  7. RhinoTuff vandal resistant lens.
  8. 120/277VAC operation.
  9. No minimum load requirement.
  10. Zero Arc Point Switching.
  11. Five-year limited warranty.
  12. 120-277Vac model.
  13. Low voltage device:24vdc.
  14. Construction: High impact injection molded plastic.
- B. Hubbell Controls: LHD-IRS-3-N-WH (White Finish)
  1. Substitutions: See Section 016000 - Product Requirements.

## **2.09 HANDHELD REMOTE CONTROLS**

- A. Battery-operated handheld 10 button configuration for remote daylight sensor configuration. Remote controls shall include the following features:
  1. Two-way infrared (IR) transceiver for line of sight communication with the Room Controller daylight sensors within up to 30 feet.
  2. Red communication LED on the daylight sensor confirms button press.
  3. Inactivity timeout to save battery life.
- B. Three intuitive daylight sensor range push buttons.
- C. Intuitive daylight zone adjustment raise/lower pushbuttons
- D. Hubbell Controls

## 2.10 ROOM CONTROLLERS

- A. Room Controllers are fully functional out of the box to the connected devices in the space without commissioning or the use of any tools. Room Controllers shall be provided to match the room lighting load and control requirements. The controllers will be simple to install and will include line voltage wiring space and will not require additional electrical junction boxes. The control units will include the following features:
- B. Fully functional room configuration to the most energy-efficient sequence of operation based upon the connected devices in the room.
- C. Simple replacement – Using the automatic configuration capabilities, a Room Controller may be replaced with an off-the-shelf unit without requiring any configuration or setup.
- D. Quick installation features including:
  - 1. Included line voltage space to simplify wiring and eliminate the need for separate junction boxes.
  - 2. Included emergency voltage space to simplify wiring of emergency luminaire connections.
  - 3. Breakouts for direct conduit connection.
  - 4. Line and low voltage sections include conduit connection points. Systems that require special accessories for direct conduit connections may not comply with local building codes and shall not be acceptable.
  - 5. Quick low voltage connections using standard RJ-45 QuickConnect cable.
  - 6. Plenum rated.
  - 7. Dual voltage (120/277 VAC, 60 Hz).
  - 8. Zero cross circuitry for each load.
  - 9. Three relay configuration.
  - 10. Efficient 150 mA switching power supply.
  - 11. Six RJ-45 Click & Go local network ports.
  - 12. All models support local network connections of wallstations, occupancy-based controls and receptacle controls.
- E. On/Off/Dimming Room Controllers shall include:
  - 1. Passive Infrared/Ultrasonic Dual Technology Ceiling Mounted Occupancy Sensors:
  - 2. 2 SPST Switched, 2 0-10V analog outputs dimming controls of compatible ballasts and LED drivers.
  - 3. Hubbell Controls: NXRC 2RD UNV.
    - a. Substitutions: See Section 016000 - Product Requirements.

## 2.11 DAYLIGHT PHOTOSENSORS

- A. Daylight photosensors work with Room Controllers to provide automatic daylight dimming capabilities for any load type connected to a room controller. Open loop daylight sensors measure incoming daylight in the space, and are capable of controlling up to three lighting zones. Daylight sensors shall be interchangeable without the need for rewiring. Daylight sensors shall be capable of daisy chaining with occupancy sensors in each room.
- B. Digital daylight sensor include the following features:
  - 1. An internal photodiode that measures only within the visible spectrum, and has a response curve that closely matches the photopic curve.
  - 2. The daylight sensor has three light level ranges: Foot candle Range 3-6,000 fc.
  - 3. For dimming daylight harvesting, the daylight sensor shall provide the capability of controlling multiple (up to three) daylight zones immediately upon connection without programming.
  - 4. Optional digital wallstations to allow occupants to reduce lighting level to increase energy savings and lower lighting levels for a selected period of time or cycle of occupancy.
  - 5. Infrared (IR) transceiver for daylight sensor range and daylight zone gain adjustments via handheld remote programmer.
  - 6. Red configuration LED that blinks to indicate data transmission.
  - 7. One RJ-45 port for connection to Room Controller local network.

8. An adjustable head and an optional mounting bracket to accommodate multiple mounting methods and building materials. The daylight sensor may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox.
- C. Open loop digital daylight sensor includes the following additional features:
  1. An internal photodiode that measures light in a 60 degree angle cutting off the unwanted light from the interior of the room.
  2. Automatically establishes dimming set-points upon power up without any programming. Optional calibration using the wireless IR handheld programmer.
  3. Hubbell Controls: NXDS.
    - a. Substitutions: See Section 016000 - Product Requirements.

## 2.12 UNIVERSAL VOLTAGE POWER PACKS

- A. Power Pack.
  1. Universal voltage: 100-277VAC; 50/60HZ.
  2. Automatic voltage detection.
  3. Electrical load switching capacity: maximum of 20amps.
  4. Regulated 24VDC current; 150mA output.
  5. Zero Arc Point Switching.
  6. Plenum rated.
  7. Mounts: inside or outside a junction box; inside fixture
  8. Available with exclusive Quick-to-install (QTI) connector
  9. Companion aux relay device available (MPSA)
  10. UL and cUL listed
  11. Five-year limited warranty.
  12. Low voltage device: 24VDC.
  13. Manual on/off control
- B. Hubbell Controls: UVPPM
  1. Substitutions: See Section 016000 - Product Requirements.
  2. Long Range Sensors: Capable of detecting motion within a distance of 80 feet at a mounting height of 10 feet.

## 2.13 ROOM CONTROLLER LOCAL NETWORK

- A. The Room Controller local network is a physical connection and communication protocol designed to optimally control a space within a building. Room Controller devices connect to the local network using CAT 5e cables with RJ-45 QuickConnect cables which provide both data and power to room devices. Features of the Room Controller local network include:
  1. Click & Go default functionality of occupancy sensors, wallstations, slider station, daylight sensors, receptacle controls, BMS status output and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
  2. Replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.

## 2.14 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Cooper Industries, Inc.
  2. Intermatic, Inc.
  3. NSi Industries LLC; TORK Products.
  4. Tyco Electronics; ALR Brand.
  5. Paragon.
- B. Description: Solid state, with SPST or DPST dry contacts rated for 1800-VA tungsten or 1000- VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
  1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.

3. Time Delay: Fifteen second minimum, to prevent false operation.
  4. Surge Protection: Metal-oxide varistor.
  5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
- C. FINISHES
- D. Device Color:
1. Wiring Devices (normal): White in all area unless otherwise indicated or required by NFPA 70 or device listing.
- E. Wall Plate Color: All cover plates in areas of renovations shall match device (white for normal) (red for emergency).
- F. Wall plates in all other areas shall be be stainless steel.

## **2.15 IN-WALL TIME SWITCHES**

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.
- F. Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.
- G. Verify that conditions are satisfactory for installation prior to starting work.

#### **3.02 PREPARATION**

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

#### **3.03 INSTALLATION**

- A. Install lighting control devices in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of lighting control devices provided under this section.
  1. Mounting Heights: Unless otherwise indicated, as follows:
    - a. Wall Switch Occupancy Sensors: 48 inches above finished floor.
    - b. In-Wall Time Switches: 48 inches above finished floor.
    - c. In-Wall Interval Timers: 48 inches above finished floor.
  2. Orient outlet boxes for vertical installation of lighting control devices unless otherwise indicated.
  3. Locate wall switch occupancy sensors on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Architect to obtain direction prior to proceeding with work.
- C. Install lighting control devices in accordance with manufacturer's instructions.
- D. Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- E. The control system shall be installed and fully wired as shown on the plans by the installing contractor. The contractor shall complete all electrical connections to all control circuits.
- F. All low voltage smart devices shall connect using QuickConnect wire provided by Hubbell Controls. When using wire for connections other than the QuickConnect low voltage wire

- (pre-defined lengths of RJ45 cable), provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements
- G. Install lighting control devices plumb and level, and held securely in place.
  - H. Where required and not furnished with lighting control device, provide wall plate in accordance with Section 262726.
  - I. Provide required supports in accordance with Section 260529.
  - J. Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
  - K. Provide written or computer-generated documentation on the commissioning of the system including room by room description including:
    - 1. Sensor parameters, time delays, sensitivities, and daylighting setpoints.
    - 2. Sequence of operation, (e.g. manual ON, Auto OFF. etc.).
    - 3. Load Parameters (e.g. blink warning, etc.).
  - L. Identify lighting control devices in accordance with Section 260553.
  - M. Occupancy Sensor Locations:
    - 1. Location Adjustments: Locations indicated are diagrammatic and only intended to indicate which rooms or areas require devices. Provide quantity and locations as required for complete coverage of respective room or area based on manufacturer's recommendations for installed devices.
    - 2. Locate ultrasonic and dual technology passive infrared/ultrasonic occupancy sensors a minimum of 4 feet from air supply ducts or other sources of heavy air flow and as per manufacturer's recommendations, in order to minimize false triggers.
  - N. Daylighting Control Photo Sensor Locations:
    - 1. Location Adjustments: Locations indicated are diagrammatic and only intended to indicate which rooms or areas require devices. Provide quantity and locations as required for proper control of respective room or area based on manufacturer's recommendations for installed devices.
    - 2. Unless otherwise indicated, locate photo sensors for closed loop systems to accurately measure the light level controlled at the designated task location, while minimizing the measured amount of direct light from natural or artificial sources such as windows or pendant luminaires.
    - 3. Unless otherwise indicated, locate photo sensors for open loop systems to accurately measure the level of daylight coming into the space, while minimizing the measured amount of lighting from artificial sources.

### 3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect each lighting control device for damage and defects.
- C. Test occupancy sensors to verify proper operation, including time delays and ambient light thresholds where applicable. Verify optimal coverage for entire room or area. Record test results in written report to be included with submittals.
- D. Test time switches to verify proper operation.
- E. Test daylighting controls to verify proper operation, including light level measurements and time delays where applicable. Record test results in written report to be included with submittals.
- F. Correct wiring deficiencies and replace damaged or defective lighting control devices.

### 3.05 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust occupancy sensor settings to minimize undesired activations while optimizing energy savings, and to achieve desired function as indicated or as directed by Architect.
- C. Adjust position of directional occupancy sensors to achieve optimal coverage as required.

- D. Where indicated or as directed by Architect, install factory masking material or adjust integral blinders on passive infrared (PIR) and dual technology occupancy sensor lenses to block undesired motion detection.
- E. Adjust time switch settings to achieve desired operation schedule as indicated or as directed by Architect. Record settings in written report to be included with submittals.
- F. Adjust daylighting controls under optimum lighting conditions after all room finishes, furniture, and window treatments have been installed to achieve desired operation as indicated or as directed by Architect. Record settings in written report to be included with submittals. Readjust controls calibrated prior to installation of final room finishes, furniture, and window treatments that do not function properly as determined by Architect.

### **3.06 CLEANING**

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

### **3.07 PRODUCT SUPPORT AND SERVICE**

- A. Factory telephone support shall be available at no cost to the owner. Factory assistance shall consist of solving programming or application questions concerning the control equipment.

### **3.08 FACTORY COMMISSIONING**

- A. The system manufacturer shall provide a factory authorized field engineer to the project site after installation has been completed and prior to system energization for the purpose of testing and adjustment of the system for a minimum of 2 full days. Factory field engineer shall test and verify all system functions and ensure proper operation of the system components in accordance with the specifications and on-site conditions. The installing contractor shall notify the system manufacturer in writing that the system is completely wired and ready to be energized and tested 2 weeks prior to scheduling a field engineer for start-up of the system. Should the field engineer arrive on the job site and find the installation incomplete, the installing contractor shall pay the cost of any future visits by the field engineer required to complete the system start-up.
- B. During the start-up procedure, the factory field engineer shall provide programming assistance and guidance to the building operating personnel in order to program the systems for initial operation.
- C. Allow for up to 4 hours of on-site training on the use and maintenance of the lighting control system to be scheduled at the completion of startup and programming of the system.

### **3.09 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. See Section 017900 - Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of lighting control devices to Architect, and correct deficiencies or make adjustments as directed.
- D. Training: Train Owner's personnel on operation, adjustment, programming, and maintenance of lighting control devices.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of 4 of training.
  - 3. Instructor: Manufacturer's authorized service representative.
  - 4. Location: At project site.

**END OF SECTION**

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## SECTION 262100 LOW-VOLTAGE ELECTRICAL SERVICE ENTRANCE

### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Electrical service requirements.

#### 1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Materials and installation requirements for cast-in-place concrete equipment pads.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260529 - Hangers and Supports for Electrical Systems.
- D. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 262413 - Switchboards: Service entrance equipment.
- F. Section 312316.13 - Trenching: Excavating, bedding, and backfilling.

#### 1.03 PRICE AND PAYMENT PROCEDURES

- A. Allowances:
  - 1. See Section 012100 - Allowances, for allowances affecting this section.

#### 1.04 DEFINITIONS

- A. Service Point: The point of connection between the facilities of the serving utility and the premises wiring as defined in NFPA 70, and as designated by the Utility Company.

#### 1.05 REFERENCE STANDARDS

- A. IEEE C2 - National Electrical Safety Code 2017.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

#### 1.06 ADMINISTRATIVE REQUIREMENTS

- A. No later than two weeks following date of the Agreement, notify Utility Company of anticipated date of service.
- B. Coordination:
  - 1. Verify the following with Utility Company representative:
    - a. Utility Company requirements, including division of responsibility.
    - b. Exact location and details of utility point of connection.
    - c. Utility easement requirements.
    - d. Utility Company charges associated with providing service.
  - 2. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for electrical service and associated equipment.
  - 3. Coordinate arrangement of service entrance equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 4. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- C. Arrange for Utility Company to provide permanent electrical service. Prepare and submit documentation required by Utility Company.
- D. Utility Company charges associated with providing permanent service to be paid by Owner.
- E. Preinstallation Meeting: Convene one week prior to commencing work of this section to review service requirements and details with Utility Company representative.
- F. Scheduling:
  - 1. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner.

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2. Arrange for inspections necessary to obtain Utility Company approval of installation.

#### **1.07 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Utility Company letter of availability for providing electrical service to project.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product. Include ratings, configurations, standard wiring diagrams, outline and support point dimensions, finishes, weights, service condition requirements, and installed features.
- D. Shop Drawings: Include dimensioned plan views and sections indicating locations and arrangement of Utility Company and service entrance equipment, metering provisions, required clearances, and proposed service routing.
  1. Obtain Utility company approval of shop drawings prior to submittal.
- E. Project Record Documents: Record actual locations of equipment and installed service routing.

#### **1.08 QUALITY ASSURANCE**

- A. Comply with the following:
  1. IEEE C2 (National Electrical Safety Code).
  2. NFPA 70 (National Electrical Code).
  3. The requirements of the Utility Company.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### **1.09 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
- B. Store products indoors in a clean, dry space having a uniform temperature to prevent condensation (including outdoor rated products which are not weatherproof until completely and properly installed). Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle products carefully to avoid damage to internal components, enclosure, and finish.

### **PART 2 PRODUCTS**

#### **2.01 ELECTRICAL SERVICE REQUIREMENTS**

- A. Provide replacement of existing electrical service consisting of all required conduits, conductors, equipment, metering provisions, supports, accessories, etc. as necessary for connection between Utility Company point of supply and service entrance equipment.
- B. Electrical Service Characteristics: As indicated on drawings.
- C. Utility Company: Central Hudson Gas & Electric Company.
  1. Point of Contact: [\_\_\_\_\_].
  2. Address: [\_\_\_\_\_].
  3. Phone: [\_\_\_\_\_].
  4. Email: [\_\_\_\_\_].
  5. Utility Company Project Reference Number: [\_\_\_\_\_].
- D. Division of Responsibility:
  1. Pad-Mounted Utility Transformers:
    - a. Transformer Vaults and Pads: Furnished and installed by Contractor per Utility Company requirements.
    - b. Transformers: Furnished and installed by Utility Company.
    - c. Transformer Grounding Provisions: Furnished and installed by Contractor per Utility Company requirements.

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- d. Transformer Protective Bollards: Furnished and installed by Contractor per Utility Company requirements.
- e. Primary:
  - 1) Trenching and Backfilling: Provided by Contractor.
  - 2) Conduits: Furnished and installed by Contractor.
  - 3) Conductors: Furnished and installed by Utility Company.
- f. Secondary:
  - 1) Trenching and Backfilling: Provided by Contractor.
  - 2) Conduits: Furnished and installed by Contractor.
  - 3) Conductors: Furnished and installed by Contractor (Service Point at transformer).
- 2. Terminations at Service Point: Provided by Utility Company.
- 3. Metering Provisions:
  - a. Meter Bases: Furnished and installed by Contractor per Utility Company requirements.
  - b. Metering Transformers: Furnished and installed by Utility Company.
  - c. Conduits Between Metering Transformers and Meters: Furnished and installed by Contractor per Utility Company requirements.
  - d. Wiring Between Metering Transformers and Meters: Furnished and installed by Utility Company.
- E. Products Furnished by Contractor: Comply with Utility Company requirements.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that ratings and configurations of service entrance equipment are consistent with the indicated requirements.
- C. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 PREPARATION**

- A. Verify and mark locations of existing underground utilities.

### **3.03 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions and Utility Company requirements.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances and required maintenance access.
- D. Provide required trenching and backfilling in accordance with Section 312316.13.
- E. Construct cast-in-place concrete pads or pre-manufactured pad for utility equipment in accordance with Utility Company requirements and Section 033000.
- F. Provide required protective bollards in accordance with Utility Company requirements.
- G. Provide required support and attachment components in accordance with Section 260529.
- H. Provide grounding and bonding for service entrance equipment in accordance with Section 260526.
- I. Identify service entrance equipment, including main service disconnect(s) in accordance with Section 260553.

### **3.04 PROTECTION**

- A. Protect installed equipment from subsequent construction operations.

## **END OF SECTION**

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**SECTION 262413  
SWITCHBOARDS****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Low-voltage (600 V and less) switchboards and associated accessories for service and distribution applications.
- B. Overcurrent protective devices for switchboards.

**1.02 RELATED REQUIREMENTS**

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260529 - Hangers and Supports for Electrical Systems.
- D. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 262100 - Low-Voltage Electrical Service Entrance.
  - 1. Includes Utility Company contact information.

**1.03 REFERENCE STANDARDS**

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service 2013e (Amended 2017).
- B. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers 2016.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- D. NECA 400 - Standard for Installing and Maintaining Switchboards 2007.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- F. NEMA PB 2 - Deadfront Distribution Switchboards 2011.
- G. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less 2013.
- H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- I. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.
- K. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.
- L. UL 891 - Switchboards Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  - 4. Coordinate with manufacturer to provide shipping splits suitable for the dimensional constraints of the installation.
  - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Service Entrance Switchboards:
  - 1. Coordinate with Utility Company to provide switchboards with suitable provisions for electrical service and utility metering, where applicable.

2. Coordinate with Owner to arrange for Utility Company required access to equipment for installation and maintenance.
3. See Section 262100 for Utility Company contact information and additional requirements.
4. Obtain Utility Company approval of switchboard prior to fabrication.
5. Arrange for inspections necessary to obtain Utility Company approval of installation.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for switchboards, enclosures, overcurrent protective devices, and other installed components and accessories.
  1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.
- C. Shop Drawings: Indicate dimensions, voltage, bus ampacities, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
  1. Include dimensioned plan and elevation views of switchboards and adjacent equipment with all required clearances indicated.
  2. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
- D. Field verify all existing switchboard fuse rating sizes prior to submittal package.
- E. Service Entrance Switchboards: Include documentation of Utility Company approval of switchboard.
- F. Source Quality Control Test Reports: Include reports for tests designated in NEMA PB 2 as production (routine) tests.
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- H. Field Quality Control Test Reports.
- I. Project Record Documents: Record actual installed locations of switchboards and final equipment settings.
- J. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- K. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  1. See Section 016000 - Product Requirements, for additional provisions.
  2. Enclosure Keys: Two of each different key.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store switchboards in accordance with manufacturer's instructions, NECA 400, and NEMA PB 2.1.
- B. Store in a clean, dry space having a uniform temperature to prevent condensation (including outdoor switchboards, which are not weatherproof until completely and properly installed). Where necessary, provide temporary enclosure space heaters or temporary power for permanent factory-installed space heaters.
- C. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

- D. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

## 1.08 FIELD CONDITIONS

- A. Maintain field conditions within required service conditions during and after installation.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. Switchboards - Basis of Design: [\_\_\_\_\_].
- B. Switchboards - Other Acceptable Manufacturers:
  - 1. Eaton Corporation; [\_\_\_\_\_]: [www.eaton.com/#sle](http://www.eaton.com/#sle).
  - 2. Schneider Electric; Square D Products: [www.schneider-electric.us/#sle](http://www.schneider-electric.us/#sle).
  - 3. Siemens Industry, Inc: [www.usa.siemens.com/#sle](http://www.usa.siemens.com/#sle).
  - 4. General Electric.
- C. Substitutions: See Section 016000 - Product Requirements.
- D. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.
- E. Source Limitations: Furnish switchboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

### 2.02 SWITCHBOARDS

- A. Provide switchboards consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Description: Dead-front switchboard assemblies complying with NEMA PB 2, and listed and labeled as complying with UL 891; ratings, configurations and features as indicated on the drawings.
- D. Front-Connected Switchboards:
  - 1. Main Device(s): Individually-mounted.
  - 2. Feeder Devices: Panel/group-mounted.
  - 3. Arrangement: Front accessible only (not rear accessible), rear aligned.
  - 4. Gutter Access: Bolted covers.
- E. Service Entrance Switchboards:
  - 1. Listed and labeled as suitable for use as service equipment according to UL 869A.
  - 2. For solidly-grounded wye systems, provide factory-installed main bonding jumper between neutral and ground busses, and removable neutral disconnecting link for testing purposes.
  - 3. Comply with Utility Company requirements for electrical service.
  - 4. See Section 262100 for additional requirements.
- F. Service Conditions:
  - 1. Provide switchboards and associated components suitable for operation under the following service conditions without derating:
    - a. Altitude: Less than 6,600 feet.
    - b. Ambient Temperature:
      - 1) Switchboards Containing Molded Case or Insulated Case Circuit Breakers: Between 23 degrees F and 104 degrees F.
  - 2. Provide switchboards and associated components suitable for operation at indicated ratings under the service conditions at the installed location.
- G. Short Circuit Current Rating:
  - 1. Provide switchboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.

2. Minimum Rating: 65,000 rms symmetrical amperes.
- H. Main Devices: Configure for top or bottom incoming feed as indicated or as required for the installation. Provide separate pull section and/or top-mounted pullbox as indicated or as required to facilitate installation of incoming feed.
- I. Bussing: Sized in accordance with UL 891 temperature rise requirements.
  1. Through bus (horizontal cross bus) to be fully rated through full length of switchboard (non-tapered). Tapered bus is not permitted.
  2. Provide solidly bonded equipment ground bus through full length of switchboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
  3. Phase and Neutral Bus Material: Copper.
  4. Ground Bus Material: Copper.
- J. Conductor Terminations: Suitable for use with the conductors to be installed.
  1. Line Conductor Terminations:
    - a. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.
    - b. Main and Neutral Lug Type: Mechanical.
  2. Load Conductor Terminations:
    - a. Lug Material: Copper, suitable for terminating copper conductors only.
    - b. Lug Type:
      - 1) Provide mechanical lugs unless otherwise indicated.
- K. Enclosures:
  1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1 or Type 2 (drip-proof).
  2. Finish: Manufacturer's standard unless otherwise indicated.
- L. Future Provisions:
  1. Prepare designated spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
  2. Equip distribution sections with full height vertical bussing to accommodate maximum utilization of space for devices.
- M. Owner Metering:
  1. Provide microprocessor-based digital electrical metering system including all instrument transformers, wiring, and connections necessary for measurements specified.
  2. Measured Parameters:
    - a. Voltage (Volts AC): Line-to-line, line-to-neutral for each phase.
    - b. Current (Amps): For each phase and neutral.
    - c. Frequency (Hz).
    - d. Real power (kW): For each phase, 3-phase total.
    - e. Reactive power (kVAR): For each phase, 3-phase total.
    - f. Apparent power (kVA): For each phase, 3-phase total.
    - g. Power factor.
  3. Meter Accuracy: Plus/minus 1.0 percent.
- N. Instrument Transformers:
  1. Comply with IEEE C57.13.
  2. Select suitable ratio, burden, and accuracy as required for connected devices.
  3. Current Transformers: Connect secondaries to shorting terminal blocks.
  4. Potential Transformers: Include primary and secondary fuses with disconnecting means.

## 2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Circuit Breakers:
  1. Interrupting Capacity:
    - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than specified minimum requirements.



- b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
- 2. Molded Case Circuit Breakers:
  - a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
    - 1) Provide electronic trip circuit breakers for circuit breaker frame sizes 400 amperes and above.
  - b. Minimum Interrupting Capacity:
    - 1) 65000 rms symmetrical amperes at 240 VAC or 208 VAC.
  - c. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
    - 1) Provide the following field-adjustable trip response settings:
      - (a) Long time pickup, adjustable by setting dial.
      - (b) Long time delay.
      - (c) Short time pickup and delay.
      - (d) Instantaneous pickup.

## 2.04 SOURCE QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Factory test switchboards according to NEMA PB 2, including the following production (routine) tests on each switchboard assembly or component:
  - 1. Dielectric tests.
  - 2. Mechanical operation tests.
  - 3. Grounding of instrument transformer cases test.
  - 4. Electrical operation and control wiring tests, including polarity and sequence tests.
  - 5. Ground-fault sensing equipment test.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the switchboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive switchboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### 3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install switchboards in accordance with NECA 1 (general workmanship), NECA 400, and NEMA PB 2.1.
- C. Arrange equipment to provide required clearances and maintenance access, including accommodations for any drawout devices.
- D. Where switchboard is indicated to be mounted with inaccessible side against wall, provide minimum clearance of 1/2 inch between switchboard and wall.
- E. Provide required support and attachment in accordance with Section 260529.
- F. Install switchboards plumb and level.
- G. Unless otherwise indicated, mount switchboards on properly sized 4 inch high concrete pad constructed in accordance with Section 033000.
- H. Provide grounding and bonding in accordance with Section 260526.
- I. Install all field-installed devices, components, and accessories.
- J. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- K. Set field-adjustable circuit breaker tripping function settings as directed.

- L. Provide filler plates to cover unused spaces in switchboards.
- M. Identify switchboards in accordance with Section 260553.

### **3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's reports with submittals.
- C. Before energizing switchboard, perform insulation resistance testing in accordance with NECA 400 and NEMA PB 2.1.
- D. Inspect and test in accordance with NETA ATS, except Section 4.
- E. Perform inspections and tests listed in NETA ATS, Section 7.1.
- F. Molded Case and Insulated Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than 400 amperes. Tests listed as optional are not required.
- G. Meters: Perform inspections and tests listed in NETA ATS, Section 7.11.2.
- H. Instrument Transformers: Perform inspections and tests listed in NETA ATS, Section 7.10. The dielectric withstand tests on primary windings with secondary windings connected to ground listed as optional are not required.
- I. Correct deficiencies and replace damaged or defective switchboards or associated components.

### **3.04 ADJUSTING**

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of switchboard covers and doors.

### **3.05 CLEANING**

- A. Clean dirt and debris from switchboard enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred surfaces to match original factory finish.

### **3.06 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. See Section 017900 - Demonstration and Training, for additional requirements.
- C. Training: Train Owner's personnel on operation, adjustment, and maintenance of switchboard and associated devices.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.
  - 3. Instructor: Manufacturer's authorized representative.
  - 4. Location: At project site.

### **3.07 PROTECTION**

- A. Protect installed switchboards from subsequent construction operations.

**END OF SECTION**

**SECTION 262416  
PANELBOARDS****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Power distribution panelboards.
- B. Lighting and appliance panelboards.
- C. Overcurrent protective devices for panelboards.

**1.02 RELATED REQUIREMENTS**

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260529 - Hangers and Supports for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.

**1.03 REFERENCE STANDARDS**

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service 2013e (Amended 2017).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA 407 - Standard for Installing and Maintaining Panelboards 2015.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- E. NEMA PB 1 - Panelboards 2011.
- F. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less 2013.
- G. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- H. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- K. UL 67 - Panelboards Current Edition, Including All Revisions.
- L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.
- M. UL 943 - Ground-Fault Circuit-Interrupters Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
  - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

**1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.

- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
  - 1. Include characteristic trip curves for each type and rating of overcurrent protective device for all main panel circuit breakers..
- C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
  - 1. Include dimensioned plan and elevation views of panelboards and adjacent equipment with all required clearances indicated.
  - 2. Include wiring diagrams showing all factory and field connections.

## **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

## **1.08 FIELD CONDITIONS**

- A. Maintain ambient temperature within the following limits during and after installation of panelboards:
  - 1. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Eaton Corporation: [www.eaton.com/#sle](http://www.eaton.com/#sle).
- B. Schneider Electric; Square D Products: [www.schneider-electric.us/#sle](http://www.schneider-electric.us/#sle).
- C. Siemens Industry, Inc: [www.usa.siemens.com/#sle](http://www.usa.siemens.com/#sle).
- D. General Electric.
- E. Substitutions: See Section 016000 - Product Requirements.
- F. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

### **2.02 PANELBOARDS - GENERAL REQUIREMENTS**

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
  - 1. Altitude: Less than 6,600 feet.
  - 2. Ambient Temperature:
    - a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
- C. Short Circuit Current Rating:
  - 1. Provide panelboards with listed short circuit current rating as indicated on the drawings.
- D. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.

- E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- F. Bussing: Sized in accordance with UL 67 temperature rise requirements.
  - 1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
  - 2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
- G. Conductor Terminations: Suitable for use with the conductors to be installed.
- H. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1.
    - b. Outdoor Locations: Type 3R.
  - 2. Boxes: Galvanized steel unless otherwise indicated.
    - a. Provide wiring gutters sized to accommodate the conductors to be installed.
    - b. Increase gutter space as required where sub-feed lugs, feed-through lugs, gutter taps, or oversized lugs are provided.
  - 3. Fronts:
    - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
    - b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
    - c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
  - 4. Lockable Doors: All locks keyed alike unless otherwise indicated.
- I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- J. Load centers are not acceptable.

### 2.03 POWER DISTRIBUTION PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Products:
  - 1. Square D I-Line.
  - 2. General Electric Spectra Power Panelboards.
- C. Conductor Terminations:
  - 1. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.
  - 2. Main and Neutral Lug Type: Mechanical.
- D. Bussing:
  - 1. Phase and Neutral Bus Material: Copper.
  - 2. Ground Bus Material: Copper.
- E. Circuit Breakers:
  - 1. Provide bolt-on type.
  - 2. Provide electronic trip circuit breakers where indicated.
- F. Enclosures:
  - 1. Provide surface-mounted enclosures unless otherwise indicated.
  - 2. Fronts: Provide door-in-door trim with hinged cover for access to load terminals and wiring gutters, and separate lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
  - 3. Provide clear plastic circuit directory holder mounted on inside of door.

### 2.04 LIGHTING AND APPLIANCE PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings,

configurations and features as indicated on the drawings.

- B. Products:
  - 1. Square D NQO.
  - 2. Eaton .
  - 3. General Electric A Series II.
  - 4. Substitutions: See Section 016000 - Product Requirements.
- C. Conductor Terminations:
  - 1. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.
  - 2. Main and Neutral Lug Type: Mechanical.
- D. Bussing:
  - 1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
  - 2. Phase and Neutral Bus Material: Copper.
  - 3. Ground Bus Material: Copper.
- E. Circuit Breakers: Thermal magnetic bolt-on type unless otherwise indicated.
- F. Enclosures:
  - 1. Provide surface-mounted or flush-mounted enclosures as indicated.
  - 2. Fronts: Provide door-in-door trim with hinged cover for access to load terminals and wiring gutters, and separate lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
  - 3. Provide clear plastic circuit directory holder mounted on inside of door.

## 2.05 OVERCURRENT PROTECTIVE DEVICES

- A. Molded Case Circuit Breakers:
  - 1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
  - 2. Interrupting Capacity:
    - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
      - 1) 22000 rms symmetrical amperes at 240 VAC or 208 VAC.
    - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
  - 3. Conductor Terminations:
    - a. Provide mechanical lugs unless otherwise indicated.
    - b. Lug Material: Copper, suitable for terminating copper conductors only.
  - 4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
    - a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
  - 5. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
  - 6. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
  - 7. Provide the following circuit breaker types where indicated:
    - a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
  - 8. Provide listed switching duty rated circuit breakers with SWD marking for all branch circuits serving fluorescent lighting.
  - 9. Do not use tandem circuit breakers.
  - 10. Do not use handle ties in lieu of multi-pole circuit breakers.

## 2.06 SOURCE QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Factory test panelboards according to NEMA PB 1.

**PART 3 EXECUTION****3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

**3.02 INSTALLATION**

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required support and attachment in accordance with Section 260529.
- F. For interior flush mounted panelboard replacement, provide all interior bussing, circuit breakers and hinged door-in-door panel cover. Reuse existing panel backbox. Refer to panel schedules on VG E900 series drawings.
- G. Install panelboards plumb.
- H. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- I. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- J. Provide minimum of six spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.
- K. Provide grounding and bonding in accordance with Section 260526.
- L. Install all field-installed branch devices, components, and accessories.
- M. Provide filler plates to cover unused spaces in panelboards.
- N. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads as directed. Also provide for the following:
  - 1. Fire detection and alarm circuits.
- O. Identify panelboards in accordance with Section 260553.

**3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than [ ] amperes. Tests listed as optional are not required.
- D. Test GFCI circuit breakers to verify proper operation.
- E. Correct deficiencies and replace damaged or defective panelboards or associated components.

**3.04 ADJUSTING**

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.
- C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

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### **3.05 CLEANING**

- A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

**END OF SECTION**



**SECTION 262726  
WIRING DEVICES****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Receptacles.
- B. Wall plates.
- C. Floor box service fittings.

**1.02 RELATED REQUIREMENTS**

- A. Section 260533.16 - Boxes for Electrical Systems.
- B. Section 271000 - Structured Cabling: Voice and data jacks.

**1.03 REFERENCE STANDARDS**

- A. FS W-C-596 - Connector, Electrical, Power, General Specification for 2017h.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2010.
- D. NEMA WD 1 - General Color Requirements for Wiring Devices 1999 (Reaffirmed 2015).
- E. NEMA WD 6 - Wiring Devices - Dimensional Specifications 2016.
- F. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. UL 498 - Attachment Plugs and Receptacles Current Edition, Including All Revisions.
- H. UL 514D - Cover Plates for Flush-Mounted Wiring Devices Current Edition, Including All Revisions.
- I. UL 943 - Ground-Fault Circuit-Interruption Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
  - 2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
  - 3. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
  - 4. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

**1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.

**1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Products: Listed, classified, and labeled as suitable for the purpose intended.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

**1.07 DELIVERY, STORAGE, AND PROTECTION**

- A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

**PART 2 PRODUCTS****2.01 WIRING DEVICE APPLICATIONS**

- A. Provide wiring devices suitable for intended use and with ratings adequate for load served.
- B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.
- C. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations.
- D. Provide GFCI protection for receptacles installed within 6 feet of sinks.
- E. Provide GFCI protection for receptacles installed in kitchens.
- F. Provide GFCI protection for receptacles serving electric drinking fountains.
- G. Unless noted otherwise, do not use combination switch/receptacle devices.
- H. For flush floor service fittings, use carpet flanges for installations in carpeted floors.

**2.02 WIRING DEVICE FINISHES**

- A. Provide wiring device finishes as described below unless otherwise indicated.
- B. Wiring Devices, Unless Otherwise Indicated: White with brushed stainless steel wall plate.
- C. Wiring Devices Installed in Finished Spaces: White with brushed stainless steel wall plate.
- D. Wiring Devices Installed in Unfinished Spaces: Gray with brushed stainless steel wall plate.
- E. Wiring Devices Installed in Wet or Damp Locations: Gray with specified weatherproof cover.
- F. Flush Floor Box Service Fittings: Gray wiring devices with aluminum cover and ring/flange.

**2.03 RECEPTACLES**

- A. Manufacturers:
  - 1. Hubbell Incorporated: [www.hubbell.com/#sle](http://www.hubbell.com/#sle).
  - 2. Leviton Manufacturing Company, Inc: [www.leviton.com/#sle](http://www.leviton.com/#sle).
  - 3. Lutron Electronics Company, Inc; Designer Style: [www.lutron.com/#sle](http://www.lutron.com/#sle).
  - 4. Pass & Seymour, a brand of Legrand North America, Inc: [www.legrand.us/#sle](http://www.legrand.us/#sle).
  - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
  - 1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
  - 2. NEMA configurations specified are according to NEMA WD 6.
- C. Convenience Receptacles:
  - 1. Standard Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.
    - a. Products:
      - 1) Legrand.
      - 2) Pass & Seymour.
      - 3) Leviton.
      - 4) Substitutions: See Section 016000 - Product Requirements.
- D. GFCI Receptacles:
  - 1. GFCI Receptacles - General Requirements: Self-testing, with feed-through protection and light to indicate ground fault tripped condition and loss of protection; listed as complying with UL 943, class A.
    - a. Provide test and reset buttons of same color as device.
  - 2. Standard GFCI Receptacles: Commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style.
    - a. Products:
      - 1) Hubbell Incorporated: [www.hubbell.com/#sle](http://www.hubbell.com/#sle).
      - 2) Legrand.

- 3) Pass & Seymour.
- 4) Leviton.
- 5) Substitutions: See Section 016000 - Product Requirements.
- 3. Weather Resistant GFCI Receptacles: Commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations.
  - a. Products:
    - 1) Legrand.
    - 2) Pass & Seymour.
    - 3) Leviton.
    - 4) Substitutions: See Section 016000 - Product Requirements.

## 2.04 WALL PLATES

- A. Manufacturers:
  - 1. Hubbell Incorporated: [www.hubbell-wiring.com/#sle](http://www.hubbell-wiring.com/#sle).
  - 2. Leviton Manufacturing Company, Inc: [www.leviton.com/#sle](http://www.leviton.com/#sle).
  - 3. Lutron Electronics Company, Inc: [www.lutron.com/#sle](http://www.lutron.com/#sle).
  - 4. Pass & Seymour, a brand of Legrand North America, Inc: [www.legrand.us/#sle](http://www.legrand.us/#sle).
  - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Wall Plates: Comply with UL 514D.
  - 1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
  - 2. Size: Standard.
  - 3. Screws: Metal with slotted heads finished to match wall plate finish.
- C. Stainless Steel Wall Plates: Brushed satin finish, Type 302 stainless steel.
- D. Weatherproof Covers for Damp Locations: Gasketed, cast aluminum, with self-closing hinged cover and corrosion-resistant screws; listed as suitable for use in wet locations with cover closed.

## 2.05 FLOOR BOX SERVICE FITTINGS

- A. Manufacturers:
  - 1. Hubbell Incorporated: [www.hubbell.com/#sle](http://www.hubbell.com/#sle).
  - 2. Thomas & Betts Corporation: [www.tnb.com/#sle](http://www.tnb.com/#sle).
  - 3. Wiremold, a brand of Legrand North America, Inc: [www.legrand.us/#sle](http://www.legrand.us/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Description: Service fittings compatible with floor boxes provided under Section 260533.16 with components, adapters, and trims required for complete installation.
- C. Flush Floor Service Fittings:
  - 1. Single Service Flush Convenience Receptacles:
    - a. Cover: Rectangular.
    - b. Configuration: One standard convenience duplex receptacle(s) with duplex flap opening(s).
  - 2. Dual Service Flush Combination Outlets:
    - a. Cover: Rectangular.
    - b. Configuration:
      - 1) Power: One standard convenience duplex receptacle(s) with duplex flap opening(s).
      - 2) Communications: [\_\_\_\_\_].
      - 3) Voice and Data Jacks: As specified in Section 271000.
  - 3. Accessories:
    - a. Carpet Flanges: Finish to match covers; configuration as required to accommodate specified covers.
  - 4. Products:
    - a. Hubbell Incorporated: [www.hubbell.com/#sle](http://www.hubbell.com/#sle).
    - b. FBS Floor Systems CO1 .
    - c. FBS Floor Systems C2X.

- d. Substitutions: See Section 016000 - Product Requirements.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that floor boxes are adjusted properly.
- F. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- G. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 PREPARATION**

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

### **3.03 INSTALLATION**

- A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of wiring devices provided under this section.
  - 1. Mounting Heights: Unless otherwise indicated, as follows:
    - a. Receptacles: 18 inches above finished floor or 6 inches above counter.
  - 2. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
  - 3. Where multiple receptacles, wall switches, or wall dimmers are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
  - 4. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.
- C. Install wiring devices in accordance with manufacturer's instructions.
- D. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- E. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.
- F. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.
- G. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- H. Provide GFCI receptacles with integral GFCI protection at each location indicated. Do not use feed-through wiring to protect downstream devices.
- I. Install wiring devices plumb and level with mounting yoke held rigidly in place.
- J. Install wall switches with OFF position down.
- K. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.
- L. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.

- M. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.

#### **3.04 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect each wiring device for damage and defects.
- C. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.
- D. Test each receptacle to verify operation and proper polarity.
- E. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.
- F. Correct wiring deficiencies and replace damaged or defective wiring devices.

#### **3.05 ADJUSTING**

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust presets for wall dimmers according to manufacturer's instructions as directed by Architect.

#### **3.06 CLEANING**

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

**END OF SECTION**

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**SECTION 262816.16  
ENCLOSED SWITCHES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Enclosed safety switches.

**1.02 RELATED REQUIREMENTS**

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260529 - Hangers and Supports for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 262813 - Fuses.

**1.03 REFERENCE STANDARDS**

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum) 2013.
- D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- G. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- H. UL 98 - Enclosed and Dead-Front Switches Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  - 4. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

**1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
- D. Field Quality Control Test Reports.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- F. Project Record Documents: Record actual locations of enclosed switches.
- G. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

## **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

## **1.08 FIELD CONDITIONS**

- A. Maintain ambient temperature between -22 degrees F and 104 degrees F during and after installation of enclosed switches.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. ABB/GE: [www.geindustrial.com/#sle](http://www.geindustrial.com/#sle).
- B. Eaton Corporation: [www.eaton.com/#sle](http://www.eaton.com/#sle).
- C. Schneider Electric; Square D Products: [www.schneider-electric.us/#sle](http://www.schneider-electric.us/#sle).
- D. Siemens Industry, Inc: [www.usa.siemens.com/#sle](http://www.usa.siemens.com/#sle).
- E. Substitutions: See Section 016000 - Product Requirements.
- F. Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

## **2.02 ENCLOSED SAFETY SWITCHES**

- A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
  - 1. Altitude: Less than 6,600 feet.
  - 2. Ambient Temperature: Between -22 degrees F and 104 degrees F.
- D. Horsepower Rating: Suitable for connected load.
- E. Voltage Rating: Suitable for circuit voltage.
- F. Short Circuit Current Rating:
  - 1. Provide enclosed safety switches, when protected by the fuses or supply side overcurrent protective devices to be installed, with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
  - 2. Minimum Ratings:
    - a. Switches Protected by Class H Fuses: 10,000 rms symmetrical amperes.
    - b. Heavy Duty Single Throw Switches Protected by Class R, Class J, Class L, or Class T Fuses: 200,000 rms symmetrical amperes.
- G. Provide with switch blade contact position that is visible when the cover is open.
- H. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
- I. Conductor Terminations: Suitable for use with the conductors to be installed.



- J. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- K. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1.
    - b. Outdoor Locations: Type 3R.
  - 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
- L. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- M. Heavy Duty Switches:
  - 1. Products:
    - a. Substitutions: See Section 016000 - Product Requirements.
  - 2. Comply with NEMA KS 1.
  - 3. Conductor Terminations:
    - a. Provide mechanical lugs unless otherwise indicated.
    - b. Lug Material: Copper, suitable for terminating copper conductors only.
  - 4. Provide externally operable handle with means for locking in the OFF position, capable of accepting three padlocks.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings of the enclosed switches are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed safety switches.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment in accordance with Section 260529.
- E. Install enclosed switches plumb.
- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G. Provide grounding and bonding in accordance with Section 260526.
- H. Provide fuses complying with Section 262813 for fusible switches as indicated or as required by equipment manufacturer's recommendations.
- I. Identify enclosed switches in accordance with Section 260553.

### **3.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.
- D. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

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#### **3.04 ADJUSTING**

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

#### **3.05 CLEANING**

- A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

**END OF SECTION**

## **SECTION 265100 INTERIOR LIGHTING**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Interior luminaires.
- B. Exit signs.
- C. Ballasts and drivers.
- D. Accessories.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 260529 - Hangers and Supports for Electrical Systems.
- B. Section 260533.16 - Boxes for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 260923 - Lighting Control Devices.

#### **1.03 REFERENCE STANDARDS**

- A. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code) 2013 (Corrigendum 2019).
- B. IES LM-79 - Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products 2008.
- C. IES LM-80 - Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules 2015, with Errata (2017).
- D. NECA/IESNA 500 - Standard for Installing Indoor Commercial Lighting Systems 2006.
- E. NECA/IESNA 502 - Standard for Installing Industrial Lighting Systems 2006.
- F. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. NFPA 101 - Life Safety Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL 924 - Emergency Lighting and Power Equipment Current Edition, Including All Revisions.
- I. UL 1598 - Luminaires Current Edition, Including All Revisions.
- J. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products Current Edition, Including All Revisions.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
  - 2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
  - 3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
  - 4. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings:

1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
2. Provide photometric calculations where luminaires are proposed for substitution upon request.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.
  1. LED Luminaires:
    - a. Include estimated useful life, calculated based on IES LM-80 test data.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Operation and Maintenance Data: Instructions for each product including information on replacement parts.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  1. See Section 016000 - Product Requirements, for additional provisions.
  2. Extra Lenses and Louvers: Two percent of total quantity installed for each type, but not less than one of each type.
- G. Project Record Documents: Record actual connections and locations of luminaires and any associated remote components.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### **1.07 DELIVERY, STORAGE, AND PROTECTION**

- A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

#### **1.08 FIELD CONDITIONS**

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

#### **1.09 WARRANTY**

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide three year manufacturer warranty for LED luminaires, including drivers.

### **PART 2 PRODUCTS**

#### **2.01 LUMINAIRE TYPES**

- A. Furnish products as indicated in luminaire schedule included on the drawings.

#### **2.02 LUMINAIRES**

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.

- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.
- F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- G. LED Luminaires:
  - 1. Components: UL 8750 recognized or listed as applicable.
  - 2. Tested in accordance with IES LM-79 and IES LM-80.
  - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.
- H. LED Tape Lighting Systems: Provide all power supplies, drivers, cables, connectors, channels, covers, mounting accessories, and interfaces as necessary to complete installation.
  - 1. LED Tape - General Requirements:
    - a. Listed.
    - b. Designed for field cutting in accordance with listing.
    - c. Wet Location Applications: IEC 60529, IP 68 (waterproof) rated.
- I. Luminaires Mounted in Continuous Rows: Provide quantity of units required for length indicated, with all accessories required for joining and aligning.

### 2.03 EXIT SIGNS

- A. Description: Exit signs complying with NFPA 101 and applicable state and local codes, and listed and labeled as complying with UL 924.
  - 1. Number of Faces: Single- or double-face as indicated or as required for installed location.
  - 2. Directional Arrows: As indicated or as required for installed location.
- B. Powered Exit Signs: Internally illuminated with LEDs unless otherwise indicated.

### 2.04 BALLASTS AND DRIVERS

- A. Ballasts/Drivers - General Requirements:
  - 1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
  - 2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.
- B. Dimmable LED Drivers:
  - 1. Dimming Range: Continuous dimming from 100 percent to five percent relative light output unless dimming capability to lower level is indicated, without flicker.
  - 2. Control Compatibility: Fully compatible with the dimming controls to be installed.
    - a. Daylighting Controls: See Section 260923.

### 2.05 LED EMERGENCY POWER SUPPLY UNITS

- A. Manufacturers:
  - 1. Iota Engineering, LLC: [www.iotaengineering.com/#sle](http://www.iotaengineering.com/#sle).
  - 2. Lithonia Lighting: [www.lithonia.com/#sle](http://www.lithonia.com/#sle).
  - 3. Philips Emergency Lighting/Bodine: [www.bodine.com/#sle](http://www.bodine.com/#sle).
  - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Description: Self-contained LED emergency power supply units suitable for use with indicated luminaires, complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
- C. Compatibility:
  - 1. LED Drivers: Compatible with LED dimming drivers.
- D. Operation: Upon interruption of normal power source, solid-state control automatically switches connected lamp(s) to the fluorescent emergency power supply for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
- E. Emergency Illumination Output:

- F. Diagnostics: Provide accessible and visible multi-chromatic combination test switch/indicator light to display charge, test, and diagnostic status and to manually activate emergency operation.
- G. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status and field selectable audible alert.
- H. Operating Temperature: From 32 degrees F to 122 degrees F unless otherwise indicated or required for the installed location.
- I. Accessories:
  - 1. Provide compatible accessory remote combination test switch/indicator light where indicated.

## **2.06 ACCESSORIES**

- A. Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.
- B. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4" size, field-painted as directed.
- C. Provide accessory plaster frames for luminaires recessed in plaster ceilings.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 PREPARATION**

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

### **3.03 INSTALLATION**

- A. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of luminaires provided under this section.
- B. Install products in accordance with manufacturer's instructions.
- C. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting) and NECA 502 (industrial lighting).
- D. Provide required support and attachment in accordance with Section 260529.
- E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- F. Suspended Ceiling Mounted Luminaires:
  - 1. Do not use ceiling tiles to bear weight of luminaires.
  - 2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.
  - 3. Secure surface-mounted and recessed luminaires to ceiling support channels or framing members or to building structure.
  - 4. Secure pendant-mounted luminaires to building structure.
  - 5. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
  - 6. In addition to ceiling support wires, provide two galvanized steel safety wire(s), minimum 12 gauge, connected from opposing corners of each recessed luminaire to building structure.

7. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.
- G. Recessed Luminaires:
  1. Install trims tight to mounting surface with no visible light leakage.
  2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.
- H. Suspended Luminaires:
  1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
  2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
  3. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet nominal length, with no more than 4 feet between supports.
  4. Install canopies tight to mounting surface.
  5. Unless otherwise indicated, support pendants from swivel hangers.
- I. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- J. Install accessories furnished with each luminaire.
- K. Bond products and metal accessories to branch circuit equipment grounding conductor.
- L. Exit Signs:
  1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- M. LED Emergency Power Supply Units:
  1. For field-installed units, install inside luminaire unless otherwise indicated. Where installation inside luminaire is not possible, install on top of luminaire.
  2. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal ballast(s) in luminaire. Bypass local switches, contactors, or other lighting controls.
- N. Identify luminaires connected to emergency power system in accordance with Section 260553.
- O. Install lamps in each luminaire.

### **3.04 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect each product for damage and defects.
- C. Operate each luminaire after installation and connection to verify proper operation.
- D. Test self-powered exit signs, emergency lighting units, and fluorescent emergency power supply units to verify proper operation upon loss of normal power supply.
- E. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.

### **3.05 ADJUSTING**

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.
- B. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Architect or authority having jurisdiction.

### **3.06 CLEANING**

- A. Clean surfaces according to NECA 500 (commercial lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

### **3.07 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals, for closeout submittals.

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- B. Demonstration: Demonstrate proper operation of luminaires to Architect, and correct deficiencies or make adjustments as directed.
- C. Just prior to Substantial Completion, replace all lamps that have failed.

### **3.08 PROTECTION**

- A. Protect installed luminaires from subsequent construction operations.

**END OF SECTION**



## **SECTION 265600 EXTERIOR LIGHTING**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

- A. Exterior luminaires.
- B. Ballasts.
- C. Poles and accessories.

#### **1.02 RELATED REQUIREMENTS**

- A. Section 033000 - Cast-in-Place Concrete: Materials and installation requirements for concrete bases for poles.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260529 - Hangers and Supports for Electrical Systems.
- D. Section 260533.16 - Boxes for Electrical Systems.

#### **1.03 REFERENCE STANDARDS**

- A. AASHTO LTS - Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signal 2013 (Revised 2019).
- B. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code) 2013 (Corrigendum 2019).
- C. IEEE C2 - National Electrical Safety Code 2017.
- D. IES LM-79 - Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products 2008.
- E. IES LM-80 - Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules 2015, with Errata (2017).
- F. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- G. NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems 2006.
- H. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 1598 - Luminaires Current Edition, Including All Revisions.
- J. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products Current Edition, Including All Revisions.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc. installed under other sections or by others. Coordinate elevation to obtain specified foundation height.
  - 2. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings:
  - 1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
  - 2. Provide photometric calculations where luminaires are proposed for substitution upon request.
  - 3. Provide structural calculations for each pole proposed for substitution.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, weight, effective projected area (EPA), and installed accessories; include model number nomenclature

clearly marked with all proposed features.

1. LED Luminaires:
  - a. Include estimated useful life, calculated based on IES LM-80 test data.
2. Poles: Include information on maximum supported effective projected area (EPA) and weight for the design wind speed.
- D. Certificates for Poles and Accessories: Manufacturer's documentation that products are suitable for the luminaires to be installed and comply with designated structural design criteria.
- E. Field Quality Control Reports.
- F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- G. Operation and Maintenance Data: Instructions for each product including information on replacement parts.
- H. Project Record Documents: Record actual connections and locations of pole foundations, luminaires, and any pull or junction boxes.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, handle, and store products according to NECA/IESNA 501 and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

#### **1.08 WARRANTY**

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide three year manufacturer warranty for all LED luminaires, including drivers.

### **PART 2 PRODUCTS**

#### **2.01 LUMINAIRE TYPES**

- A. Furnish products as indicated in luminaire schedule included on the drawings.
- B. Substitutions: See Section 016000 - Product Requirements.

#### **2.02 LUMINAIRES**

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, poles, foundations, supports, trims, accessories, etc. as necessary for a complete operating system.
- F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- G. LED Luminaires:
  1. Components: UL 8750 recognized or listed as applicable.
  2. Tested in accordance with IES LM-79 and IES LM-80.

3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.
- H. LED Tape Lighting Systems: Provide all power supplies, drivers, cables, connectors, channels, covers, mounting accessories, and interfaces as necessary to complete installation.
  1. LED Tape - General Requirements:
    - a. Listed.
    - b. Designed for field cutting in accordance with listing.
    - c. Wet Location Applications: IEC 60529, IP 68 (waterproof) rated.

## 2.03 BALLASTS AND DRIVERS

- A. Ballasts/Drivers - General Requirements:
  1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
  2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.
- B. Dimmable LED Drivers:
  1. Dimming Range: Continuous dimming from 100 percent to five percent relative light output unless dimming capability to lower level is indicated, without flicker.
  2. Control Compatibility: Fully compatible with the dimming controls to be installed.

## 2.04 POLES

- A. All Poles:
  1. Provide poles and associated support components suitable for the luminaire(s) and associated supports and accessories to be installed.
  2. Structural Design Criteria:
    - a. Comply with AASHTO LTS.
    - b. Wind Load: Include effective projected area (EPA) of luminaire(s) and associated supports and accessories to be installed.
    - c. Dead Load: Include weight of proposed luminaire(s) and associated supports and accessories.
  3. Material: Steel, unless otherwise indicated.
  4. Shape: Square straight, unless otherwise indicated.
  5. Finish: Match luminaire finish, unless otherwise indicated.
  6. Mounting: Install on concrete foundation, height as indicated on the drawings, unless otherwise indicated.
  7. Unless otherwise indicated, provide with the following features/accessories:
    - a. Top cap.
    - b. Handhole, 2"x4" size.
    - c. Anchor bolts with leveling nuts or leveling shims.
    - d. Anchor base cover.
    - e. Brackets: [\_\_\_\_\_].
- B. Metal Poles: Provide ground lug, accessible from handhole or transformer base.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

### 3.02 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of luminaires provided under this section.

- B. Install products in accordance with manufacturer's instructions.
- C. Install luminaires in accordance with NECA/IESNA 501.
- D. Provide required support and attachment in accordance with Section 260529.
- E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- F. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- G. Pole-Mounted Luminaires:
  - 1. Maintain the following minimum clearances:
    - a. Comply with IEEE C2.
    - b. Comply with utility company requirements.
  - 2. Foundation-Mounted Poles:
    - a. Provide cast-in-place concrete foundations for poles as indicated, in accordance with Section 033000.
      - 1) Install anchor bolts plumb per template furnished by pole manufacturer.
      - 2) Position conduits to enter pole shaft.
    - b. Install foundations plumb.
    - c. Install poles plumb, using leveling nuts or shims as required to adjust to plumb.
    - d. Tighten anchor bolt nuts to manufacturer's recommended torque.
  - 3. Grounding:
    - a. Bond luminaires, metal accessories, metal poles, and foundation reinforcement to branch circuit equipment grounding conductor.
    - b. Provide supplementary ground rod electrode as specified in Section 260526 at each pole bonded to grounding system as indicated.
  - 4. Install separate service conductors, 12 AWG copper, from each luminaire down to handhole for connection to branch circuit conductors.
- H. Install accessories furnished with each luminaire.
- I. Bond products and metal accessories to branch circuit equipment grounding conductor.
- J. Install lamps in each luminaire.

### 3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect each product for damage and defects.
- C. Operate each luminaire after installation and connection to verify proper operation.
- D. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.

### 3.04 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.
- B. Luminaires with Field-Rotatable Optics: Position optics according to manufacturer's instructions to achieve lighting distribution as indicated or as directed by Architect.

### 3.05 CLEANING

- A. Clean surfaces according to NECA/IESNA 501 and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

### 3.06 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of luminaires to Architect, and correct deficiencies or make adjustments as directed.
- C. Just prior to Substantial Completion, replace all lamps that have failed.

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### **3.07 PROTECTION**

- A. Protect installed luminaires from subsequent construction operations.

**END OF SECTION**

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**SECTION 271000  
STRUCTURED CABLING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Communications system design requirements.
- B. Communications pathways.
- C. Fiber optic cable and interconnecting devices.
- D. Communications equipment room fittings.
- E. Communications outlets.
- F. Communications grounding and bonding.
- G. Communications identification.

**1.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260533.13 - Conduit for Electrical Systems.
- D. Section 260533.16 - Boxes for Electrical Systems.
- E. Section 260553 - Identification for Electrical Systems: Identification products.

**1.03 REFERENCE STANDARDS**

- A. BICSI N1 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure, 1st Edition 2019.
- B. EIA/ECA-310 - Cabinets, Racks, Panels, and Associated Equipment Revision E, 2005.
- C. ICEA S-83-596 - Indoor Optical Fiber Cables 2016.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. TIA-455-21 - FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices 1988a (Reaffirmed 2012).
- F. TIA-492AAAC - Detail Specification for 850-nm Laser-Optimized, 50-um Core Diameter/125-um Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers 2009b.
- G. TIA-526-14 - Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant 2015c.
- H. TIA-568 (SET) - Commercial Building Telecommunications Cabling Standard Set 2019.
- I. TIA-568.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards 2009c, with Addendum (2016).
- J. TIA-568.3 - Optical Fiber Cabling and Components Standard 2016d.
- K. TIA-569 - Telecommunications Pathways and Spaces 2019e.
- L. TIA-598 - Optical Fiber Cable Color Coding 2014d.
- M. TIA-606 - Administration Standard for Telecommunications Infrastructure 2017c.
- N. TIA-607 - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises 2019d.
- O. UL 444 - Communications Cables Current Edition, Including All Revisions.
- P. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers Current Edition, Including All Revisions.
- Q. UL 1651 - Fiber Optic Cable Current Edition, Including All Revisions.
- R. UL 1863 - Communications-Circuit Accessories Current Edition, Including All Revisions.

#### 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for communications equipment.
  - 2. Coordinate arrangement of communications equipment with the dimensions and clearance requirements of the actual equipment to be installed.

#### 1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.
- C. Evidence of qualifications for installer.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- E. Field Test Reports.
- F. Project Record Documents: Prepared and approved by BICSI Registered Communications Distribution Designer (RCDD).
  - 1. Record actual locations of outlet boxes and distribution frames.
  - 2. Show as-installed color coding, pair assignment, polarization, and cross-connect layout.
  - 3. Identify distribution frames and equipment rooms by room number on drawings.
- G. Operation and Maintenance Data: List of all components with part numbers, sources of supply, and operation and maintenance instructions; include copy of project record documents.

#### 1.06 QUALITY ASSURANCE

- A. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- B. Manufacturer Qualifications: At least 3 years experience manufacturing products of the type specified.
- C. Installer Qualifications: A company having at least 3 years experience in the installation and testing of the type of system specified, and:
  - 1. Employing a BICSI Registered Communications Distribution Designer (RCDD).
  - 2. Supervisors and installers factory certified by manufacturers of products to be installed.
- D. Products: Listed, classified, and labeled as suitable for the purpose intended.
- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Keep stored products clean and dry.

#### 1.08 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a 2 year period after Date of Substantial Completion.

### PART 2 PRODUCTS

#### 2.01 SYSTEM DESIGN

- A. Provide a complete permanent system of cabling and pathways for voice and data communications, including cables, conduits and wireways, pull wires, support structures, enclosures and cabinets, and outlets.
  - 1. Comply with TIA-568 (SET) (cabling) and TIA-569 (pathways) (commercial standards).



2. Provide fixed cables and pathways that comply with NFPA 70 and TIA-607 and are UL listed or third party independent testing laboratory certified.
  3. Provide connection devices that are rated for operation under conditions of 32 to 140 degrees F at relative humidity of 0 to 95 percent, noncondensing.
  4. In this project, the term plenum is defined as return air spaces above ceilings, inside ducts, under raised floors, and other air-handling spaces.
- B. System Description:
1. Backbones - Within Building: Fiber optic, 12-Pair Multi-mode 50 micron -fiber.
  2. Offices and Work Areas: Provide one voice outlet and one data outlet in each work area.
  3. Classrooms: 2 -data outlets and cables.
  4. Provide additional outlets where indicated on drawings.
- C. Main Distribution Frame (MDF): Centrally located support structure for terminating backbone cables that extend to intermediate distribution frames (IDFs), functioning as point of presence to external service provider.
1. Existing main distribution frame as indicated on the drawings.
- D. Intermediate Distribution Frames (IDF): Support structures for terminating horizontal cables that extend to data outlets.
1. Locate intermediate distribution frames as indicated on the drawings.
- E. Backbone Cabling: Cabling, pathways, and terminal hardware connecting intermediate distribution frames (IDF's) with main distribution frame (MDF), wired in star topology with main distribution frame at center hub of star.
- F. Cabling to Outlets: Specified horizontal cabling, wired in star topology to distribution frame located at center hub of star; also referred to as "links".

## 2.02 PATHWAYS

- A. Conduit: As specified in Section 260533.13; provide pull cords in all conduit.
- B. Firestop Sleeves: Listed; provide as required to preserve fire resistance rating of building elements.
1. Products:
    - a. HoldRite, a brand of Reliance Worldwide Corporation; HydroFlame Pro Series/HydroFlame Custom Built: [www.holdrite.com/#sle](http://www.holdrite.com/#sle).
    - b. Substitutions: See Section 016000 - Product Requirements.

## 2.03 COPPER CABLE AND TERMINATIONS

- A. Manufacturers:
1. CommScope: [www.commscope.com/#sle](http://www.commscope.com/#sle).
  2. General Cable Technologies Corporation: [www.generalcable.com/#sle](http://www.generalcable.com/#sle).
  3. Siemon Company: [www.siemon.com/#sle](http://www.siemon.com/#sle).
  4. Substitutions: See Section 016000 - Product Requirements.
- B. Copper Horizontal Cable:
1. Description: 100 ohm, balanced twisted pair cable complying with TIA-568.2 and listed and labeled as complying with UL 444.
  2. Cable Type - Voice and Data: TIA-568.2 Category 6A UTP (unshielded twisted pair); 23 AWG.
  3. Cable Capacity: 4-pair.
  4. Cable Applications:
    - a. Plenum Applications: Use listed NFPA 70 Type CMP plenum cable.
    - b. Riser Applications: Use listed NFPA 70 Type CMR riser cable or Type CMP plenum cable.
    - c. General Purpose Applications: Use listed NFPA 70 Type CM/CMG general purpose cable, Type CMR riser cable, or Type CMP plenum cable.
  5. Cable Jacket Color -Data Cable: Blue.
  6. Cable Jacket Color - Voice Cable: Yellow.
  7. Product(s):

- a. CommScope; SYSTIMAX Twisted Pair Cables; GigaSPEED XL Category 6 U/UTP Cable: [www.commscope.com/#sle](http://www.commscope.com/#sle).
  - b. CommScope; Uniprise Twisted Pair Cables; CS34 Series Category 6 U/UTP Cable: [www.commscope.com/#sle](http://www.commscope.com/#sle).
  - c. General Cable Technologies Corporation; GenSPEED Cables: [www.generalcable.com/#sle](http://www.generalcable.com/#sle).
- C. Copper Cable Terminations: Insulation displacement connection (IDC) type using appropriate tool; use screw connections only where specifically indicated.
- D. Jacks and Connectors: Modular RJ-45, non-keyed, terminated with 110-style insulation displacement connectors (IDC); high impact thermoplastic housing; suitable for and complying with same standard as specified horizontal cable; UL 1863 listed.
  1. Performance: 500 mating cycles.
  2. Voice and Data Jacks: 8-position modular jack, color-coded for both T568A and T568B wiring configurations.
  3. Product(s):
    - a. CommScope; SYSTIMAX RJ45 Jacks; MGS400 Series Category 6 U/UTP Modular Jacks: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - b. CommScope; Uniprise RJ45 Jacks; UNJ600 Series Category 6 U/UTP Modular Jacks: [www.commscope.com/#sle](http://www.commscope.com/#sle).
- E. Copper Patch Cords:
  1. Description: Factory-fabricated 4-pair cable assemblies with 8-position modular connectors terminated at each end.
  2. Patch Cords for Patch Panels:
    - a. Quantity: One for each pair of patch panel ports.
    - b. Length: 3 feet.
  3. Patch Cords for Work Areas:
    - a. Quantity: One for each work area outlet port.
    - b. Length: 10 feet.
  4. Product(s):
    - a. CommScope; SYSTIMAX Category 6 U/UTP Patch Cords: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - b. CommScope; Uniprise Category 6 U/UTP Patch Cords: [www.commscope.com/#sle](http://www.commscope.com/#sle).

## 2.04 FIBER OPTIC CABLE AND INTERCONNECTING DEVICES

- A. Manufacturers:
  1. CommScope: [www.commscope.com/#sle](http://www.commscope.com/#sle).
  2. General Cable Technologies Corporation: [www.generalcable.com/#sle](http://www.generalcable.com/#sle).
  3. Siemon Company: [www.siemon.com/#sle](http://www.siemon.com/#sle).
  4. Substitutions: See Section 016000 - Product Requirements.
- B. Fiber Optic Backbone Cable:
  1. Description: Tight buffered, non-conductive fiber optic cable complying with TIA-568.3, TIA-598, ICEA S-83-596 and listed as complying with UL 444 and UL 1651.
  2. Cable Type: Multimode, laser-optimized 50/125 um (OM3) complying with TIA-492AAAC.
  3. Cable Capacity: 12 -fiber.
  4. Cable Applications:
    - a. Plenum Applications: Use listed NFPA 70 Type OFNP plenum cable.
  5. Cable Jacket Color:
    - a. Multimode Fiber (OM1/OM2): Orange.
  6. Product(s):
    - a. CommScope Fiber Optic Cables; TeraSpeed Zero Water Peak Single-Mode Fiber: [www.commscope.com/#sle](http://www.commscope.com/#sle).
- C. Fiber Optic Interconnecting Devices:
  1. Connector Type: Type Lc or SC, Coordinate with Owner's IT Department..

2. Connector Performance: 500 mating cycles, when tested in accordance with TIA-455-21.
3. Maximum Attenuation/Insertion Loss: 0.3 dB.
4. Product(s):
  - a. CommScope Fiber Optic Connectors; QWIK II-LC Fiber Connectors: [www.commscope.com/#sle](http://www.commscope.com/#sle).
- D. Fiber Optic Patch Cords:
  1. Description: Factory-fabricated 2-fiber cable assemblies with suitable connectors at each end.
  2. Patch Cords for Patch Panels:
    - a. Quantity: One for each pair of patch panel ports.
    - b. Length: 6 feet.
  3. Product(s):
    - a. CommScope Fiber Optic Patch Cords; TeraSpeed Fiber Patch Cords: [www.commscope.com/#sle](http://www.commscope.com/#sle).

## 2.05 COMMUNICATIONS EQUIPMENT ROOM FITTINGS

- A. Copper Cross-Connection Equipment:
  1. Manufacturers:
    - a. CommScope: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - b. Siemon Company: [www.siemon.com/#sle](http://www.siemon.com/#sle).
    - c. Substitutions: See Section 016000 - Product Requirements.
  2. Patch Panels for Copper Cabling: Sized to fit EIA/ECA-310 standard 19 inch wide equipment racks; 0.09 inch thick aluminum; cabling terminated on Type 110 insulation displacement connectors; printed circuit board interface.
    - a. Jacks: Non-keyed RJ-45, suitable for and complying with same standard as cable to be terminated; maximum 48 ports per standard width panel.
    - b. Capacity: Provide ports sufficient for cables to be terminated plus 25 percent spare.
    - c. Labels: Factory installed laminated plastic nameplates above each port, numbered consecutively; comply with TIA-606.
    - d. Provide incoming cable strain relief and routing guides on back of panel.
  3. Product(s):
    - a. CommScope; SYSTIMAX Copper Panels; 360-IPR-1100-XX Series Patch Panels: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - b. CommScope; Uniprise Copper Panels; UNP-XX-DM Series Patch Panels: [www.commscope.com/#sle](http://www.commscope.com/#sle).
- B. Fiber Optic Cross-Connection Equipment:
  1. Manufacturers:
    - a. CommScope: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - b. Siemon Company: [www.siemon.com/#sle](http://www.siemon.com/#sle).
  2. Patch Panels for Fiber Optic Cabling: Sized to fit EIA/ECA-310 standard 19 inch wide equipment racks; 0.09 inch thick aluminum.
    - a. Adapters: As specified above under FIBER OPTIC CABLE AND INTERCONNECTING DEVICES; maximum of 24 duplex adapters per standard panel width.
    - b. Labels: Factory installed laminated plastic nameplates above each port, numbered consecutively; comply with TIA-606.
    - c. Provide incoming cable strain relief and routing guides on back of panel.
    - d. Provide rear cable management tray at least 8 inches deep with removable cover.
    - e. Provide dust covers for unused adapters.
  3. Product(s):
    - a. CommScope; SYSTIMAX Fiber Panels; HD Series Patch Panels: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - b. CommScope; Uniprise Fiber Panels; SD Series Patch Panels: [www.commscope.com/#sle](http://www.commscope.com/#sle).
- C. Backboards: Interior grade plywood without voids, 3/4 inch thick; UL-labeled fire-retardant.

1. Do not paint over UL label.
- D. Equipment Frames, Racks and Cabinets:
  1. Manufacturers:
    - a. CommScope; [ ]: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - b. Siemon Company; [ ]: [www.siemon.com/#sle](http://www.siemon.com/#sle).
    - c. Substitutions: See Section 016000 - Product Requirements.
  2. Component Racks: EIA/ECA-310 standard 19 inch wide.
  3. Wall Mounted Racks: Steel construction, hinged to allow access to back of installed components.
  4. Wall Mounted Cabinets: Front doors with locks, louvered side panels, top and bottom cable access, and ground lug.
    - a. Cover inside of cabinet back with plywood backboard as specified.
    - b. Roof mounted fan, capacity 500 cfm.
  5. Cabinets: Steel construction with corrosion resistant finish.
  6. Locks: Keyed alike.
  7. Product(s):
- E. Cable Management:
  1. Manufacturers:
    - a. CommScope; [ ]: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - b. Siemon Company; [ ]: [www.siemon.com/#sle](http://www.siemon.com/#sle).
    - c. Substitutions: See Section 016000 - Product Requirements.
  2. Product(s):
    - a. CommScope Cable Runway: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - b. CommScope Horizontal/Vertical Cable Managers; HCM-SS-XX-XX/VCM-DS-XX-XX Series: [www.commscope.com/#sle](http://www.commscope.com/#sle).
    - c. CommScope FiberGuide Raceway: [www.commscope.com/#sle](http://www.commscope.com/#sle).

## 2.06 COMMUNICATIONS OUTLETS

- A. Outlet Boxes: Comply with Section 260533.16.
  1. Provide depth as required to accommodate cable manufacturer's recommended minimum conductor bend radius.
- B. Wall Plates:
  1. Comply with system design standards and UL 514C.
  2. Accepts modular jacks/inserts.
  3. Capacity:
    - a. Data or Combination Voice/Data Outlets: [ ] ports.
  4. Wall Plate Material/Finish - Flush-Mounted Outlets: High impact thermoplastic, color to be selected.
  5. Product(s):
    - a. CommScope Faceplates; M Series: [www.commscope.com/#sle](http://www.commscope.com/#sle).

## 2.07 GROUNDING AND BONDING COMPONENTS

- A. Comply with TIA-607.
- B. Comply with Section 260526.

## 2.08 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606.
- B. Comply with Section 260553.

## 2.09 SOURCE QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Factory test cables according to TIA-568 (SET).

## PART 3 EXECUTION

### 3.01 INSTALLATION - GENERAL

- A. Comply with latest editions and addenda of TIA-568 (SET) (cabling), TIA-569 (pathways), TIA-607 (grounding and bonding), BICSI N1, NFPA 70, and SYSTEM DESIGN as specified

in PART 2.

- B. Comply with Communication Service Provider requirements.
- C. Grounding and Bonding: Perform in accordance with TIA-607 and NFPA 70.
- D. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.

### 3.02 INSTALLATION OF PATHWAYS

- A. Install pathways with the following minimum clearances:
  - 1. 48 inches from motors, generators, frequency converters, transformers, x-ray equipment, and uninterruptible power systems.
  - 2. 12 inches from power conduits and cables and panelboards.
  - 3. 5 inches from fluorescent and high frequency lighting fixtures.
  - 4. 6 inches from flues, hot water pipes, and steam pipes.
- B. Conduit, in Addition to Requirements of Section 260533.13:
  - 1. Arrange conduit to provide no more than the equivalent of two 90 degree bend(s) between pull points.
  - 2. Conduit Bends: Inside radius not less than 10 times conduit internal diameter.
  - 3. Arrange conduit to provide no more than 100 feet between pull points.
  - 4. Do not use conduit bodies.
- C. Outlet Boxes:
  - 1. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of telecommunications outlets provided under this section.
    - a. Mounting Heights: Unless otherwise indicated, as follows:
      - 1) Telephone and Data Outlets: 18 inches above finished floor.
    - b. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
    - c. Provide minimum of 12 inches horizontal separation between flush mounted outlet boxes installed on opposite sides of fire rated walls.
    - d. Unless otherwise indicated, provide separate outlet boxes for line voltage and low voltage devices.
    - e. Locate outlet boxes so that wall plate does not span different building finishes.

### 3.03 INSTALLATION OF EQUIPMENT AND CABLING

- A. Cabling:
  - 1. Do not bend cable at radius less than manufacturer's recommended bend radius; for unshielded twisted pair use bend radius of not less than 4 times cable diameter.
  - 2. Do not over-cinch or crush cables.
  - 3. Do not exceed manufacturer's recommended cable pull tension.
  - 4. When installing in conduit, use only lubricants approved by cable manufacturer and do not chafe or damage outer jacket.
- B. Service Loops (Slack or Excess Length): Provide the following minimum extra length of cable, looped neatly:
  - 1. At Distribution Frames: 120 inches.
  - 2. At Outlets - Copper: 12 inches.
- C. Copper Cabling:
  - 1. Category 5e and Above: Maintain cable geometry; do not untwist more than 1/2 inch from point of termination.
  - 2. For 4-pair cables in conduit, do not exceed 25 pounds pull tension.
  - 3. Use T568B wiring configuration.
- D. Fiber Optic Cabling:
  - 1. Prepare for pulling by cutting outer jacket for 10 inches from end, leaving strength members exposed. Twist strength members together and attach to pulling eye.
  - 2. Support vertical cable at intervals as recommended by manufacturer.
- E. Wall-Mounted Racks and Enclosures:
  - 1. Install to plywood backboards only, unless otherwise indicated.
  - 2. Mount so height of topmost panel does not exceed 78 inches above floor.

- F. Identification:
  - 1. Use wire and cable markers to identify cables at each end.
  - 2. Use manufacturer-furnished label inserts, identification labels, or engraved wallplate to identify each jack at communications outlets with unique identifier.
  - 3. Use identification nameplate to identify cross-connection equipment, equipment racks, and cabinets.

### **3.04 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Comply with inspection and testing requirements of specified installation standards.
- C. Visual Inspection:
  - 1. Inspect cable jackets for certification markings.
  - 2. Inspect cable terminations for color coded labels of proper type.
  - 3. Inspect outlet plates and patch panels for complete labels.
  - 4. Inspect patch cords for complete labels.
- D. Testing - Copper Cabling and Associated Equipment:
  - 1. Test backbone cables after termination but before cross-connection.
  - 2. Category 5e and Above Backbone: Perform near end cross talk (NEXT) and attenuation tests.
  - 3. Category 5e and Above Links: Perform tests for wire map, length, attenuation, NEXT, and propagation delay.
- E. Testing - Fiber Optic Cabling:
  - 1. Backbone: Perform optical fiber end-to-end attenuation test using an optical time domain reflectometer (OTDR) and manufacturer's recommended test procedures; perform verification acceptance tests and factory reel tests.
  - 2. Multimode Backbone: Perform tests in accordance with TIA-526-14.
- F. Final Testing: After all work is complete, including installation of telecommunications outlets, and telephone dial tone service is active, test each voice jack for dial tone.

**END OF SECTION**

## **SECTION 275116 PUBLIC ADDRESS SYSTEMS**

### **PART 1 GENERAL**

#### **1.01 SECTION INCLUDES**

#### **1.02 RELATED REQUIREMENTS**

- A. Section 260526 - Grounding and Bonding for Electrical Systems.

#### **1.03 REFERENCE STANDARDS**

- A. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

#### **1.04 SYSTEM DESCRIPTION**

- A. Public address system for voice. Replace existing PA system rack and equipment mounted within rack. Replacement head end system rack and equipment shall be compatible with existing to remain Dukane. Reconnect and provide amplifier power for 50 plus existing speakers and 50 in room handsets. Verify in field exact quantities required to provide a complete and operational systems.
- B. Input components:
  - 1. Compact disc player.
  - 2. USB Input.
  - 3. MP3/USB music file player.
  - 4. AM/FM tuner.
  - 5. Master Microphone.
- C. Features:
  - 1. One-way paging by zone.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements. Indicate layout of equipment mounted in racks and cabinets, component interconnecting wiring, and wiring diagrams of field wiring to speakers and remote input devices.
- C. Product Data: Provide data showing electrical characteristics and connection requirements for each component.
- D. Test Reports: Indicate satisfactory completion of each test recommended by the manufacturer.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- F. Manufacturer's Field Reports: Indicate that installation is complete and system performs according to specified requirements.
- G. Project Record Documents: Record actual locations of speakers, control equipment, and outlets for input/output connectors.
- H. Operation Data: Include instructions for adjusting, operating, and extending the system.
- I. Maintenance Data: Include repair procedures and spare parts documentation.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70 and Federal Communications Commission.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience with service facilities within 100 miles of Project.
- C. Installer Qualifications: Authorized installer of specified manufacturer with service facilities within 100 miles of Project.
- D. Products: Listed, classified, and labeled as suitable for the purpose intended.

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

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Bogen Communications, Inc; [ ]: [www.bogen.com/#sle](http://www.bogen.com/#sle).  
B. Toa Electronics, Inc; [ ]: [www.toaelectronics.com/#sle](http://www.toaelectronics.com/#sle).  
C. Carehawk.  
D. Substitutions: See Section 016000 - Product Requirements.

### **2.02 AMPLIFICATION AND CONTROL EQUIPMENT**

- A. Microphone Inputs: Two low impedance inputs with 600 microvolt sensitivity and noise level at least 55 dB below rated output.  
B. Auxiliary Inputs: One high impedance input with 0.4 volt sensitivity and noise level at least 70 dB below rated output.  
C. System Frequency Response: 50 to 15,000 Hz, plus or minus 2 dB.  
D. System Distortion: Less than 1.5 percent, 100 to 100,000 Hz at rated power.  
E. System Output Power: As required rms watts.  
F. System Output: 4 ohms 25 volts. Verify existing speaker ohms and volts.  
G. Volume Controls: One for each input and one master volume.  
H. Bass Control: Plus 8 dB to minus 12 dB at 50 Hz.  
I. Treble Control: Plus 8 dB to minus 12 dB at 10,000 Hz.  
J. Program Selector: Provide program, listen-talk, and mode selector switches.

### **2.03 COMPONENTS**

- A. Compact Disc Player: [ ].  
B. AM/FM Tuner: Tuner with 525 to 1605 kHz AM and 88 to 108 MHz FM tuning range.  
1. AM Performance:  
a. AM IF Rejection: Over 30 dB.  
b. AM Selectivity: 7 kHz at minus 6 dB.  
c. AM Fidelity: 100 to 4500 Hz, plus or minus 3 dB.  
d. AM Antenna Input: 75 ohms, unbalanced.  
2. FM Performance:  
a. FM IF Rejection: Over 50 dB.  
b. FM Fidelity: 50 to 15,000 Hz, plus or minus 3 dB.  
c. FM Antenna Input: 300 ohms, balanced.  
3. Substitutions: See Section 016000 - Product Requirements.  
C. Microphone: Desk type low impedance microphone with push-to-talk switch.  
D. Speakers: 8 inch coaxial speaker with integral crossover circuit.  
1. Power Rating: 20 watts.  
2. Frequency Range: 45 to 18,000 Hz.  
3. Sound Pressure Level: 95 dB at 3 feet with 1 watt input.  
4. Magnet: Ceramic; 10 ounces low frequency unit; 3 ounces high frequency unit.  
5. Dispersion: Minus 3 dB at 90 degrees, minus 5 dB at 110 degrees.  
E. Speaker Baffles and Enclosure: Square, painted steel, with uniform perforations.  
1. Size: 12 inch.  
2. Finish: White.  
3. Speaker Backbox: Insulated with sound-deadening material.  
F. Horns: Wide dispersion indoor/outdoor horn with driver.  
1. Power Rating: 60 watts.  
2. Low Frequency Cutoff: 250 Hz.



3. Sound Distribution: 20 x 50 degrees.
4. Sound Pressure Level: 120 dB at 4 feet with full range input.
5. Material: Cast aluminum.
- G. Matching Transformers: Tapped from 0.5 to 4 watts in 1 watt steps, with primary/secondary ratio to match amplifier to speaker impedances.
- H. Volume Pads: Transformer type rated 10 watts.
- I. Equipment Rack: Floor mounted equipment rack.
  1. Equipment Mounting Width: 19 inch.
  2. Equipment Mounting Height: [ ] inches minimum.
  3. Finish: Black enamel finish.
  4. Include front hinged and latched door.
  5. Include six receptacle multioutlet assembly inside rack.
- J. Antenna: Folded dipole FM antenna.
  1. Impedance: 300 ohm with matching transformer for 75 ohm coaxial cable.
  2. Construction: Use tubular metal elements.
  3. Wind Resistance: Withstand 100 miles per hour wind.

## 2.04 WIRE AND CABLE

- A. Microphone Cord: 20 AWG stranded copper conductor, 600 volt insulation, rated 60 degrees C, two conductor shielded cable with rubber jacket.
- B. Input Cable: 22 AWG copper conductor, 300 volt insulation, rated 60 degrees C, paired conductors twisted together, shielded, and covered with a PVC jacket.
- C. Speaker Wire and Cable: 22 AWG copper conductor, 300 volt insulation, rated 60 degrees C, paired conductors twisted together shielded and covered with a PVC jacket.
- D. Plenum Cable for Speaker Circuits: 22 AWG copper conductor, 300 volt insulation, rated 200 degrees C, paired conductors twisted together shielded and covered with a nonmetallic jacket; suitable for use for Class 2 circuits in air handling ducts, hollow spaces used as ducts, and plenums.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Mounting Heights: Coordinate locations of outlet boxes specified in Section 260533.16 to obtain mounting heights indicated.
  1. Wall-mounted Speaker: [ ] feet above finished floor.
  2. Volume Pad Outlets: [ ] feet above finished floor.
  3. Microphone Outlets: [ ] feet above finished floor.
- C. Splice cable only in accessible junction boxes or at terminal block units.
- D. Make cable shields continuous at splices and connect speaker circuit shield to equipment ground only at amplifier.
- E. Install input circuits in separate cables and raceways from output circuits.
- F. Leave 18 inches excess cable at each termination at microphone, volume pad, speaker, and other system outlet.
- G. Leave 6 feet excess cable at each termination at system cabinet
- H. Provide protection for exposed cables where subject to damage.
- I. Use armored cable for outside speaker circuits.
- J. Support cables above accessible ceilings to keep them from resting on ceiling tiles. Use spring metal clips or plastic cable ties to support cables from structure for ceiling suspension system. Include bridle rings or drive rings.
- K. Use suitable cable fittings and connectors.
- L. Connect reproducers to amplifier with matching transformers.
- M. Ground and bond equipment and circuits in accordance with Section 260526.

**3.02 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Provide the services of manufacturer's technical representative to prepare and start system.
  - 1. Include making of final wiring connections, inspection and adjusting of completed installation, and systems demonstration.
  - 2. Certify that installation is complete and performs according to specified requirements.
- C. Measure and record sound power levels at designated locations.

**3.03 ADJUSTING**

- A. Adjust transformer taps for appropriate sound level.
- B. Adjust devices and wall plates to be flush and level.

**3.04 CLOSEOUT ACTIVITIES**

- A. See Section 017900 - Demonstration and Training, for additional requirements.
- B. Demonstration: Demonstrate operation of system to Owner's personnel.
  - 1. Use operation and maintenance data as reference during demonstration.
  - 2. Briefly describe function, operation, and maintenance of each component.
- C. Training: Train Owner's personnel on operation and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.
  - 3. Instructor: Manufacturer's training personnel.
  - 4. Location: At project site.

**3.05 MAINTENANCE**

- A. See Section 017000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide service and maintenance of public address and music system for one year from Date of Substantial Completion.

**END OF SECTION**

**SECTION 275313  
CLOCK SYSTEMS****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Clock system requirements.
- B. Wireless clock systems and associated components:
  - 1. Master clock unit.
  - 2. Wireless secondary indicating clocks.
- C. Accessories.

**1.02 RELATED REQUIREMENTS**

- A. Section 275116 - Public Address Systems: For interface with clock system.

**1.03 REFERENCE STANDARDS**

- A. 47 CFR 15 - Radio Frequency Devices current edition.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the placement of clocks with potential conflicts and/or view obstructions installed under other sections or by others.
  - 2. Coordinate the work with other installers to provide power for clocks and equipment at required locations.
  - 3. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

**1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- C. Maintenance contracts.
- D. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
  - 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- E. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- F. Project Record Documents: Record actual locations of system components and installed wiring arrangements and routing.
- G. Software: One copy of software not resident in read-only memory.

**1.06 QUALITY ASSURANCE**

- A. Comply with the following:
  - 1. NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Installer Qualifications: Company with minimum three years documented experience with similar clock systems and providing contract maintenance service as a regular part of their business; manufacturer's authorized installer.

1. Contract maintenance office located within 200 miles of project site.
- E. Products: Listed, classified, and labeled as suitable for the purpose intended.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

#### **1.08 FIELD CONDITIONS**

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

#### **1.09 WARRANTY**

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

### **PART 2 PRODUCTS**

#### **2.01 CLOCK SYSTEM REQUIREMENTS**

- A. Provide new clock system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Interface with Other Systems:
  1. Provide products compatible with other systems requiring interface with clock system.
  2. Interface with public address system as specified in Section 275116.
    - a. Capable of initiating selected public address system events according to clock system program schedule.
- C. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of 47 CFR 15, for Class B, consumer application.

#### **2.02 WIRELESS CLOCK SYSTEMS**

- A. Manufacturers:
  1. Wireless Clock System:
    - a. American Time: [www.american-time.com/#sle](http://www.american-time.com/#sle).
    - b. Midwest Time Control: [www.midwest-time.com/#sle](http://www.midwest-time.com/#sle).
    - c. The Sapling Company, Inc: [www.sapling-inc.com/#sle](http://www.sapling-inc.com/#sle).
  2. Substitutions: See Section 016000 - Product Requirements.
  3. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer.
  4. Source Limitations: Furnish system components and accessories produced by a single manufacturer and obtained from a single supplier.
- B. Master Clock Unit:
  1. Description: Microprocessor-based controller and associated accessories for maintaining time reference and correcting connected wireless secondary indicating clocks.
  2. Acceptable Time Reference Source(s): Based on Network Time Protocol (NTP) server time data obtained via local area network (LAN) or Global Positioning System (GPS) satellite antenna/receiver.
  3. Wireless Time Correction Signal Transmitter/Antenna: Compatible with wireless secondary clocks, including any existing clocks (where indicated).
  4. Wired Secondary Indicating Clock Power and Time Correction Signal Circuit(s): As required for connection to wired secondary clocks, including any existing clocks (where indicated).
  5. Features:
    - a. Battery backup for timekeeping and settings; rated for 10 years.
    - b. Supports security access control for system programming functions.
    - c. Supports remote interface via web browser or software.

- d. Supports automatic daylight savings time adjustment.
- C. Analog Wireless Secondary Indicating Clocks:
  - 1. Power Source: 120 VAC; provide required transformers.
  - 2. Time Reference Source: Synchronized with master clock unit wireless time correction signal.
  - 3. Clock Movements: Microprocessor-controlled.
  - 4. Clock Face:
    - a. Shape: Round.
    - b. Size: 12 inch, nominal.
    - c. Color: White face with black numerals and markings, unless otherwise indicated or approved by Architect.
    - d. Hands: For indicating hour, minute, and second.
  - 5. Clock Crystal/Lens: Glass or shatter-resistant plastic.
  - 6. Case Material/Color/Finish: Black.
  - 7. Mounting:
    - a. Single-Face Clocks: Surface.
    - b. Double-Face Clocks: Surface.
- D. Provide components as indicated or as required for extension of wireless time correction signal between master clock unit and wireless secondary indicating clocks.
  - 1. Product(s):
    - a. Wireless Repeater: .

## 2.03 ACCESSORIES

- A. Provide components and wiring as indicated or as required for connection to auxiliary devices and other systems indicated.
- B. Auxiliary Devices:
  - 1. Product(s):
    - a. Tone/Audio Generator: [\_\_\_\_\_].
- C. Protective Covers/Guards for Clocks: Where indicated.
- D. Racks/Cabinets: Provide as indicated or as required for equipment mounting.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that characteristics of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### 3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.

### 3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Prepare and start system in accordance with manufacturer's instructions.
- C. Program system parameters according to requirements of Owner.
- D. Test for proper interface with other systems.
- E. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
- F. Submit detailed reports indicating inspection and testing results and corrective actions taken.

**3.04 CLEANING**

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

**3.05 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- C. Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.
  - 3. Location: At project site.

**3.06 PROTECTION**

- A. Protect installed system components from subsequent construction operations.

**3.07 MAINTENANCE**

- A. Conduct site visit upon Owner's request within one year from Date of Substantial Completion to make additional adjustments to system programming.
- B. Provide trouble call-back service upon notification by Owner:
  - 1. Include allowance for call-back service during normal working hours at no extra cost to Owner.
  - 2. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.

**END OF SECTION**

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**SECTION 284600**  
**FIRE DETECTION AND ALARM - NOTIFIER ONYX (FIRE COMMAND SYSTEMS)**  
**(NEW ADDITION)**

**PART 1 GENERAL**

**2.01 SECTION INCLUDES**

- A. Fire alarm system requirements.
- B. Fire alarm control panels and accessory equipment.
- C. Fire alarm system initiating devices.
- D. Fire alarm system notification appliances.
- E. Fire alarm system accessories.

**2.02 RELATED REQUIREMENTS**

- A. Section 078400 - Firestopping.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 271000 - Structured Cabling: Cables for fire alarm system network connections.

**2.03 REFERENCE STANDARDS**

- A. 521 CMR - Architectural Access Board Current Edition.
- B. 527 CMR 1.00 - Massachusetts Comprehensive Fire Safety Code Current Edition.
- C. 527 CMR 12.00 - Massachusetts Electrical Code Current Edition.
- D. 780 CMR - Massachusetts State Building Code Current Edition.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- F. NFPA 72 - National Fire Alarm and Signaling Code Most Recent Edition Cited by Referring Code or Reference Standard.
- G. UL 38 - Standard for Manual Signaling Boxes for Fire Alarm Systems Current Edition, Including All Revisions.
- H. UL 268 - Standard for Smoke Detectors for Fire Alarm Systems Current Edition, Including All Revisions.
- I. UL 268A - Standard for Smoke Detectors for Duct Application Current Edition, Including All Revisions.
- J. UL 864 - Control Units and Accessories for Fire Alarm Systems Current Edition, Including All Revisions.
- K. UL 1449 - Standard for Surge Protective Devices Current Edition, Including All Revisions.
- L. UL 1480 - Standard for Speakers for Fire Alarm and Signaling Systems, Including Accessories Current Edition, Including All Revisions.
- M. UL 1638 - Standard for Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories Current Edition, Including All Revisions.
- N. UL 1971 - Standard for Signaling Devices for the Hearing Impaired Current Edition, Including All Revisions.

**2.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 2. Coordinate the placement of devices with potential conflicts and/or view obstructions installed under other sections or by others.

3. Coordinate the work with other installers to provide power for equipment at required locations.
- B. Preinstallation Meetings:
  1. Conduct meeting with facility representative to review device and equipment locations.
  2. Conduct meeting with facility representative and other related equipment manufacturers to discuss fire alarm system interface requirements.
- C. Sequencing:
  1. Do not install devices until final surface finishes and painting are complete.

## 2.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Submittal Documents:
  1. Prepare and submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, details, and calculations.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- D. Shop Drawings:
  1. Include system interconnection schematic riser diagram that shows proposed and approved cable size and type.
  2. Include requirements for interface with other systems.
  3. Indicate system zone boundaries.
  4. Include sequence of operation with input/output matrix as provided in Tier One Construction Documents.
  5. Graphic Annunciators: Include proof for approval prior to fabrication.
- E. Circuit Calculations:
  1. Notification appliance circuit ampacity and voltage drop calculations.
  2. Emergency Voice/Alarm Communication Systems (EVACS): Include speaker circuit audio loss calculations.
  3. Standby battery calculations.
  4. Spare capacity calculations.
- F. Manufacturer's certification that products meet or exceed specified requirements.
- G. Manufacturer's equipment seismic qualification certification.
- H. Evidence of installer name and state license number with expiration date.
- I. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- J. Inspection and Test Reports:
  1. Installer to submit inspection and test plan prior to closeout demonstration.
  2. Installer to submit NFPA 72 "Record of Inspection and Testing" forms, filled out by installer.
- K. Installer to submit NFPA 72 "Record of Completion" forms, filled out completely by installer and signed by Owner and authorized representative of authorities having jurisdiction.
- L. Operation and Maintenance Data:
  1. Include detailed information on system operation, equipment programming and setup.
  2. Include manufacturer's preventive maintenance recommendations.
  3. Other data as defined in NFPA 72 section 14.3.1 and 14.4.3.2, with any variations noted by design professional as required by 780 CMR 901.2.1 (1) (a) (iii).
  4. Include contact information for entity that will be providing contract maintenance and trouble call-back service.



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- M. Executed Warranty: Submit documentation of final executed product warranties completed in Owner's name and registered with manufacturer.
- N. Maintenance contracts.
- O. Project Record Documents:
  - 1. Comply with 780 CMR Chapter 9 requirements for Tier Three Record Drawings.
  - 2. Installer to record actual locations of system components and installed wiring arrangements and routing. Indicate final device and terminal identifications.
  - 3. Indicate actual programmed operating sequences, including control events by device, updated input/output matrix, and voice messages by event or printed copy of program.
  - 4. Place in as-built documents cabinet(s).
- P. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  - 1. See Section 016000 - Product Requirements, for additional provisions.
  - 2. Extra Spot-Type Detectors: 2 percent of total quantity installed for each type, but not less than one of each type supplied.
  - 3. Extra Notification Appliances: 2 percent of total quantity installed for each type, but not less than one of each type supplied.
  - 4. Extra Addressable Modules: One of each type supplied.
  - 5. Extra Fuses: Two of each size and type; store inside applicable control cabinet.
  - 6. Software: One copy of software not resident in read-only memory.

## 2.06 QUALITY ASSURANCE

- A. Comply with the following:
  - 1. 521 CMR (Massachusetts Architectural Access Board).
  - 2. 527 CMR 1.00 (Massachusetts Comprehensive Fire Safety Code).
  - 3. 527 CMR 12.00 (Massachusetts Electrical Code).
  - 4. 780 CMR (Massachusetts State Building Code).
  - 5. Applicable local codes.
  - 6. NFPA 72.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
  - 1. Authorized support facilities located within 50 miles of project site.
- D. Installer Qualifications:
  - 1. Company with minimum three years documented experience with similar fire alarm systems and providing contract maintenance service as a regular part of their business.
  - 2. Familiar with products to be installed through documented manufacturer training, authorization, or equivalent demonstrated experience.
    - a. Notifier Basis of Design System: Specialized training as provided by Notifier Premier representative.
  - 3. Installer Personnel: At least three years experience installing fire alarm systems.
  - 4. Supervisor: State licensed and NICET Level III or IV certified fire alarm technician.
  - 5. Licensed electrical or systems contractor in the State in which the Project is located.
- E. Products: Listed, classified, and labeled as suitable for the purpose intended.
- F. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

## 2.07 DELIVERY, STORAGE, AND HANDLING

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

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- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

## **2.08 FIELD CONDITIONS**

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

## **2.09 WARRANTY**

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide minimum three year manufacturer warranty for fire alarm control panels and accessories covering repair or replacement due to defective materials or workmanship.

## **PART 2 PRODUCTS**

### **3.01 MANUFACTURERS**

- A. Fire Alarm Control Panels and Accessory Equipment - Basis of Design: Notifier ONYX Series by Honeywell as indicated under product descriptions below;  
[www.securityandfire.honeywell.com/notifier/en-us/#sle](http://www.securityandfire.honeywell.com/notifier/en-us/#sle).
- B. Substitutions: See Section 016000 - Product Requirements.
- C. Source Limitations: Where possible, furnish system components and accessories produced by a single manufacturer and obtained from a single supplier.
- D. Suppliers:
  - 1. Notifier Basis of Design System: Fire Command Systems, Inc; 7 Eustis Street, Unit B, Saugus, MA 01906; (978) 401-9840; [www.firecommandsystems.com](http://www.firecommandsystems.com).

### **3.02 FIRE ALARM SYSTEM REQUIREMENTS**

- A. Provide new fire alarm system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Power Sources:
  - 1. Primary: Dedicated branch circuits of the facility power distribution system.
  - 2. Secondary: Storage batteries with capacity to operate system for period specified by NFPA 72.
    - a. Systems Without Voice (EVACS): 24 hours standby time with 10 minutes of alarm.
    - b. Systems With Voice (EVACS): 24 hours standby time with 15 minutes of alarm.
- C. Spare Capacity:
  - 1. Signaling Line Circuits: Minimum 25 percent spare capacity.
  - 2. Notification Appliance Circuits: Minimum 25 percent spare capacity.
  - 3. Speaker Amplifiers: Minimum 25 percent spare capacity.
- D. Exterior Notification:
  - 1. In addition to required occupant notification, provide notification on exterior of building as follows:
    - a. Fire Alarm Visible Notification: Provide strobe beacon (Edwards Signaling Model 125STRNR1248DB) with red lens; interface to dedicated notification appliance circuit or control module (Notifier Model FCM-1), 24 VDC, supervised.
- E. Wiring Methods:
  - 1. Comply with 527 CMR 12.00 (Massachusetts Electrical Code).
  - 2. Pathway class designations and pathway survivability are as defined in NFPA 72.
  - 3. Pathway Class Designations:
    - a. Unless otherwise indicated or required, pathways to meet the following requirements:
      - 1) Signaling Line Circuits (SLC): Class B (star, tee-tap, multi-tap, with no return).

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- 2) Initiating Device Circuits (IDC): Class B (daisy-chain with end-of-line resistor device installed at end of circuit).
  - 3) Notification Appliance Circuits (NAC): Class B (daisy-chain with end-of-line resistor device installed at end of circuit).
  - 4) Network Communications: Class B.
  - 5) Other Wiring:
    - (a) Other life safety control features not covered above (e.g. door holder circuits, elevator recall circuits, fire smoke dampers, air handling system interfaces, etc) to be wired as Class D (failsafe, where the intended operation is performed in the event of a pathway failure).
    - (b) Where Class D wiring is not possible due to limitation of equipment, wiring to be limited to 3 feet between control module and equipment and be installed in metal conduit.
  4. Pathway Survivability:
    - a. Unless otherwise indicated or required, pathways to meet requirements for Pathway Survivability Level 2 (rated cable, building not protected by automatic sprinkler system).
      - 1) Exceptions:
        - (a) For voice evacuation (EVACS) systems employing relocation or partial evacuation, pathways for notification and communication circuits and other circuits necessary to ensure continued operation of emergency communication system to meet requirements for Pathway Survivability Level 3 (rated cable, building protected by automatic sprinkler system).
    - b. Rated cable to be one of the following in accordance with NFPA 72:
      - 1) 2-hour fire-rated circuit integrity (CI) or fire-resistive cable.
      - 2) 2-hour fire-rated cable system (mineral insulated cable).
      - 3) 2-hour fire-rated enclosure or protected area.
      - 4) Performance alternative approved by authorities having jurisdiction.
  - F. Fire Alarm System Interfaces:
    1. Fire alarm system interfaces to be listed to UL 864 unless otherwise indicated.
    2. Descriptions below are intended to provide means for interface. Refer to project sequence of operations, narrative, and/or input/output matrix for execution requirements.
    3. Provide addressable monitor modules (Notifier Model FMM-1, Model FMM-101, or multi-point module) as indicated or as required for connection to addressable fire alarm control panel. Unless devices are explicitly permitted to be connected together as a zone, provide separate addressable monitoring point(s) for each device in order to be individually identifiable by addressable fire alarm control panel.
    4. Provide addressable relay module (Notifier Model FRM-1 or multi-point module) as indicated or as required to perform necessary functions via dry-contact interface. Where load exceeds module contact rating, provide accessory power isolation relays (Notifier Model PR-1) suitable for load as required.
    5. Fire Suppression Systems:
      - a. Releasing Service by Separate Panel (Not by Fire Alarm Control Panel):
        - 1) Provide minimum of four monitoring point inputs per system unless otherwise indicated.
        - 2) Kitchen Hood Suppression Systems: Provide minimum of one monitoring point input per system.
      - b. Releasing Service by Fire Alarm Control Panel:
        - 1) Fire alarm control panel to be listed for releasing service.
        - 2) Provide addressable releasing control modules (Notifier Model FCM-1-REL) as indicated or as required for control of solenoids listed for releasing applications.
        - 3) Provide manual releasing station(s) (Notifier Model NBG-12LR) for suppression system activation as indicated.

- 4) Provide bell(s) (Notifier Model SSM24-6) for audible notification as indicated. Interface to dedicated notification appliance circuit or control module (Notifier Model FCM-1), 24 VDC, supervised. Default operation to be march time pattern on activation of first event, continuous tone on release.
  - 5) Provide strobe(s) (Notifier Model SRL-P with Model LENS-R2 red lens) for visible notification as indicated. Interface to dedicated notification appliance circuit or control module, 24 VDC, supervised. Default operation to be flash on activation of first event, flash on release.
  - 6) Provide abort switch(es) (Potter Electric Signal Company Model 3001000) as indicated.
6. Elevators:
- a. Elevator Emergency Recall Operation:
    - 1) In each elevator machine room, provide interface for each elevator car or group of elevator cars as determined by authorities having jurisdiction via separate addressable relay modules for each of the output signals below where applicable.
      - (a) Recall elevator to designated (primary) level.
      - (b) Recall elevator to alternate level.
      - (c) Smoke detection in elevator machine room (fire fighter's hat light).
      - (d) Hoistway ventilation control.
7. Fire and Smoke Doors/Shutters/Curtains:
- a. Electromagnetic Door Holder Release:
    - 1) Provide output signal for release of electromagnetic door holders via addressable relay module and power isolation relay.
    - 2) Door holders to be powered via 120 VAC unless otherwise indicated.
    - 3) Door release to be activated as determined by authorities having jurisdiction.
8. HVAC Systems:
- a. Air Handling Units (AHUs) and Roof Top Units (RTUs):
    - 1) Provide duct smoke detector on supply side of air stream for units indicated on drawings.
    - 2) Provide duct smoke detector on return side of air stream for units with supply side duct smoke detectors.
    - 3) Provide remote test station for each duct smoke detector unless explicitly indicated as not required.
    - 4) Provide output signal to shut down units with at least one duct smoke detector via addressable relay module.
    - 5) Where fire/smoke dampers are located downstream of unit, provide monitoring point input to determine that unit is not operational and subsequently provide output signal to close such dampers via addressable relay module and power isolation relay.
  - b. Energy Recovery Units (ERUs):
    - 1) Provide duct smoke detector on supply side of air stream.
    - 2) Provide duct smoke detector on return side of air stream.
    - 3) Provide remote test station for each duct smoke detector unless explicitly indicated as not required.
    - 4) Provide output signal to shut down units with at least one duct smoke detector via addressable relay module.
    - 5) Where fire/smoke dampers are located downstream of unit, provide monitoring point input to determine that unit is not operational and subsequently provide output signal to close such dampers via addressable relay module and power isolation relay.
9. Fire/Smoke Dampers:
- a. Provide output signal to close fire/smoke damper via addressable relay module and power isolation relay.
  - b. Fire/smoke damper to be activated by the following method(s); where more than one method is listed see drawings for method to be used at each location.

- 1) By addressable duct smoke detector as specified in this section.
- 2) By conventional duct smoke detector furnished with fire/smoke damper (along with remote test station) as specified in other section(s); provide addressable monitor module.
- 3) By corridor smoke detection, where fire/smoke damper(s) serve only corridors provided with smoke detection throughout and all dampers serving such corridor are activated.
- 4) By smoke detector installed within 5 feet of fire/smoke damper air diffuser (in lieu of duct smoke detection), where fire/smoke dampers serve spaces other than corridors or corridors not provided with smoke detection; smoke detectors installed solely for activation of fire/smoke damper to be programmed as supervisory signal (not alarm) unless otherwise required by authorities having jurisdiction.

### 3.03 FIRE ALARM CONTROL PANELS AND ACCESSORY EQUIPMENT

- A. Fire Alarm Control Panels and Accessory Equipment: Listed and labeled as complying with UL 864.
- B. Provide cabinets and enclosures as indicated or as required to house system components.
- C. Fire Alarm Control Panels:
  1. Basis of Design: Notifier ONYX Series Model NFS2-640 configured with voice and networking capability.
    - a. Supports up to 636 devices (318 detectors and 318 modules) on two signaling line circuits (SLCs) configurable for Class B or Class A with Notifier Model LEM-320 loop expander module.
    - b. Furnished with four integral notification appliance circuits (NACs) configurable for Class B or Class A, each rated at 1.5 A at 24 VDC.
    - c. Provide Notifier Model NCA-2 640-character display/network control annunciator.
    - d. Provide Notifier CAB-4 Series enclosure for mounting; include required dress plates and finish trims.
- D. Emergency Voice/Alarm Communications System (EVACS):
  1. Provide digital multi-channel voice evacuation (EVACS) system integrated with fire alarm control panel capable of automatic and manual paging, messaging, evacuation, and alerting on a selective and all-call basis.
  2. Provide switch points of command as follows, unless otherwise approved by Engineer and authorities having jurisdiction:
    - a. All-Call: Provides manual paging for all zones simultaneously.
    - b. Total Evacuation: Provides complete building-wide activation of audio and visual evacuation signals; restore on switch deactivation, signal silence, or system reset command.
    - c. Provide minimum of two switch points of manual controls per evacuation zone for manual paging and/or manual evacuation.
      - 1) Manual Evacuation: Activate audio and visual evacuation signals on selected zone. Restore on switch deactivation, signal silence, or system reset command.
      - 2) Manual Paging: Where active evacuation zone is selected, pause evacuation signal for manual page. Resume evacuation signal upon completion of paging function unless silence or reset command has been initiated.
    - d. In addition to required emergency messaging, provide switch points of command for minimum of three pre-recorded messages for non-emergency all-call notifications including "event has cleared", "testing of system", and "clear from testing of system".
    - e. Door Release: Provide switch points of command as required for unlocking of provisioned doors.
    - f. Provide minimum of six switch points of command for speaker bypass, visual bypass, elevator recall bypass, door control bypass, HVAC bypass, and auxiliary

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- bypass.
3. Audio Transponders:
    - a. Audio hardware, including multiple primary and backup amplifiers, speaker circuit interfaces, power supplies, supervision hardware, cabinets, and battery backup systems may be configured to support multiple notification zones and packaged as audio transponders.
    - b. Transponders to be considered system control equipment and located, installed, and interfaced accordingly.
    - c. Components mounted in transponders to be listed and approved for the installed configuration.
  4. Basis of Design Products:
    - a. Notifier DVC Series digital multi-channel voice evacuation (EVACS) system integrated with fire alarm control panel.
      - 1) Include auxiliary input for external 1 VRMS audio source (e.g. music, paging, etc), configurable to mute during emergency events and/or power loss.
      - 2) Digital Audio Protocol (DAP) communication channel allows connection to Notifier DAA2/DS Series amplifiers via manufacturer-approved cable media. DAP loop to be considered part of the fire alarm system network and meet specified requirements for wiring methods and pathway survivability.
      - 3) Capable of supporting up to 8 channels of simultaneous audio; each identified evacuation zone to allow broadcast of automatic audio or manual paging independent of other evacuation zones.
      - 4) Utilize 70 VRMS audio to ensure maximum speaker circuit lengths with minimum signal loss for both current scope and future expansion consideration. Maximum signal loss to be minus 3 dB per speaker circuit.
    - b. Notifier DAA2/DS Series primary digital audio amplifiers.
      - 1) Interface with DAP loop via individual address to allow for dedicated communication of audio, activation, and fault status.
      - 2) Capable of delivering full rated power to single integrated speaker circuit or distributed to multiple integrated speaker circuits.
      - 3) Provide minimum of two integrated speaker circuits per amplifier, each with unique system sub-address to allow for individual activation, control, and fault supervision. Systems that utilize control or relay modules to provide speaker circuits are not permitted.
      - 4) Provide capability to charge or supervise batteries and allow for inherent ground fault detection.
      - 5) Provide capability for local mode alarm trigger for local activation and broadcast of evacuation tone on integrated speaker circuits in the event of communication loss with system control hardware.
      - 6) Include auxiliary input for external 1 VRMS audio source (e.g. music, paging, etc), configurable to mute during emergency events and/or power loss.
      - 7) Provide capability to communicate detailed status of faults and conditions affecting operation of amplifiers and individual circuits. Systems that combine audio and communication into single points via addressable modules or other hardware are not permitted.
    - c. Notifier BDA Series backup digital audio amplifiers.
      - 1) Provide dedicated backup amplifier for each primary amplifier. A backup amplifier may serve multiple primary amplifiers installed in a single enclosure.
      - 2) Provide automatic switching to backup amplification without use of additional hardware (e.g. relay modules, special tools) or programming.
    - d. Remote command annunciator with remote microphone for selective zone paging consisting of:
      - 1) Notifier Model LCD-160 remote annunciator, 160-character LCD, indoor-rated.
      - 2) Notifier Model RM-1 remote microphone.

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- 3) Notifier ACM/AEM-24AT Series speaker control module; provide annunciation/control points as indicated or as required, each with alarm/circuit active LED, fault LED, touch-key switch, and provision for slip-in label.
  - 4) Notifier CAB-4 Series indoor-rated enclosure for housing components listed above.
- E. Networking:
1. Fire alarm control panel to be capable of communicating over network utilizing peer-to-peer, inherently regenerative communication and format.
  2. Networks with Copper Media:
    - a. Provide surge protection for all wiring that leaves the structure.
  3. Basis of Design Products:
    - a. Networks with Copper Media: Notifier Model NCM-W standard network communications module, twisted-pair copper wire interface; enables fire alarm control panel support of up to 103 network nodes over NOTI-FIRE-NET; Class B or Class A operation.
- F. Releasing Service:
1. Fire alarm control panel to be capable of supporting 10 releasing zones for independent hazards, with each zone capable of three cross-zone and four abort options; provide adjustable delay and discharge timers.
  2. Basis of Design Products:
    - a. Potter Electric Signal Company Model 3001000 abort switch, with momentary red push button, stainless steel wallplate, and text "SUPPRESSION SYSTEM ABORT"; mounts to 2-gang box.
    - b. Releasing Control Modules: See "Addressable Modules" in this article below.
    - c. Manual Release Station: See "Manual Pull Stations" under "Initiating Devices" article below.
    - d. Bells and Strobes: See "Notification Appliances" article below.
- G. Alarm Communication:
1. Digital Alarm Communicator Transmitters (DACT):
    - a. Supports point and zone reporting via two telephone (POTS) lines.
  2. Basis of Design Products:
    - a. Notifier Model UDACT-2 digital alarm communicator transmitter (DACT).
- H. Remote Annunciators:
1. Basis of Design Products:
    - a. Notifier Model LCD-160 remote annunciator, 160-character LCD, indoor-rated.
      - 1) Provide Notifier Model ABS-2DR backbox (flush- or surface-mounting capability).
    - b. For remote command annunciator with remote microphone for selective zone paging, see "Emergency Voice/Alarm Communications System (EVACS) Equipment" above.
    - c. Space Age Electronics custom-fabricated remote annunciator, LED graphical.
      - 1) Indoor Locations: Space Age Electronics GL8 Series.
      - 2) Interface with fire alarm control panel utilizing Notifier Model LDM-32 serial lamp driver module(s) as necessary for required lamp outputs.
      - 3) Provide local lamp test switch to confirm operation of each lamp.
- I. Notification Appliance Circuit Expansion:
1. Where notification appliance circuit requirements exceed capacity of fire alarm control panel, provide accessories as required for expansion.
  2. Basis of Design Products:
    - a. Notifier FCPS-24S Series remote power supply/notification appliance circuit expansion panel.
      - 1) Provide four Class B notification appliance circuits (NACs), each rated for 2.5 A at 24 VDC and supervised for open, short, and overload conditions.

- 2) Provide supervised auxiliary power output rated for 0.5 A at 24 VDC.
  - 3) Provide minimum of one Notifier Model FCM-1 control module for each panel to allow for individual control and supervision of panel and reporting of fault conditions. Do not trigger or control multiple expansion panels via a single control module, NAC, or other "daisy chain" means that may result in loss of control due to failure or fault in one circuit.
  - 4) Where panel split operation is required, provide additional Notifier Model FCM-1 control module (two total per panel); each module to trigger and control two of the four panel NACs.
  - 5) Provide integral synchronization of both audio and visual circuits to match protocol assigned by fire alarm control panel.
  - 6) Include provision for a "master sync circuit" to allow all system NACs (including fire alarm control panel and expansion panel circuits) in one building to have synchronized audio/visual circuits. Master sync circuit to be Class B and be independent of trigger and control circuits such that loss of master sync circuit does not cause loss of operation for audio and visual circuits.
- J. Addressable Modules:
1. Provide addressable modules suitable for connection to fire alarm control panel signaling line circuits.
  2. Unless otherwise indicated, use addressable modules only in clean, dry, indoor, non-hazardous locations.
  3. Monitor Modules: Unless devices are explicitly permitted to be connected together as a zone, provide separate addressable monitor module for each conventional dry-contact input device in order to be individually identifiable by addressable fire alarm control panel.
  4. Control Modules: Provide as indicated or as required for selective control of notification appliances.
  5. Releasing Control Modules: Provide as indicated or as required for control of listed solenoids in releasing applications.
  6. Relay Modules: Provide as indicated or as required to perform necessary functions via dry-contact interface. Where load exceeds module contact rating, provide accessory power isolation relays suitable for load as required.
  7. Signaling Line Circuit (SLC) Isolating Modules: Provide as indicated or as required to automatically isolate short circuits on connected sections of SLC loops and allow other sections to continue to function normally. Provide automatic reset upon correction of short circuit.
  8. Basis of Design Products:
    - a. Monitor Modules:
      - 1) Notifier Model FMM-1 addressable monitor module; single monitoring point, supervises one Class A or Class B circuit of conventional dry-contact input devices; uses single module address on SLC; mounts to nominal 4 inch square or 2-gang box, includes white finish cover.
      - 2) Notifier Model FDM-1 addressable monitor module; two monitoring points, supervises two Class B circuits of dry-contact input devices; uses two module addresses on SLC; mounts to nominal 4 inch square or 2-gang box, includes white finish cover.
      - 3) Notifier Model FMM-101 addressable monitor module, miniature; single monitoring point, supervises one Class B circuit of conventional dry-contact input devices; suitable for installation within appropriately sized device box behind monitored unit; uses single module address on SLC.
      - 4) Notifier Model FZM-1 addressable monitor module; single zone monitoring point, supervises one Class A or Class B zone of compatible two-wire conventional smoke detectors; requires separate 24 VDC power; uses single module address on SLC; mounts to nominal 4 inch square or 2-gang box, includes white finish cover.
    - b. Control Modules:



- 1) Notifier Model FCM-1 addressable control module; single supervised control output, Class A or Class B, suitable for controlling 24 VDC notification appliance circuits (NAC) and speakers up to 70.7 VRMS; requires separate 24 VDC power; uses single module address on SLC; mounts to nominal 4 inch square or 2-gang box, includes white finish cover.
- c. Releasing Control Module:
  - 1) Notifier Model FCM-1-REL addressable releasing control module; single supervised solenoid release output, Class A or Class B, suitable for connection to one 24 VDC solenoid or up to two 12 VDC solenoids (in series) listed for releasing service; utilizes redundant protocol; requires separate 24 VDC power; uses single module address on SLC; mounts to nominal 4 inch square or 2-gang box, includes white finish cover.
- d. Relay Modules:
  - 1) Notifier Model FRM-1 addressable relay module; two Form C dry contacts that switch together; uses single module address on SLC; mounts to nominal 4 inch square or 2-gang box, includes white finish cover.
- e. Multi-Input/Output Modules:
  - 1) Notifier Model FDRM-1 addressable multi-input/output module; two monitoring points, supervises two Class B circuits of dry-contact input devices; two Form C dry contacts that operate independently; uses up to four module addresses on SLC; mounts to nominal 4 inch square or 2-gang box, includes white finish cover.
- f. Signaling Line Circuit (SLC) Isolating Modules:
  - 1) Notifier Model ISO-X addressable signaling loop circuit (SLC) isolating module; does not use any module addresses on SLC; mounts to nominal 4 inch square or 2-gang box, includes white finish cover.
- g. Accessories:
- K. Fire Alarm System Printers:
  1. Listed to UL 864 for use with fire alarm system.
  2. Capable of providing written record of system events and status changes.
  3. Power via 120 VAC emergency power.
  4. Basis of Design Products:
    - a. Notifier Model PRN-7 fire alarm system printer, 24-pin dot-matrix.
- L. Electromagnetic Door Holders:
  1. Select according to door type and associated installation conditions.
  2. Basis of Design: Edwards Signaling 150\* Series (\* indicates placeholder for model number selected according to application).

### 3.04 FIRE ALARM SYSTEM INITIATING DEVICES

- A. General Requirements:
  1. Addressable Devices: Individually identifiable by addressable fire alarm control panel; suitable for connection to fire alarm control panel signaling line circuits.
  2. Conventional (Non-Addressable) Devices: Provide addressable monitor modules (Notifier Model FMM-1, Model FMM-101, or multi-point module) as indicated or as required for connection to addressable fire alarm control panel. Unless devices are explicitly permitted to be connected together as a zone, provide separate addressable monitoring point for each device in order to be individually identifiable by addressable fire alarm control panel.
  3. Provide devices and associated accessories suitable for intended application and location to be installed. Unless otherwise indicated, use addressable devices and addressable monitor modules only in clean, dry, indoor, non-hazardous locations.
  4. Surface-Mounted Devices: Provide manufacturer's accessory surface mount backboxes or suitable outlet/device box.
  5. Devices for Outdoor and Damp/Wet Locations: Weatherproof, suitable for outdoor use; provide manufacturer's accessory backboxes and/or enclosures in accordance with product listing.

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6. Devices for Hazardous (Classified) Locations: Listed and labeled as suitable for the classification of the installed location.
- B. Manual Fire Alarm Boxes (Pull Stations):
1. Description: Non-coded manual signaling boxes listed and labeled as complying with UL 38.
  2. Alarm Initiation: Configured for general alarm initiation unless otherwise indicated; pre-signal stations (where indicated) require use of key to initiate general alarm.
  3. Operation: Dual-action unless otherwise indicated; first requires pushing in then pulling down of lever.
  4. Color: Red, in accordance with NFPA 72.
  5. Station Reset: Requires use of key or tool.
  6. Protective Covers for Manual Pull Stations:
    - a. Provide protective covers with hinged access for manual pull stations.
    - b. Listed and labeled as complying with UL 38.
  7. Basis of Design Products:
    - a. Manual Pull Stations:
      - 1) Notifier Model NBG-12LX addressable manual pull station, indoor-rated, dual-action, key lock.
      - 2) Notifier Model NBG-12LR conventional manual release station, indoor-rated, dual-action, key lock, labeled "AGENT RELEASE".
    - b. Surface Mount Backboxes:
- C. Spot-Type Detectors:
1. Addressable Detectors:
    - a. Provide LED indication of normal operation/regular communication with fire alarm control panel and alarm condition.
    - b. Furnished with output for remote LED alarm indicator.
    - c. Utilizes plug-in mounting to separate base with tamper-resistant feature; compatible with available sounder, relay, and isolator bases; provide base as indicated or as required.
  2. Detector/Base Color: White, unless otherwise indicated.
  3. Basis of Design Products:
    - a. Smoke Detectors:
      - 1) Notifier Model FSP-951 addressable smoke detector, indoor-rated, photoelectric, integral drift compensation, self-diagnostics, transient rejection, local test via application of external magnet.
    - b. Thermal (Heat) Detectors:
      - 1) Notifier Model FST-951 addressable thermal detector, indoor-rated, fixed temperature, 135 degrees F, local test via application of external magnet.
    - c. Carbon Monoxide Detectors:
      - 1) Notifier Model CO1224TR conventional carbon monoxide detector, indoor-rated, wall- or ceiling-mounting capable.
    - d. Bases for Addressable Detectors:
      - 1) Notifier Model B300-6 Series standard base, flanged low-profile.
    - e. Detector Accessories:
      - 1) Notifier Model RA100Z remote indicator; provides LED indication of alarm condition.
        - (a) Up to two remote indicators may be connected to single detector.
        - (b) Provide addressable relay modules (Notifier Model FRM-1 or multi-point module) where more than two remote indicators are required for single detector or where multiple detectors are to control the same remote indicator(s).
- D. Duct Smoke Detectors:
1. Listed and labeled as complying with UL 268A.
  2. Sampling Tubes: Select as required for installation in duct to be monitored.

3. Remote Test Stations: Provide remote test station for each duct smoke detector unless explicitly indicated as not required. Unless otherwise indicated, use remote test stations only in clean, dry, indoor, non-hazardous locations.
4. Basis of Design Products:
  - a. Addressable duct smoke detector assembly for indoor applications consisting of:
    - 1) Notifier Model DNR duct smoke detector housing, indoor-rated.
    - 2) Notifier Model FSP-951R addressable smoke detector, indoor-rated, photoelectric, remote test capable.
    - 3) Notifier DST Series sampling tube of appropriate length.
  - b. Addressable duct smoke detector assembly for outdoor applications consisting of:
    - 1) Notifier Model DNRW duct smoke detector housing, weatherproof.
    - 2) Notifier Model FSP-951R addressable smoke detector, indoor-rated, photoelectric, remote test capable.
    - 3) Notifier DST Series sampling tube of appropriate length.
    - 4) Notifier Model DH400OE-1 weatherproof enclosure for housing components listed above. Fill interior of enclosure with appropriate insulation media to minimize condensation.
  - c. Notifier Model RTS151 remote test station for addressable detectors; allows for detector test (via external magnet application) and reset; provides LED indication of alarm condition.
- E. Beam Smoke Detectors:
  1. Listed and labeled as complying with UL 268.
  2. Basis of Design Products:
    - a. Notifier Model FS-OSI-RI addressable beam smoke detector, single-ended reflected beam type with transmitter unit and reflector; protection range of 16 to 328 feet with standard reflector; beam adjustment angle of plus/minus 10 degrees. Furnish accessories as indicated or as required.
      - 1) Notifier Model 6500-MMK multi-mount kit, provides ceiling or wall mounting capability with increased angular adjustment.
    - b. Notifier Model RTS151 remote test station for addressable detectors; allows for detector test (via external magnet application) and reset; provides LED indication of alarm condition.

### 3.05 FIRE ALARM SYSTEM NOTIFICATION APPLIANCES

- A. Notification Appliances - General Requirements:
  1. Provide signaling devices listed for fire-protective service and intended operating mode (public or private); suitable for connection to fire alarm control panel notification appliance circuits (NAC).
  2. Provide control modules (Notifier Model FCM-1) as indicated or as required for selective control of notification appliances.
  3. Provide devices and associated accessories suitable for intended application and location to be installed. Use devices only according to listed mounting (e.g. ceiling, wall).
  4. Surface-Mounted Devices: Provide manufacturer's accessory surface mount backboxes or suitable outlet/device box.
  5. Devices for Outdoor and Damp/Wet Locations: Weatherproof, suitable for outdoor use; provide manufacturer's accessory backboxes and/or enclosures in accordance with product listing.
  6. Device Derating: Account for device derating adjustments in accordance with listing where applicable, including but not limited to the following.
    - a. Where accessory protective guards, enclosures, etc. are utilized.
    - b. Where required by field conditions (e.g. ambient temperature).
- B. Visible Notification Appliances:
  1. Public Mode Operation: Listed and labeled as complying with UL 1971.
  2. Private Mode Operation: Listed and labeled as complying with UL 1638.

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3. Strobes: Clear or nominal white lens with flash rate of 1 Hz unless otherwise indicated or required; xenon light source with maximum pulse duration of 0.2 seconds; candela rating as indicated.
  - a. Where field-selectable candela strobes are specified, substitution of fixed candela strobes is not permitted.
- C. Speakers for Emergency Voice/Alarm Communications Systems (EVACS):
  1. Listed and labeled as complying with UL 1480.
  2. Rated Sound Pressure Level: As required to achieve design sound pressure levels, but not less than 75 dB(A) at 10 feet in accordance with UL 1480.
  3. Frequency Range: 400 to 4,000 Hz minimum in accordance with UL 1480; listed for producing 520 Hz low frequency alarm signal for sleeping areas in accordance with NFPA 72.
  4. Speaker Voltage: Field-selectable (25 V, 70.7 V); matched to audio distribution circuit.
  5. Furnished with minimum of four field-selectable power taps.
- D. Combination Notification Appliances: Comply with respective requirements for each signaling method.
- E. Basis of Design Products:
  1. Strobes:
    - a. Notifier Model SRL strobe, indoor-rated, wall-mounted, red, selectable candela output (15, 30, 75, 95, 110, 135, 185 at 24 VDC nominal).
    - b. Notifier Model SRK strobe, weatherproof (includes backbox), wall-mounted, red, selectable candela output (15, 15/75, 30, 75, 95, 110, 115, 135, 150, 177, 185 at 24 VDC nominal).
    - c. Notifier Model SRL-P strobe with Model LENS-R2 red lens, plain (no "FIRE" marking), indoor-rated, wall-mounted, red, selectable candela output (15, 30, 75, 95, 110, 135, 185 at 24 VDC nominal).
  2. Speakers:
    - a. Notifier Model SPRL speaker, indoor-rated, wall-mounted, red.
    - b. Notifier Model SPCRL speaker, indoor-rated, ceiling-mounted, red.
    - c. Notifier Model SPRK speaker, weatherproof (includes backbox), wall-mounted, red.
  3. Speaker/Strobes:
    - a. Notifier Model SPSRL speaker/strobe, indoor-rated, wall-mounted, red, selectable candela output (15, 30, 75, 95, 110, 135, 185 at 24 VDC nominal).
    - b. Notifier Model SPSRK speaker/strobe, weatherproof (includes backbox), wall-mounted, red, selectable candela output (15, 15/75, 30, 75, 95, 110, 115 at 24 VDC nominal).
  4. Strobe Beacons:
    - a. Edwards Signaling Model 125STRN\*1248DB strobe beacon (\* indicates placeholder for lens color designation), weatherproof; normal light output, black base, 12-48 VDC; listed for private mode operation only.
  5. Bells:
    - a. Notifier Model SSM24-6 bell, 6 inch nominal, red, 24 VDC.
      - 1) Outdoor and Damp/Wet Locations: Provide Model WBB weatherproof backbox.
  6. Surface Mount Backboxes:
    - a. Notifier Model SBBRL surface mount backbox for indoor wall-mounted horn, strobe, or horn/strobe, red.
    - b. Notifier Model SPBBRL surface mount backbox for indoor wall-mounted speaker or speaker/strobe, red.

### 3.06 FIRE ALARM SYSTEM ACCESSORIES

- A. Cables for Network Connections: Comply with Section 271000 and manufacturer's minimum requirements.
- B. Fire Alarm System Documents and Software (FAD) Cabinet:

1. Provide fire alarm document (FAD) cabinet with size as indicated or as required.
  2. Cabinet: Steel with red finish; permanently identified with text "FIRE ALARM SYSTEM DOCUMENTS"; keyed to match fire alarm system equipment; include fixed integral minimum 2GB flash drive for electronic storage of system documents and system database program
  3. Basis of Design Products:
    - a. Space Age Electronics FAD Series, Model SSU00690 cabinet, 12 inches wide by 13 inches high by 2-1/4 inches deep, keyed; provide special keying complying with requirements of authorities having jurisdiction where necessary.
- C. Terminal Cabinets:
1. Provide terminal cabinets with quantity of termination points as indicated or as required for application.
  2. Cabinet: Steel, with red finish; permanently identified with text "FIRE ALARM TERMINAL CABINET"; keyed to match fire alarm system equipment.
  3. Terminal Strips: Rated for 20 A at 250 V; terminal points rated for 12 AWG conductors.
  4. Basis of Design Products:
    - a. Space Age Electronics TC Series, Model SSU00645 terminal cabinet with 32 termination points, keyed.
    - b. Space Age Electronics TC Series, Model SSU00651 terminal cabinet with 64 termination points, keyed.
- D. As-Built Document Cabinets:
1. Provide as-built document cabinet with size as indicated or as required.
  2. Cabinet: Steel with red finish; permanently identified with text "AS-BUILT DRAWINGS"; keyed to match fire alarm system equipment.
  3. Basis of Design Products:
    - a. Space Age Electronics DBX Series, Model SSU00677 drawing cabinet, 26-1/4 inches wide by 14-1/4 inches high by 4 inches deep, keyed; provide special keying complying with requirements of authorities having jurisdiction where necessary.
- E. Framed Passive Graphic Maps:
1. Provide appropriately-sized passive graphic map of protected premises that identifies:
    - a. Location and address of all system addressable input devices.
    - b. Room numbers or descriptions for rooms with devices that match device labels.
    - c. Current location (labeled "YOU ARE HERE").
    - d. North reference.
  2. Provide concealed mounting hardware.
  3. Basis of Design Products:
    - a. Space Age Electronics GD8 Series graphic display frame; aluminum with matte finish and red trim.
- F. Emergency Access Key Vaults:
1. Listed; complying with requirements of authorities having jurisdiction.
  2. Unless otherwise indicated, utilize recess mounting for new construction and surface-mounting for existing structures.
  3. Color: Black, unless otherwise indicated or directed by Engineer.
- G. Surge Protection:
1. Line Voltage Surge Protection: UL 1449 listed; provide for each line voltage circuit that supplies operating power for fire alarm system control equipment (e.g. fire alarm control panel, field booster panels, nodes, transponders, etc).
  2. Basis of Design Products:
    - a. Space Age Electronics Model E120V-GT line voltage surge protection, 120 VAC.

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**PART 3 EXECUTION****4.01 EXAMINATION (BY INSTALLER)**

- A. Verify that field measurements are as indicated.
- B. Verify that characteristics of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that circuit wiring installation is completed, tested, and ready for connection to system where applicable per conductor requirements of NFPA 72 Table 14.4.3.2 (15) and (16).
- E. Verify that conditions are satisfactory for installation prior to starting work.

**4.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install products in accordance with applicable requirements of NECA 1 (general workmanship).
- C. Adjust selectable candela strobes to rating indicated on design documents.
- D. Provide grounding and bonding in accordance with manufacturer's recommendations and Section 260526.
- E. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- F. Identify system wiring, components, and overcurrent protective devices for branch circuits serving fire alarm system in accordance with Section 260553.

**4.03 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Notify Owner and Engineer at least two weeks prior to scheduled inspections and tests.
- C. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- D. Provide equipment, tools, supplies, two-way radios, and personnel required to accomplish inspection and testing.
- E. Prepare and start system in accordance with manufacturer's instructions.
- F. Program system parameters according to project requirements.
- G. Perform initial and acceptance inspection and testing in accordance with NFPA 72 and requirements of authorities having jurisdiction; document each inspection and test.
- H. Test for proper interface with other systems.
- I. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.
- J. Installer to submit NFPA 72 reports indicating inspection and testing results and corrective actions taken.

**4.04 CLEANING**

- A. See Section 017419 - Construction Waste Management and Disposal, for additional requirements.
- B. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

**4.05 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
  - 1. Be prepared to conduct any of the required tests.

2. Have at least one copy of operation and maintenance data, copy of project record drawings, input/output matrix, and operator instructions available during demonstration.
  3. Have manufacturer's authorized representative present during demonstration.
  4. Demonstration may be combined with inspection and testing required by authorities having jurisdiction.
- C. Training: Owner Personnel Instruction:
1. Provide the following instruction to designated Owner personnel:
    - a. Hands-On Instruction: On-site, using operational system.
    - b. Classroom Instruction: Owner furnished classroom, on-site or at other local facility.
    - c. Factory-Certified Instruction: At control unit manufacturer's authorized training facility.
  2. Basic Operation: One 1-hour session pre-closeout for attendant personnel, security officers, and engineering staff; combination of classroom and hands-on.
  3. Furnish the services of instructors and teaching aids; have copies of operation and maintenance data available during instruction.

#### 4.06 PROTECTION

- A. Protect installed system components from subsequent construction operations.

#### 4.07 MAINTENANCE

- A. See Section 017000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide to Owner at no extra cost, a separate maintenance contract for the service and maintenance of fire alarm system for entire manufacturer's warranty period to include the work described below; include a complete description of preventive maintenance, systematic examination, adjustment, inspection, and testing, with a detailed schedule.
- C. Perform routine inspection, testing, and preventive maintenance required by NFPA 72 and 527 CMR 1.00, including:
1. Maintenance of fire safety interface and supervisory devices connected to fire alarm system.
  2. Repairs required outside of warranty as approved by Owner.
  3. Record keeping required by NFPA 72 and authorities having jurisdiction.
- D. Provide trouble call-back service upon notification by Owner:
1. Provide on-site response within 4 hours of notification.
  2. Include fee schedule for call-back service during and outside normal working hours; include definition of normal working hours.
- E. Maintain an on-site log listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced.

#### END OF SECTION

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**SECTION 284601  
FIRE ALARM SYSTEM (EXISTING SYSTEM)  
(EXISTING BUILDING)**

**PART 1 - GENERAL**

**2.01 SCOPE & RELATED DOCUMENTS**

- A. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials, and performance of all operations in connection with the modifications and additions to the existing Fire Alarm System(s) as shown on the drawings and as herein specified.
- B. The requirements of the conditions of the Contract, Supplementary Conditions and General Requirements, apply to the work specified in this section.
- C. The complete installation is to conform to the applicable sections of NFPA-72, NFPA-71, Local Code Requirements and National Electrical Code with particular attention to Article 760.
- D. Additionally, the entire installed system and all integrated system operations shall be within the guidelines of the SBCCI Standard Building Code.
- E. The work covered by this section of the specifications is to be coordinated with the related work as specified elsewhere under the project specifications.
- F. The contractor shall provide all required modifications and additions to the existing Fire Alarm System for the removal, relocation of existing devices and addition of new devices. This shall include all additional wiring, devices, modifications to the existing control panel, additional components and modules, addressable cards, testing, troubleshooting and instructions to the owner.

**2.02 QUALITY ASSURANCE**

- A. Each and all items of the Fire Alarm System shall be listed compatible with the existing system under the appropriate category by Underwriters' Laboratories, Inc. (UL), and shall bear the "U.L." label. All control equipment is to be listed under UL category UOJZ as a single control unit. Partial listing shall NOT be acceptable
- B. All items shall match and be of the same manufacturer as the existing system.
- C. The equipment and installation supervision furnished under this specification is to be provided by a manufacturer who has been engaged in production of this type (software driven) of equipment for at least ten (10) years, and has a fully-equipped service organization within thirty-five (35) miles of the installation.
- D. All control equipment must have transient protection devices to comply with UL864 requirements.
- E. In addition to the UL-UOJZ requirement mentioned above, the system controls shall be UL listed for Power Limited Applications per NEC 760. All circuits must be marked in accordance with NEC article 760-23.
- F. Supplier shall provide documentation that fire alarm technicians are NICET LEVEL 2 certified (minimum of four).
- G. Suppliers' service organization must have been established in the local area for a minimum of ten (10) years with ten (10) years experience on specific equipment brand supplied.

**2.03 SUBMITTALS**

- A. Submit shop drawings for each piece of equipment specified including complete wiring and connection diagrams.
- B. All submittals shall be submitted in a single complete brochure, which shall be in the form of a soft cover binder with each group separated by an identified index tab.
- C. Submittals that fail to comply with the above requirements will automatically be rejected.

- D. It is the Contractor's responsibility to provide submittals in an organized and timely manner in order so as not to delay the project schedule and hamper the work of other trades.
- E. Submit certificate of Fire Alarm System operating tests.

## **PART 2 PRODUCTS**

### **3.01 PERIPHERAL DEVICES**

- A. The Contractor shall furnish and install addressable devices that are compatible with the existing Silent Knight Intelliknight Model 5820XL fire alarm System.
- B. Devices Required but not limited to:
  - 1. Manual Pull Stations
  - 2. Smoke Detectors
  - 3. Duct Smoke Detectors
  - 4. Heat Detectors
  - 5. Combination Speaker/Strobe Stations
  - 6. Visual Alarm (Strobe) Stations
  - 7. Auxiliary contacts on devices where indicated on drawings.
  - 8. Power Supplies
  - 9. Addressable Relay modules

### **3.02 MAGNETIC DOOR HOLDERS**

- A. Description: Units shall be listed to UL 228. Units shall be equipped for wall or floor mounting as indicated on plans and are complete with matching door plate and extension arms as required. Unit shall operate from a 120VAC, a 24VAC or a 24VDC source from fire alarm panel. Magnets must develop a minimum of 25 lbs. holding force for any of these voltages.
- B. Material and Finish: Match door hardware. All final hardware material and finishes must be coordinate with the GC.

## **PART 3 EXECUTION**

### **4.01 INSTALLATION**

- A. Provide and install all devices in accordance with the plans and specifications, all applicable codes and the manufacturer's recommendations. All wiring shall be installed in strict compliance with all the provisions of NEC - Article 760 A and C, Power-Limited Fire Protective Signaling Circuits or if required may be reclassified as non-power limited and wired in accordance with NEC-Article 760 A and B. Upon completion, the contractor shall so certify in writing to the owner and general contractor.
  - 1. All junction boxes shall be sprayed red and labeled "Fire Alarm". Wiring color code shall be maintained throughout the installation.
- B. Installation of equipment and devices that pertain to other work in the contract shall be closely coordinated with the appropriate subcontractors.
- C. The contractor shall clean all dirt and debris from the inside and the outside of the fire alarm equipment after completion of the installation.
- D. The manufacturer's authorized representative shall provide on-site supervision of installation.

### **4.02 TESTING**

- A. The completed fire alarm system shall be fully tested in accordance with NFPA-72H by the contractor in the presence of the owner's representative and the Local Fire Marshal. Upon completion of a successful test, the contractor shall so certify in writing to the owner and general contractor.

### **4.03 WARRANTY**

- A. The contractor shall warrant the completed fire alarm system wiring and equipment to be free from inherent mechanical and electrical defects for a period of one (1) year from the date of the completed and certified test or from the date of first beneficial use.

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- B. The equipment manufacturer shall make available to the owner a maintenance contract proposal to provide a minimum of two (2) inspections and tests per year in compliance with NFPA-72H guidelines.

**END OF SECTION**

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## SECTION 311000 - SITE CLEARING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Removing above- and below-grade site improvements.

#### 1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at one of the installation sites.

#### 1.3 MATERIAL OWNERSHIP

- A. Cleared materials shall become Contractor's property and shall be removed from Project site.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
  - 1. Use sufficiently detailed photographs or video recordings.
  - 2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.

#### 1.5 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
  - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
  - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

### PART 2 - PRODUCTS

### PART 3 - EXECUTION

#### 3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Protect existing site improvements to remain from damage during construction.
  - 1. Restore damaged improvements to their original condition, as acceptable to Owner.

#### 3.2 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.

### **3.3 DISPOSAL OF SURPLUS AND WASTE MATERIALS**

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
- B. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

**SECTION 312000 - EARTH MOVING**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

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

**1.2 SUMMARY**

- A. Section Includes:
1. Excavating and filling for rough grading the Site.
  2. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
  3. Excavating and backfilling for buildings and structures.
  4. Drainage course for concrete slabs-on-grade.
  5. Subbase course for concrete walks.
  6. Subbase course and base course for asphalt paving.
  7. Subsurface drainage backfill for walls and trenches.
  8. Excavating and backfilling trenches for utilities and pits for buried utility structures.
  9. Excavating well hole to accommodate elevator-cylinder assembly.
- B. Related Requirements:
1. Section 013200 "Construction Progress Documentation" and Section 013233 "Photographic Documentation" for recording preexcavation and earth-moving progress.
  2. Section 033000 "Cast-in-Place Concrete" for granular course if placed over vapor retarder and beneath the slab-on-grade.
  3. Section 311000 "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
  4. Section 312319 "Dewatering" for lowering and disposing of ground water during construction.
  5. Section 315000 "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
  6. Section 316329 "Drilled Concrete Piers and Shafts" for excavation of shafts and disposal of surplus excavated material.
  7. Section 329200 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.
  8. Section 329300 "Plants" for finish grading in planting areas and tree and shrub pit excavation and planting.

**1.3 UNIT PRICES**

- A. Work of this Section is affected by unit prices for earth moving specified in Section 012200 "Unit Prices."
- B. Quantity allowances for earth moving are included in Section 012100 "Allowances."
- C. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following. Unit prices for rock excavation include replacement with approved materials.
1. 24 inches outside of concrete forms other than at footings.
  2. 12 inches outside of concrete forms at footings.
  3. 6 inches outside of minimum required dimensions of concrete cast against grade.
  4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
  5. 6 inches beneath bottom of concrete slabs-on-grade.
  6. 6 inches beneath pipe in trencheswide.

## **1.4 DEFINITIONS**

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
  - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
  - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
  - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
  - 2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
  - 3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
- H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. for bulk excavation or 3/4 cu. Yd. for footing, trench, and pit excavation that cannot be removed by rock-excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
- I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- J. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- L. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

## **1.5 PREINSTALLATION MEETINGS**

- A. Preinstallation Conference: Conduct preexcavation conference at Project site
  - 1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
    - a. Personnel and equipment needed to make progress and avoid delays.
    - b. Coordination of Work with utility locator service.
    - c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
    - d. Extent of trenching by hand or with air spade.
    - e. Field quality control.



## 1.6 ACTION SUBMITTALS

- A. Product Data: For each type of the following manufactured products required:
  - 1. Geotextiles.
  - 2. Controlled low-strength material, including design mixture.
  - 3. Geofoam.
  - 4. Warning tapes.
- B. Samples for Verification: For the following products, in sizes indicated below:
  - 1. Geotextile: 12 by 12 inches.
  - 2. Warning Tape: 12 inches long; of each color.

## 1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
  - 1. Classification according to ASTM D 2487.
  - 2. Laboratory compaction curve according to ASTM D 698
- C. Seismic survey report from seismic survey agency.
- D. Preexcavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

## 1.8 QUALITY ASSURANCE

- A. Blasting: Comply with applicable requirements in NFPA 495, "Explosive Materials Code," and prepare a blasting plan reporting the following:
  - 1. Types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
  - 2. Seismographic monitoring during blasting operations.
- B. Seismic Survey Agency: An independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform the following services:
  - 1. Report types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
  - 2. Seismographic monitoring during blasting operations.
- C. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

## 1.9 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.
  - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
  - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
  - 1. Do not proceed with work on adjoining property until directed by Architect.

- C. Utility Locator Service: Notify "Dig Safe System" for area where Project is located before beginning earth-moving operations.
- D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in Section 015000 "Temporary Facilities and Controls" and Section 311000 "Site Clearing" are in place.
- E. Do not commence earth-moving operations until plant-protection measures specified in Section 015639 "Temporary Tree and Plant Protection" are in place.
- F. The following practices are prohibited within protection zones:
  - 1. Storage of construction materials, debris, or excavated material.
  - 2. Parking vehicles or equipment.
  - 3. Foot traffic.
  - 4. Erection of sheds or structures.
  - 5. Impoundment of water.
  - 6. Excavation or other digging unless otherwise indicated.
  - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- G. Do not direct vehicle or equipment exhaust towards protection zones.
- H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

## PART 2 - PRODUCTS

### 2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487 or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- C. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- D. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M 0; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.
- E. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- F. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.
- G. Drainage Course: Narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and zero to 5 percent passing a No. 8 sieve.
- H. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and zero to 5 percent passing a No. 4 sieve.
- I. Sand: ASTM C 33/C 33M; fine aggregate.
- J. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

## 2.2 GEOTEXTILES

- A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
1. Survivability: Class 2; AASHTO M 288.
  2. Survivability: As follows:
    - a. Grab Tensile Strength: 157 lbf; ASTM D 4632.
    - b. Sewn Seam Strength: 142 lbf; ASTM D 4632.
    - c. Tear Strength: 56 lbf; ASTM D 4533.
    - d. Puncture Strength: 56 lbf; ASTM D 4833.
  3. Apparent Opening Size: =No. 60 sieve, maximum; ASTM D 4751.
  4. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.
- B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
1. Survivability: Class 2; AASHTO M 288.
  2. Survivability: As follows:
    - a. Grab Tensile Strength: 247 lbf; ASTM D 4632.
    - b. Sewn Seam Strength: 222 lbf; ASTM D 4632.
    - c. Tear Strength: 90 lbf; ASTM D 4533.
    - d. Puncture Strength: 90 lbf; ASTM D 4833.
  3. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
  4. Permittivity: 0.02 per second, minimum; ASTM D 4491.
  5. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

## 2.3 CONTROLLED LOW-STRENGTH MATERIAL

- A. Controlled Low-Strength Material: Self-compacting, low-density, flowable concrete material produced from the following:
1. Portland Cement: ASTM C 150/C 150M, Type II
  2. Fly Ash: ASTM C 618, Class C or F.
  3. Normal-Weight Aggregate: ASTM C 33/C 33M, 3/4-inch nominal maximum aggregate size.
  4. Foaming Agent: ASTM C 869/C 869M.
  5. Water: ASTM C 94/C 94M.
  6. Air-Entraining Admixture: ASTM C 260/C 260M.

## 2.4 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:
1. Red: Electric.
  2. Yellow: Gas, oil, steam, and dangerous materials.
  3. Orange: Telephone and other communications.
  4. Blue: Water systems.
  5. Green: Sewer systems.
- B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:
1. Red: Electric.
  2. Yellow: Gas, oil, steam, and dangerous materials.

3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth-moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

### 3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
  1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

### 3.3 EXPLOSIVES

- A. Explosives: Do not use explosives.
- B. Explosives: Obtain written permission from authorities having jurisdiction before bringing explosives to Project site or using explosives on Project site.
  1. Perform blasting without damaging adjacent structures, property, or site improvements.
  2. Perform blasting without weakening the bearing capacity of rock subgrade and with the least-practicable disturbance to rock to remain.

### 3.4 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
  1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
- B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.

### 3.5 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
  1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

2. Pile Foundations: Stop excavations 6 to 12 inches above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
  3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.
- B. Excavations at Edges of Tree- and Plant-Protection Zones:
1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
  2. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

### **3.6 EXCAVATION FOR WALKS AND PAVEMENTS**

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

### **3.7 EXCAVATION FOR UTILITY TRENCHES**

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
1. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
  2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
  3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
  4. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
- D. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
- E. Trenches in Tree- and Plant-Protection Zones:
1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
  2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
  3. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

### **3.8 SUBGRADE INSPECTION**

- A. Notify Architect when excavations have reached required subgrade.
- B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
  - 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction.
  - 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

### **3.9 UNAUTHORIZED EXCAVATION**

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Architect.
  - 1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

### **3.10 STORAGE OF SOIL MATERIALS**

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
  - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

### **3.11 BACKFILL**

- A. Place and compact backfill in excavations promptly, but not before completing the following:
  - 1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
  - 2. Surveying locations of underground utilities for Record Documents.
  - 3. Testing and inspecting underground utilities.
  - 4. Removing concrete formwork.
  - 5. Removing trash and debris.
  - 6. Removing temporary shoring, bracing, and sheeting.
  - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

### **3.12 UTILITY TRENCH BACKFILL**

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

- D. Trenches under Roadways: Provide 4-inch thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- E. Backfill voids with satisfactory soil while removing shoring and bracing.
- F. Initial Backfill:
  - 1. Soil Backfill: Place and compact initial backfill of satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
    - a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
  - 2. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.
- G. Final Backfill:
  - 1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
  - 2. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.
- H. Warning Tape: Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

### **3.13 SOIL FILL**

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
  - 1. Under grass and planted areas, use satisfactory soil material.
  - 2. Under walks and pavements, use satisfactory soil material.
  - 3. Under steps and ramps, use engineered fill.
  - 4. Under building slabs, use engineered fill.
  - 5. Under footings and foundations, use engineered fill.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

### **3.14 OIL MOISTURE CONTROL**

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
  - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
  - 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

### **3.15 COMPACTION OF SOIL BACKFILLS AND FILLS**

- A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698
  - 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.

2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 92 percent.
3. Under turf or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.

### **3.16 GRADING**

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
  1. Provide a smooth transition between adjacent existing grades and new grades.
  2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations.

### **3.17 SUBSURFACE DRAINAGE**

- A. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
  1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698
- B. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
  1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.
  2. Place and compact impervious fill over drainage backfill in 6-inch-thick compacted layers to final subgrade.

### **3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS**

- A. Place subbase course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase course under pavements and walks as follows:
  1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
  2. Place base course material over subbase course under hot-mix asphalt pavement.
  3. Shape subbase course to required crown elevations and cross-slope grades.
  4. Place subbase course 6 inches or less in compacted thickness in a single layer.
  5. Place subbase course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
  6. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698

### **3.19 FIELD QUALITY CONTROL**

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
  1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
  2. Determine that fill material classification and maximum lift thickness comply with requirements.



3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
  1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab but in no case fewer than three tests.
  2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length but no fewer than two tests.
  3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length but no fewer than two tests.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

### **3.20 PROTECTION**

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
  1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
  1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

### **3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS**

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.
- B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.
  1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

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**SECTION 312316  
EXCAVATION****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Excavating for building volume below grade, footings, slabs-on-grade, paving, site structures, and utilities within the building.
- B. Trenching for utilities outside the building to utility main connections.
- C. Temporary excavation support and protection systems.

**1.02 RELATED REQUIREMENTS**

- A. Section 015713 - Temporary Erosion and Sediment Control: Slope protection and erosion control.
- B. Section 024100 - Demolition: Shoring and underpinning existing structures.
- C. Section 210553 - Identification for Fire Suppression Piping and Equipment: Underground warning tapes at underground fire suppression lines.
- D. Section 220553 - Identification for Plumbing Piping and Equipment: Underground warning tapes at underground plumbing lines.
- E. Section 230553 - Identification for HVAC Piping and Equipment-CPL: Underground warning tapes at underground HVAC lines.
- F. Section 260553 - Identification for Electrical Systems: Underground warning tapes at underground electrical lines.
- G. Section 311000 - Site Clearing: Vegetation and existing debris removal.
- H. Section 312200 - Grading: Soil removal from surface of site.
- I. Section 312316.13 - Trenching: Excavating for utility trenches outside the building to utility main connections.
- J. Section 312323 - Fill: Fill materials, backfilling, and compacting.

**1.03 REFERENCE STANDARDS**

- A. 29 CFR 1926 - U.S. Occupational Safety and Health Standards current edition.

**1.04 QUALITY ASSURANCE**

- A. Temporary Support and Excavation Protection Plan:
  - 1. Indicate sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property.
  - 2. Bracing and shoring design to meet requirements of OSHA's Excavation Standard, 29 CFR 1926, Subpart P.
- B. Designer Qualifications: For design of temporary shoring and bracing, employ a Professional Engineer experienced in design of this type of work and licensed in the State in which the Project is located.

**PART 2 PRODUCTS****2.01 MATERIALS**

- A. Bedding and Fill to Correct Over-Excavation:
  - 1. See Section 312323 for bedding and corrective fill materials at general excavations.
- B. Underground Warning Tapes:
  - 1. See Section for 260553 underground warning tapes at underground electrical lines.

**PART 3 EXECUTION****3.01 EXAMINATION**

- A. Verify that survey bench mark and intended elevations for the work are as indicated.
- B. Survey existing adjacent structures and improvements and establish exact elevations at fixed points to act as benchmarks.

- C. Determine the prevailing groundwater level prior to excavation. If the proposed excavation extends less than 1 foot into the prevailing groundwater, control groundwater intrusion with perimeter drains routed to sump pumps, or as directed by Architect. If the proposed excavation extends more than 1 foot into the prevailing groundwater, control groundwater intrusion with a comprehensive dewatering procedures, or as directed by Geotechnical Engineer.

### **3.02 PREPARATION**

- A. Identify required lines, levels, contours, and datum locations.
- B. Locate, identify, and protect utilities that remain and protect from damage.
- C. Grade top perimeter of excavation to prevent surface water from draining into excavation. Provide temporary means and methods, as required, to maintain surface water diversion until no longer needed, or as directed by Architect.

### **3.03 TEMPORARY EXCAVATION SUPPORT AND PROTECTION**

- A. Excavation Safety: Comply with OSHA's Excavation Standard, 29 CFR 1926, Subpart P.
  - 1. Excavations in stable rock or in less than 5 feet in depth in ground judged as having no cave-in potential do not require excavation support and protection systems.
  - 2. Depending upon excavation depth, time that excavation is open, soil classification, configuration and slope of excavation sidewalls, design and provide an excavation support and protection system that meets the requirements of 29 CFR 1926, Subpart P:
- B. Excavation support and protection systems not required to remain in place may be removed subject to approval of Owner or Owner's Representative.

### **3.04 EXCAVATING**

- A. Excavate to accommodate new structures and construction operations.
  - 1. Excavate to the specified elevations.
  - 2. Cut utility trenches wide enough to allow inspection of installed utilities.
- B. Notify Architect of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- C. Do not interfere with 45 degree bearing splay of foundations.
- D. Provide temporary means and methods, as required, to remove all water from excavations until directed by Architect. Remove and replace soils deemed suitable by classification and which are excessively moist due to lack of dewatering or surface water control.

### **3.05 FILLING AND BACKFILLING**

- A. Do not fill or backfill until all debris, water, unsatisfactory soil materials, obstructions, and deleterious materials have been removed from excavation.
- B. Install underground warning tape at buried utilities according to Sections 260553.
- C. See Section 312316.13 for fill, backfill, and compaction requirements at utility trenches.

### **3.06 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for general requirements for field inspection and testing.
- B. Provide for visual inspection of load-bearing excavated surfaces by Architect before placement of foundations.

### **3.07 CLEANING**

- A. Remove excavated material that is unsuitable for re-use from site.
- B. Remove excess excavated material from site.

### **3.08 PROTECTION**

- A. Divert surface flow from rains or water discharges from the excavation.
- B. Prevent displacement of banks and keep loose soil from falling into excavation; maintain soil stability.

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- C. Protect open excavations from rainfall, runoff, freezing groundwater, or excessive drying so as to maintain foundation subgrade in satisfactory, undisturbed condition.
- D. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.
- E. Keep excavations free of standing water and completely free of water during concrete placement.

**END OF SECTION**

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**SECTION 312316.13  
TRENCHING****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Backfilling and compacting for utilities outside the building to utility main connections.

**1.02 RELATED REQUIREMENTS**

- A. Section 312200 - Grading: Site grading.
- B. Section 312316 - Excavation: Building and foundation excavating.
- C. Section 312323 - Fill: Backfilling at building and foundations.

**1.03 REFERENCE STANDARDS**

- A. AASHTO T 180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18 in.) Drop 2018.
- B. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>)) 2012 (Reapproved 2021).
- C. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)) 2012 (Reapproved 2021).

**1.04 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Materials Sources: Submit name of imported materials source.
- C. Fill Composition Test Reports: Results of laboratory tests on proposed and actual materials used.
- D. Compaction Density Test Reports.

**PART 2 PRODUCTS****2.01 FILL MATERIALS**

- A. General Fill - Fill Type 203.07: Complying with State of New York Highway Department standard.

**PART 3 EXECUTION****3.01 EXAMINATION**

- A. Verify that survey bench marks and intended elevations for the work are as indicated.

**3.02 PREPARATION**

- A. Identify required lines, levels, contours, and datum locations.
- B. Grade top perimeter of trenching area to prevent surface water from draining into trench. Provide temporary means and methods, as required, to maintain surface water diversion until no longer needed, or as directed by the Architect.

**3.03 TRENCHING**

- A. Notify Architect of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- B. Slope banks of excavations deeper than 4 feet to angle of repose or less until shored.
- C. Do not interfere with 45 degree bearing splay of foundations.
- D. Cut trenches wide enough to allow inspection of installed utilities.
- E. Hand trim excavations. Remove loose matter.
- F. Remove excavated material that is unsuitable for re-use from site.
- G. Remove excess excavated material from site.
- H. Provide temporary means and methods, as required, to remove all water from trenching until directed by the Architect. Remove and replace soils deemed unsuitable by classification and which are excessively moist due to lack of dewatering or surface water control.

- I. Determine the prevailing groundwater level prior to trenching. If the proposed trench extends less than 1 foot into the prevailing groundwater, control groundwater intrusion with perimeter drains routed to sump pumps, or as directed by the Architect.

### **3.04 PREPARATION FOR UTILITY PLACEMENT**

- A. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill.
- B. Compact subgrade to density equal to or greater than requirements for subsequent fill material.
- C. Until ready to backfill, maintain excavations and prevent loose soil from falling into excavation.

### **3.05 BACKFILLING**

- A. Backfill to contours and elevations indicated using unfrozen materials.
- B. Employ a placement method that does not disturb or damage other work.
- C. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.
- D. Maintain optimum moisture content of fill materials to attain required compaction density.
- E. Slope grade away from building minimum 2 inches in 10 feet, unless noted otherwise. Make gradual grade changes. Blend slope into level areas.
- F. Correct areas that are over-excavated.
  1. Other areas: Use general fill, flush to required elevation, compacted to minimum 97 percent of maximum dry density.
- G. Compaction Density Unless Otherwise Specified or Indicated:
- H. Reshape and re-compact fills subjected to vehicular traffic.

### **3.06 BEDDING AND FILL AT SPECIFIC LOCATIONS**

- A. Use general fill unless otherwise specified or indicated.
- B. Utility Piping, Conduits, and Duct Bank:
  1. Bedding: Use general fill.
  2. Compact in maximum 8 inch lifts to 95 percent of maximum dry density.

### **3.07 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for general requirements for field inspection and testing.
- B. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D1557 ("modified Proctor"), AASHTO T 180, or ASTM D698 ("standard Proctor").
- C. If tests indicate work does not meet specified requirements, remove work, replace and retest.
- D. Frequency of Tests: [\_\_\_\_\_].

**END OF SECTION**



**SECTION 312323  
FILL****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Filling, backfilling, and compacting for building volume below grade.
- B. Backfilling and compacting for utilities outside the building to utility main connections.
- C. Filling holes, pits, and excavations generated as a result of removal (demolition) operations.
- D. Rigid plastic foam block fill.
- E. Lightweight concrete fill.

**1.02 RELATED REQUIREMENTS**

- A. Section 033000 - Cast-in-Place Concrete.
- B. Section 312200 - Grading: Site grading.
- C. Section 312316 - Excavation: Removal and handling of soil to be re-used.
- D. Section 312316.13 - Trenching: Excavating for utility trenches outside the building to utility main connections.
- E. Section 334100 - Subdrainage: Filter aggregate and filter fabric for foundation drainage systems.

**1.03 DEFINITIONS**

- A. Finish Grade Elevations: Indicated on drawings.
- B. Subgrade Elevations: Indicated on drawings.
- C. Subgrade Elevations: 4 inches below finish grade elevations indicated on drawings, unless otherwise indicated.
- D. Finish Grade Elevations: 4 inches above subgrade elevations indicated on drawings , unless otherwise indicated.

**1.04 REFERENCE STANDARDS**

- A. AASHTO M 147 - Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses 2017.
- B. AASHTO T 180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18 in.) Drop 2018.
- C. ASTM C136/C136M - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates 2019.
- D. ASTM C150/C150M - Standard Specification for Portland Cement 2020.
- E. ASTM C1602/C1602M - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete 2012.
- F. ASTM C796/C796M - Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam 2019.
- G. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>)) 2012 (Reapproved 2021).
- H. ASTM D1556/D1556M - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method 2015, with Editorial Revision (2016).
- I. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)) 2012 (Reapproved 2021).
- J. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method 2015.
- K. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) 2017, with Editorial Revision.
- L. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils 2017, with Editorial Revision (2018).

- M. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth) 2017a, with Editorial Revision.
- N. ASTM D7557/D7557M - Standard Practice for Sampling of Expanded Geofoam Specimens 2009, with Editorial Revision (2013).
- O. ICC-ES AC239 - Acceptance Criteria for Termite-Resistant Foam Plastic 2008, with Editorial Revision (2014).

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data for Manufactured Fill.
- C. Shop Drawings for Manufactured Fill.
  - 1. Submit plan, section, and profile drawings. Indicate size, type, location, and orientation of each geofoam block.
  - 2. Submit location and type of connectors.
  - 3. Indicate proposed weighting or guying.
- D. Soil Samples: 10 pounds sample of each type of fill; submit in air-tight containers to testing laboratory.
- E. Materials Sources: Submit name of imported materials source.
- F. Fill Composition Test Reports: Results of laboratory tests on proposed and actual materials used, including manufactured fill.
- G. Compaction Density Test Reports.
- H. Lightweight Concrete Test Reports.
- I. Designer's Qualification Statement.
- J. Testing Agency Qualification Statement.
- K. Specimen Warranty.

#### **1.06 QUALITY ASSURANCE**

- A. Designer Qualifications: Perform design of structural fill under direct supervision of a Professional Engineer experienced in design of this type of work and licensed in the State in which the Project is located.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than ten years of documented experience.
- C. Lightweight Concrete Fill Applicator Qualifications: Company specializing in performing work of the type specified and with at least 13,000 cubic yards in five years of documented experience and approved by manufacturer.
- D. Testing Agency Qualifications: Independent firm specializing in performing testing and inspections of the type specified in this section.
- E. Copies of Documents at Project Site: Maintain at the project site a copy of each referenced document that prescribes execution requirements.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. When necessary, store materials on site in advance of need.
- B. When fill materials need to be stored on site, locate stockpiles where indicated.
  - 1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
  - 2. Prevent contamination.
  - 3. Protect stockpiles from erosion and deterioration of materials.

#### **1.08 WARRANTY**

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a five year period after Date of Substantial Completion.

**PART 2 PRODUCTS****2.01 FILL MATERIALS**

- A. General Fill - Fill Type Satisfactory Soils: Subsoil excavated on-site.
  - 1. Graded.
  - 2. Free of lumps larger than 3 inches, rocks larger than 2 inches, and debris.
  - 3. Complying with ASTM D2487 Group Symbol CL.
- B. Structural Fill - Fill Type [\_\_\_\_]: Subsoil excavated on-site.
  - 1. Graded.
  - 2. Free of lumps larger than 3 inches, rocks larger than 2 inches, and debris.
  - 3. Complying with ASTM D2487 Group Symbol CL.
- C. Concrete for Fill: See Section 033000; compressive strength of 2,500 psi.
- D. Granular Fill - Fill Type 203.07: Coarse aggregate, complying with State of New York Highway Department standard.
- E. Sand - Fill Type [\_\_\_\_]: Natural river or bank sand; free of silt, clay, loam, friable or soluble materials, and organic matter.
- F. Topsoil - Fill Type [\_\_\_\_]: Topsoil excavated on-site.
  - 1. Graded.
  - 2. Free of roots, rocks larger than 1/2 inch, subsoil, debris, large weeds and foreign matter.
  - 3. Acidity range (pH) of 5.5 to 7.5.
  - 4. Containing a minimum of 4 percent and a maximum of 25 percent inorganic matter.
  - 5. Complying with ASTM D2487 Group Symbol OH.

**2.02 ACCESSORIES**

- A. Geotextile: Non-biodegradable, woven.
- B. Vapor Retarder: 10 mil thick, polyethylene.

**2.03 SOURCE QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for general requirements for testing and analysis of soil material.
- B. Where fill materials are specified by reference to a specific standard, testing of samples for compliance will be provided before delivery to site.
- C. If tests indicate materials do not meet specified requirements, change material and retest.
- D. Provide materials of each type from same source throughout the Work.

**PART 3 EXECUTION****3.01 EXAMINATION**

- A. Identify required lines, levels, contours, and datum locations.
- B. Verify areas to be filled are not compromised with surface or ground water.

**3.02 PREPARATION**

- A. Scarify and proof roll subgrade surface to a depth of 6 inches to identify soft spots.
- B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill.
- C. Compact subgrade to density equal to or greater than requirements for subsequent fill material.
- D. Until ready to fill, maintain excavations and prevent loose soil from falling into excavation.

**3.03 FILLING**

- A. Fill to contours and elevations indicated using unfrozen materials.
- B. Employ a placement method that does not disturb or damage other work.
- C. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.
- D. Maintain optimum moisture content of fill materials to attain required compaction density.

- E. Slope grade away from building minimum 2 inches in 10 feet, unless noted otherwise. Make gradual grade changes. Blend slope into level areas.
- F. Correct areas that are over-excavated.
  - 1. Other areas: Use general fill, flush to required elevation, compacted to minimum 97 percent of maximum dry density.
- G. Compaction Density Unless Otherwise Specified or Indicated:
- H. Reshape and re-compact fills subjected to vehicular traffic.
- I. Maintain temporary means and methods, as required, to remove all water while fill is being placed as required, or until directed by the Architect. Remove and replace soils deemed unsuitable by classification and which are excessively moist due to lack of dewatering or surface water control.

### **3.04 FILL AT SPECIFIC LOCATIONS**

### **3.05 FIELD QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements, for general requirements for field inspection and testing.
- B. Soil Fill Materials:
  - 1. Perform compaction density testing on compacted fill in accordance with ASTM D1556, ASTM D2167, or ASTM D6938.
  - 2. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D698 ("standard Proctor"), ASTM D1557 ("modified Proctor"), or AASHTO T 180.
  - 3. If tests indicate work does not meet specified requirements, remove work, replace and retest.
  - 4. Frequency of Tests: as needed.

### **3.06 CLEANING**

- A. See Section 017419 - Construction Waste Management and Disposal, for additional requirements.
- B. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.
- C. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

**END OF SECTION**

**SECTION 31 2500 – EROSION AND SEDIMENTATION CONTROL**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.
- B. New York State Standards and Specifications for Erosion and Sediment Control

**1.2 WORK OF THIS SECTION**

- A. Work covered in this section includes the control of erosion, siltation, and sedimentation pursuant to Section 402 of the Clean Water Act. All costs associated with the temporary or permanent erosion control measures shall be included in the Contractor's bid.
- B. All Contractors and their subcontractors must agree to implement all applicable provisions of the Erosion Control Plans and Stormwater Pollution Prevention Plan (SWPPP) prior to commencement of any construction activity. The SWPPP is appended to this Specification.

**1.3 QUALITY ASSURANCE**

- A. Contractor shall comply with the Erosion Control Plans and Stormwater Pollution Prevention Plan prepared for the site. All workers responsible for site work activities shall be familiar with these Plans.
- B. Contractor shall designate one individual responsible for implementing and maintaining site-wide erosion and sediment control measures who shall be thoroughly familiar with the types of materials being installed and the best methods for their installation. This individual shall conduct daily inspections of erosion and sediment control measures.
- C. Clear only what is required for immediate construction activities. Disturbed areas of the site that will not be re-disturbed for 21 days or more must be stabilized by the 14<sup>th</sup> day following the last disturbance.
- D. Upstream storm water runoff should be diverted away from disturbed areas. Contractor shall provide and maintain temporary erosion and sediment control measures, such as berms, dikes, slope drains, silt stops, and sedimentation basins, until permanent drainage facilities and erosion control features have been completed and are operative.
- E. The limits of cleared areas shall be physically delineated to protect areas designated as undisturbed.
- F. Take every reasonable precaution and do whatever is necessary to avoid erosion and to prevent silting of rivers, streams, impoundments, and drainage ditches, swales or any off-site water body.
- G. Continue erosion control measures until the permanent measures have been sufficiently established and are capable of controlling erosion on their own.
- H. The control of dust, erosion and sediment originating from construction operations is considered a critical responsibility of the Contractor. The Owner's Representative will be the final judge of the adequacy of the Contractor's dust, erosion and sedimentation control. The Owner's Representative may suspend work until adequate dust, erosion and sedimentation control is attained. The Contractor shall bear the costs of repair work and restoration of damaged items.

## PART 2 - PRODUCTS

### 2.1 MULCHING

- A. Hay and straw mulches shall be air-dried mowings (<15% moisture content) of acceptable herbaceous growth reasonably free from swamp grass, weeds, twigs, debris, and other deleterious material, and free from rot, mold, primary noxious weed seeds, and rough or woody materials. Mulches containing mature seed of species which would volunteer and be detrimental to the permanent seeding, or would result in overseeding, or would produce growth which is aesthetically unpleasing, are not permitted. Materials may be baled, however, loose or broken bales are not acceptable.
- B. Temporary Type Mulch Nets: Lightweight, extruded photodegradable netting, with approximate openings of 1½" x ¾", with manufacturer recommended staples or anchoring method.
- C. Wood fiber mulch with tackifier (Terra Tack). Apply wood fibers at the rate of 500 lbs./acre and tackifier at the rate of 40-45 gallons/acre.
- D. Hardwood Stakes: Stakes shall be new hardwood, 1½" x 1½", minimum 3 feet long.

### 2.2 MATTING/BLANKETS

- A. Jute Matting: Undyed and unbleached jute yarn woven into a uniform open, plain weave mesh, furnished in rolled strip, with 78 warp ends per yard width of cloth, 41 weft ends per linear yard, weighing approximately 0.9 pounds per square yard of fabric.
- B. Erosion Control Blanket: Blanket shall be machine-produced 100% biodegradable consisting of a 70% agricultural straw / 30% coconut fiber blend having a functional longevity of 18 months. Blanket shall covered top and bottom sides with 100% biodegradable woven natural organic fiber netting, with an approximate mesh of 0.5 x 1 inch. Blanket mesh and netting shall be sewn together on 1.5-inch centers.
- C. Staples: As specified by the manufacturer of the blanket/matting, constituting a complete system.

### 2.3 SEED AND SOD FOR EROSION CONTROL

- A. For temporary seeding in spring, summer or early fall, seed the area with ryegrass, (annual or perennial) or approved equal at 30 lbs per acre. For temporary seeding in late fall or early winter, seed the area with Certified winter rye (cereal rye) or approved equal at 100 lbs per acre. Mulch area with hay or straw at 2 tons per acre. Mulch anchoring may be required where wind or areas of concentrated water are a concern.
- B. For permanent seeding on slopes, provide a seed according to the following or as shown on the Contract Drawings
  - 1. Erosion control areas are to be seeded at a rate of: 50 pounds per acre with a mix consisting of 70% Ernst Best Strip Mine Mix (ERNMX-101) and 30% Ernst Shaded Roadside Mix (ERNMX-140), as supplied by Ernst Conservation Seeds, or as approved by Owner.

### 2.4 SILT FENCES

- A. Prefabricated silt fencing with UV-stabilized geotextile fabric, with hardwood or steel posts, mesh reinforced backing and appropriate fasteners. Fabric shall be 48" minimum width.

### 2.5 STABILIZED CONSTRUCTION ENTRANCE

- A. Material shall be clean, sound, crushed stone of uniform quality.
- B. Geotextile filter cloth (Mirafi 500X, or equal) designed for heavy-duty haul road use.

## **2.6 TEMPORARY STRUCTURAL MEASURES**

- A. Temporary structural measures for erosion control include, but are not limited to, earth dikes, temporary swales, perimeter swales, sediment traps, and sediment basins.
- B. Each measure shall be designed in accordance with New York State Guidelines for Urban Erosion and Sediment Control. Materials and construction measures shall be consistent with these measures.

## **PART 3 - EXECUTION**

### **3.1 HAY AND STRAW MULCHING**

- A. Install hay or straw mulch immediately after each area has been properly prepared. Place at a rate of 2 tons per acre (approximately 100 to 120 bales per acre). Mulching shall be applied to a uniform thickness of 2 to 3 inches (loose, uncompacted) by hand or broadcast. No clumping, matting, bale fragments, or excessive thickness shall be permitted. The intent is to allow 20% to 40% of the ground surface to be seen in a uniform coverage.
- B. Place mulch on seeded areas within 24 hours after seeding.
- C. Where winds may blow the mulch, or when ground slopes exceed 10%, or when otherwise required to maintain the mulch firmly in place. Apply temporary netting, chemical bonding, or other anchoring devices, or use mechanical crimping, punching or rolling, to anchor the mulch. Unless otherwise directed, remove netting or other acceptable anchoring system prior to the acceptance of the work.

### **3.2 MATTING/BLANKETS - GENERAL (if required)**

- A. Prepare surfaces of ditches and slopes to conform to the grades, contours and cross sections as shown on the Drawings and finish to a smooth and even condition with all debris, roots, stone, and lumps raked out and removed. Loosen the soil surface to permit bedding of the matting. Unless otherwise noted, seed prior to the placement of the matting.
- B. Unroll matting parallel to the direction of flow of water and loosely drape, without folds or stretching, so that continuous ground contact is maintained.
- C. The ditches and swales, and on slopes, each upslope and each downslope end of each piece of matting shall be placed in a 6" trench, stapled at 12" on center, backfilled, and tamped. Similarly, bury edges of matting along the edges of catch basins and other structures. Owner's Representative may require that any other edge, exposed to more than normal flow of water, be buried in a similar fashion.
- D. Tightly secure matting to the soil by staples driven approximately vertically into the ground, flush with the surface of the matting. In driving the staples, take care not to form depressions or bulges in the surface of the matting.
- E. Decrease the specified spacing of staples when varying factors, such as the season of the year or the amount of water encountered or anticipated, requires additional anchoring.

### **3.3 SEED FOR EROSION CONTROL**

- A. Sow seed when soils are moderately dry and when wind does not exceed five miles per hour or as directed by the Owner's Representative.
- B. Areas that will be regraded or otherwise disturbed later during construction may be seeded as directed by the Owner's Representative to obtain temporary control.

### **3.4 SILT FENCES**

- A. Provide silt fences, as required, for the temporary control of erosion and to stop silt and sediment from reaching surface waters, adjacent properties, or entering catch basins, or damaging the work.
- B. Erect silt fences and bury bottom edge in accordance with the manufacturer's recommended installation instructions. Provide a sufficient length of fence to accommodate runoff without causing any flooding and to adequately store any silt, sediment, and debris reaching it. Place silt fences along contours so that low areas are minimized.
- C. Maintain and leave silt fences in place until permanent erosion control measures have been established.

### **3.5 STABILIZED CONSTRUCTION ENTRANCES**

- A. Stabilized pads of aggregate underlain with filter cloth shall be constructed as shown on the Contract Drawings.
- B. Geotextile fabric shall be placed over the entire area to be covered with aggregate prior to placing of the stone.

### **3.6 TEMPORARY STRUCTURAL MEASURES**

- A. Temporary structural measures shall be maintained throughout the duration of the contract or until the drainage area has been properly stabilized as approved by the Owner's Representative.
- B. Temporary sediment traps must provide at least 3,600 cubic feet of storage for every acre of drainage area.
- C. Sediment shall be removed and trap restored to its original dimensions when sediment has accumulated to 1/2 the design depth of the trap.
- D. Removed sediment shall be properly disposed of.
- E. Inspect all erosion control measures following each rainfall event exceeding ½ inch in a 24- hour period. Correct all damage immediately.

### **3.7 MAINTENANCE**

- A. If any staples become loosened or raised, or if any matting becomes loose, torn, or undermined, or if any temporary erosion and sediment control measures are disturbed, repair them immediately.
- B. If the seed is washed out before germination, repair any damage, refertilize, and reseed.
- C. Maintain mulched and matted areas, silt stops, and other temporary control measures until the permanent control measures are established and no further erosion is likely.
- D. All sediment spilled, dropped, or washed onto the driveway or public right-of-way shall be removed immediately.
- E. Maintain ditches and swales at all times so that they effectively drain. Refill, reshape, and recompact where ruts or erosion occurs.
- F. Maintain areas temporarily seeded including repair of all damages, re-seeding, and refertilizing.
- G. Take special precautions in the use of construction equipment to minimize erosion. Do not leave wheel tracks where erosion might begin. Prevent direct discharge from dewatering pumps and surface runoff from the construction sites to storm sewers, culverts, streams or ditches. Intercept and conduct surface runoff and discharge from dewatering pumps to siltation ponds before discharging to natural drainage channels.

END OF SECTION 31 2500



## SECTION 321216 - ASPHALT PAVING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
1. Hot-mix asphalt paving.

#### 1.2 ACTION SUBMITTALS

- A. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.

#### 1.3 FIELD CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
1. Prime Coat: Minimum surface temperature of 50 deg F.
  2. Tack Coat: Minimum surface temperature of 50 deg F.
  3. Slurry Coat: Comply with weather limitations in ASTM D 3910.
  4. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
  5. Asphalt Top Course: Minimum surface temperature of 45 deg F at time of placement.
  6. Seasonal Limitations: Place asphalt between April 15<sup>th</sup> and October 31, unless otherwise authorized in writing by the Owner's Representative.

### PART 2 - PRODUCTS

#### 2.1 AGGREGATES

- A. General: Use materials and gradations that are from an NYSDOT-approved supplier of Fine and Coarse Aggregate.
- B. Coarse Aggregate: ASTM D 692/D 692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
- C. Fine Aggregate: ASTM D 1073 or AASHTO M 29, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.
1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.
- D. Mineral Filler: ASTM D 242/D 242M or AASHTO M 17, rock or slag dust, hydraulic cement, or other inert material.

#### 2.2 ASPHALT MATERIALS

- A. Asphalt Binder: AASHTO M 320, PG 64-22.
- B. Tack Coat: ASTM D 977 emulsified asphalt, or ASTM D 2397 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

#### 2.3 AUXILIARY MATERIALS

- A. Sand: ASTM D 1073, Grade No. 2 or No. 3.
- B. Paving Geotextile: AASHTO M 288 paving fabric; nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.

- C. Joint Sealant: ASTM D 6690, Type II or III, hot-applied, single-component, polymer-modified bituminous sealant.

## **2.4 MIXES**

- A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes complying with the following requirements:
  - 1. Binder Course: NYSDOT Type 3 Dense Binder Course
  - 2. Top Course: NYSDOT Type 7

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Verify that subgrade is dry and in suitable condition to begin paving.
- B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
  - 1. Completely proof-roll subgrade in one direction. Limit vehicle speed to 3 mph.
  - 2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
  - 3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Owner's Representative, and replace with compacted backfill or fill as directed.
- C. Proceed with paving only after unsatisfactory conditions have been corrected.

### **3.2 SURFACE PREPARATION**

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
- B. Cutback Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.
  - 1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
  - 2. Protect primed substrate from damage until ready to receive paving.
- C. Emulsified Asphalt Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.10 to 0.30 gal./sq. yd. per inch depth. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.
  - 1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
  - 2. Protect primed substrate from damage until ready to receive paving.
- D. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
  - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
  - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

### **3.3 PAVING GEOTEXTILE INSTALLATION (WHERE REQUIRED)**

- A. Apply tack coat uniformly to existing pavement surfaces at a rate of 0.20 to 0.30 gal./sq. yd.

- B. Place paving geotextile promptly according to manufacturer's written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints 4 inches and transverse joints 6 inches.
- C. Protect paving geotextile from traffic and other damage, and place hot-mix asphalt overlay the same day.

### **3.4 PLACING HOT-MIX ASPHALT**

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
  - 1. Place hot-mix asphalt base / binder course in number of lifts and thicknesses indicated.
  - 2. Place hot-mix asphalt surface course in single lift.
  - 3. Spread mix at a minimum temperature of 250 deg F.
  - 4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
  - 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
  - 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.
  - 2. Complete a section of asphalt base course before placing asphalt surface course.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

### **3.5 JOINTS**

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
  - 1. Clean contact surfaces and apply tack coat to joints.
  - 2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
  - 3. Offset transverse joints, in successive courses, a minimum of 24 inches.
  - 4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time.
  - 5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
  - 6. Compact asphalt at joints to a density within 2 percent of specified course density.

### **3.6 COMPACTION**

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
  - 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 96 percent of reference laboratory density according to ASTM D 6927 or AASHTO T 245, but not less than 94 percent or greater than 100 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

### **3.7 INSTALLATION TOLERANCES**

- A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
  1. Base / Binder Course: Plus or minus 1/2 inch.
  2. Surface Course: Plus 1/4 inch, no minus.
- B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
  1. Base / Binder Course: 1/4 inch.
  2. Surface Course: 1/8 inch.

### **3.8 FIELD QUALITY CONTROL**

- A. Testing Agency: Owner may engage a qualified testing agency to perform tests and inspections.
- B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
- C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979 or AASHTO T 168.
  1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
  2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
    - a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than three cores taken.
    - b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
- E. Replace and compact hot-mix asphalt where core tests were taken.
- F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

END OF SECTION 321216

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

**1.1 SUMMARY**

- A. Section Includes Concrete Paving Including the Following:
  - 1. Curbs and gutters.
  - 2. Walks.

**1.2 DEFINITIONS**

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.
- B. W/C Ratio: The ratio by weight of water to cementitious materials.

**1.3 PREINSTALLATION MEETINGS**

- A. Preinstallation Conference: Conduct conference at one of the installation sites.
  - 1. Review methods and procedures related to concrete paving, including but not limited to, the following:
    - a. Concrete mixture design.
    - b. Quality control of concrete materials and concrete paving construction practices.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.
- C. Samples for Verification: For each type of product or exposed finish, prepared as Samples of size indicated below:
  - 1. Exposed Aggregate: 10-lb Sample of each mix.
- D. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

**1.5 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For qualified ready-mix concrete manufacturer and testing agency.
- B. Material Certificates: For the following, from manufacturer:
  - 1. Cementitious materials.
  - 2. Steel reinforcement and reinforcement accessories.
  - 3. Admixtures.
  - 4. Curing compounds.
  - 5. Applied finish materials.
  - 6. Bonding agent or epoxy adhesive.
  - 7. Joint fillers.
- C. Material Test Reports: For each of the following:
  - 1. Aggregates: Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
- D. Field quality-control reports.

## **1.6 QUALITY ASSURANCE**

- A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
- B. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
  - 1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
- C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
  - 1. Build full size barrier mockup including concrete paving and curbing to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.
  - 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
  - 3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

## **1.7 PRECONSTRUCTION TESTING**

- A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

## **1.8 FIELD CONDITIONS**

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
  - 1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
  - 2. Do not use frozen materials or materials containing ice or snow.
  - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.
- C. Hot-Weather Concrete Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
  - 1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
  - 2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
  - 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

## **PART 2 - PRODUCTS**

### **2.1 CONCRETE, GENERAL**

- A. ACI Publications: Comply with ACI 301 unless otherwise indicated.

## 2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
  - 1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

## 2.3 STEEL REINFORCEMENT

- A. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, fabricated from galvanized-steel wire into flat sheets.
- B. Deformed-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, flat sheet.
- C. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.
- D. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60 deformed bars; assembled with clips.
- E. Deformed-Steel Wire: ASTM A 1064/A 1064M.
- F. Tie Bars: ASTM A 615/A 615M, Grade 60; deformed.
- G. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
- H. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
  - 1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
  - 2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
- I. Tie Wire: 16 gauge annealed type.

## 2.4 CONCRETE MATERIALS

- A. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:
  - 1. Portland Cement: ASTM C 150/C 150M, portland cement Type I or Type II.
  - 2. Fly Ash: ASTM C 618, Class F.
- B. Normal-Weight Aggregates: ASTM C 33/C 33M, Class 4S, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.
  - 1. Maximum Coarse-Aggregate Size: 1-inch nominal.
  - 2. Percentage passing No. 200 sieve shall be less than 0.7%.
  - 3. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
    - a. Percentage passing No. 200 sieve shall be less than 3%.
- C. Air-Entraining Admixture: ASTM C 260/C 260M.
- D. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
  2. Retarding Admixture: ASTM C 494/C 494M, Type B.
  3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
  4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
  5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
  6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
- E. Water: Potable and complying with ASTM C 94/C 94M.

## **2.5 CURING MATERIALS**

- A. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- B. Water: Potable.

## **2.6 RELATED MATERIALS**

- A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork in preformed strips.
- B. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- C. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Euclid Chemical Company (The); an RPM company.
    - b. Scofield, a Business Unit of Sika Corporation.
    - c. W.R. Meadows, Inc.

## **2.7 CONCRETE MIXTURES**

- A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience. Proportion design mixes per the recommendations of ACI 211.1.
1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
  2. Design mixes to meet or exceed each requirement specified. Adjust mix design to meet the most stringent requirement.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
1. Fly Ash or Pozzolan: 15 percent.
  2. Combined Fly Ash and Pozzolan: 15 percent.
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
1. Air Content: 4-1/2 percent plus or minus 1-1/2 percent for 1-1/2-inch nominal maximum aggregate size.
  2. Air Content: 4-1/2 percent plus or minus 1-1/2 percent for 1-inch nominal maximum aggregate size.
  3. Air Content: 5 percent plus or minus 1-1/2 percent for 3/4-inch nominal maximum aggregate size.
- D. Limit water-soluble, chloride-ion content in hardened concrete to 0.06 percent by weight of cement.
- E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
1. Use water-reducing, high-range water-reducing or plasticizing and retarding admixture in concrete as required for placement and workability.



2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
- F. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.
- G. Concrete Mixtures: Normal-weight concrete.
  1. Compressive Strength (28 Days): 4000 psi.
  2. Maximum W/C Ratio at Point of Placement: 0.45.
  3. Slump Limit: 4 inches, plus or minus 1 inch.

## **2.8 CONCRETE MIXING**

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
  1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
  1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
  2. For concrete batches larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
  3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
  1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
  2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
  3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 312000 "Earth Moving."
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

- A. Remove loose material from compacted subbase surface immediately before placing concrete.

### **3.3 EDGE FORMS AND SCREED CONSTRUCTION**

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

### 3.4 STEEL REINFORCEMENT INSTALLATION

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- E. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
  - 1. "Hooking-up" or "Walking-in" of any reinforcement will not be permitted.
- F. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.
- G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

### 3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
  - 1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
  - 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
  - 2. Provide tie bars at sides of paving strips where indicated.
  - 3. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
  - 1. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
  - 2. Extend joint fillers full width and depth of joint.
  - 3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
  - 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
  - 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
  - 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
  - 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/8-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.

2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/8-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

### **3.6 CONCRETE PLACEMENT**

- A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
- B. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- C. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.
- D. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
- E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- F. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
  1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement and joint devices.
- G. Screed paving surface with a straightedge and strike off.
- H. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

### **3.7 FLOAT FINISHING**

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
  1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.

### **3.8 CONCRETE PROTECTION AND CURING**

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound as follows:
  1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

- a. Water.
- b. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

### 3.9 PAVING TOLERANCES

- A. Comply with tolerances in ACI 117 and as follows:
1. Elevation: 3/4 inch.
  2. Thickness: Plus 3/8 inch, minus 1/4 inch.
  3. Surface: Gap below 10-feet-long; unleveled straightedge not to exceed 1/2 inch.
  4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.
  5. Lateral Alignment and Spacing of Dowels: 1 inch.
  6. Vertical Alignment of Dowels: 1/4 inch.
  7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
  8. Joint Spacing: 3 inches.
  9. Contraction Joint Depth: Plus 1/4 inch, no minus.
  10. Joint Width: Plus 1/8 inch, no minus.

### 3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:
1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.
    - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
  2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
  3. Air Content: ASTM C 231/C 231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
  4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
  5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
  6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
    - a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.
- C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
- D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

- E. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
- F. Concrete paving will be considered defective if it does not pass tests and inspections.
- G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- H. Prepare test and inspection reports.

**3.11 REPAIR AND PROTECTION**

- A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
- B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

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## SECTION 321723 - PAVEMENT MARKINGS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes painted markings applied to asphalt and concrete pavement.

#### 1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
1. Review methods and procedures related to marking pavement including, but not limited to, the following:
    - a. Pavement aging period before application of pavement markings.
    - b. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include technical data and tested physical and performance properties.
- B. Shop Drawings: For pavement markings.
1. Indicate pavement markings, colors, lane separations, defined parking spaces, and dimensions to adjacent work.
  2. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

#### 1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of NYSDOT for pavement-marking work for any work within public right-of-way.

#### 1.5 FIELD CONDITIONS

- A. Environmental Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55° and a maximum of 95°.

### PART 2 - PRODUCTS

#### 2.1 PAVEMENT-MARKING PAINT

- A. Formulated for use as a pavement marking material.
- B. Be VOC compliant and lead chromate free.
- C. Yellow paints must use organic yellow pigments Color Index Pigment Yellow 65 (C.I. 11740) and/or 74 (C.I. 11741).
- D. Display no bleeding on the surface upon which the paint is applied.
- E. Conform to current Federal, State and Local air pollution regulations, including those for the control (emission) of volatile organic compounds (VOC) as established by the U.S. EPA, and the NYSDEC
- F. % Pigment. (ASTM D3723) 58.0% – 62.0%

- G. % Total Solids. (ASTM D3723) 76.0 % minimum
- H. % Vehicle Non-Volatile. (ASTM D3723) 43.0 % minimum
- I. Directional Reflectance (ASTM E1347)
  - 1. White: 84% minimum
  - 2. Yellow: 54% minimum

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Verify that pavement is dry and in suitable condition to begin pavement marking according to manufacturer's written instructions.
- B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

#### 3.2 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Owner's Representative.
- B. Allow paving to age for a minimum of 30 days before starting pavement marking, unless approved in writing by Owner's Representative.
- C. Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates.
  - 1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to pavement. Mask an extended area beyond edges of each stencil to prevent paint application beyond stencil. Apply paint so that it cannot run beneath stencil.

#### 3.3 PROTECTING AND CLEANING

- A. Protect pavement markings from damage and wear until completely dry, as recommended by paint manufacturer.
- B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 321723



**SECTION 323113 - CHAIN LINK FENCES AND GATES**

**PART 1 - GENERAL**

**1.1 REFERENCES**

- A. Comply with ASTM A 53 for requirements of Schedule 40 piping.

**1.2 SUBMITTALS**

- A. Shop Drawings: Complete detailed drawings for each height and style of fence and gate required. Include separate schedule for each listing all materials required and technical data such as size, weight, and finish, to ensure conformance to specifications.
- B. Product Data: Manufacturer's catalog cuts, specifications, and installation instructions for each item specified.

**1.3 QUALITY ASSURANCE**

- A. Comply with standards of the Chain Link Fence Manufacturer's Institute.
- B. Provide steel fence and related gates as a complete compatible system including necessary erection accessories, fittings, and fastenings.
- C. Posts and rails shall be continuous without splices.

**PART 2 - PRODUCTS**

**2.1 STEEL FRAMEWORK (FOR FENCES UP TO 6'-0" HIGH)**

- A. End Posts, Corner Posts and Pull Posts:
  - 1. Pipe: 2.375 inches OD, 3.65 pounds per linear foot (Schedule 40).
- B. Line Posts:
  - 1. Pipe: 1.90 inches OD, 2.72 pounds per linear foot (Schedule 40).

**2.2 STEEL FABRIC**

- A. One-piece widths for fence heights up to 12'-0".
- B. Chain link, 2 inch mesh, No. 9 gauge.
- C. Selvages: Top edge and bottom edge knuckled.

**2.3 SWING GATE POSTS**

- A. Single width of gate up to 6'-0" wide and less than 10'-0" high:
  - 1. Pipe: 2.875 inches OD, 5.79 pounds per linear foot (Schedule 40).
- B. Single width of gate 6'-0" to 12'-0" wide or over 10'-0" high:
  - 1. Pipe: 4 inches OD, 9.11 pounds per linear foot (Schedule 40).

**2.4 2.4 SWING GATE FRAMES**

- A. Up to 6'-0" high, and leaf width 8'-0" or less.
  - 1. Pipe: 1.660 inches OD, 2.27 pounds per linear foot (Schedule 40).
- B. Assemble gate frames by welding or with special steel fittings and rivets for rigid connections. Install mid-height horizontal rails on gates over 10 feet high. When width of gate leaf exceeds 10 feet, install mid-distance vertical bracing of the same size and weight as frame members. When either

horizontal or vertical bracing is not required, provide truss rods as cross bracing to prevent sag or twist.

## **2.5 SWING GATE HARDWARE**

- A. Hinges: Non-lift-off type, offset to permit 180 degree swing, and of suitable size and weight to support gate. Provide 1-1/2 pair of hinges for each leaf over 6 feet high.
- B. Latch: Forked type for single gates 10 feet wide or less. Drop bar type with keeper for double gates and single gates over 10 feet wide complete with flush plate set in concrete. Drop bar length shall be 2/3 the height of the gate. Padlock eye shall be an integral part of latch construction.

## **2.6 MISCELLANEOUS MATERIALS AND ACCESSORIES**

- A. Rails and Post Braces:
  - 1. Pipe: 1.660 inches OD, 2.27 pounds per linear foot (Schedule 40).
- B. Fittings and Post Tops: Steel, wrought iron, or malleable iron.
  - 1. Fasteners: Tamper-resistant cadmium plated steel screws.
- C. Stretcher Bars: One piece equal to full height of fabric, minimum cross-section 3/16 inch by 3/4 inch.
- D. Metal Bands (for securing stretcher bars): Steel, wrought iron, or malleable iron.
- E. Wire Ties: Conform to American Steel Wire gauges.
  - 1. For tying fabric to line posts, rails and braces: 9 gauge (.1483 inch) steel wire.
- F. Truss Rods: 3/8 inch diameter.
- G. Concrete: Portland Cement concrete having a minimum compressive strength of 4000 psi at 28 days.
- H. Spiral Paper Tubes:
  - 1. Sonotube by Sonoco Products Co., North Second St., Hartsville, SC 29550, (800) 377-2692.
  - 2. Slek/tubes by Jefferson Smurfit Corp., P.O. Box 66820, St. Louis, Mo 63166, (314) 746-1100.
- I. Cold Galvanizing Compound: Single component compound giving 93 percent pure zinc in the dried film, and meeting the requirements of DOD-P-21035A (NAVY).
- J. Bolts and Nuts: ASTM A 307, Grade A.

## **2.7 FINISHES**

- A. Steel Framework:
  - 1. Pipe: Galvanized in accordance with ASTM A 53, 1.8 ounces zinc per square foot.
- B. Fabric; one of the following:
  - 1. Galvanized Finish: ASTM A 392 class II zinc coated after weaving, with 2.0 ounces per square foot.
  - 2. Aluminized Finish: ASTM A 491 aluminum coated with 0.40 ounces per square foot.
- C. Fence and Gate Hardware, Miscellaneous Materials, Accessories:
  - 1. Wire Ties: Galvanized Finish, ASTM A 90 1.6 ounces zinc per square foot, or aluminized finish, ASTM A 809 0.40 ounces per square foot.
  - 2. Hardware and Miscellaneous Items: Galvanized Finish, ASTM A 153 (Table 1).
- D. Tension Wire; one of the following:
  - 1. Galvanized Finish: ASTM A 121 class 3, 0.80 ounces per square foot.
  - 2. Aluminized Finish: ASTM A 585 class 2, 0.30 ounces per square foot.

**PART 3 - EXECUTION**

**3.1 PREPARATION**

- A. Clear and grub along fence line as required to eliminate growth interfering with alignment. Remove debris.
- B. Do not begin installation of fence in areas to be cut until finished grading has been completed.

**3.2 INSTALLATION**

- A. Space posts equidistant in the fence line with a maximum of 10 feet on center.
- B. Setting Posts in Earth: Drill holes for post footings. If existing grade at the time of installation is below finished grade, provide spiral paper tubes to contain concrete to finish grade elevation. Set posts in center of hole and fill hole with concrete. Plumb and align posts. Vibrate or tamp concrete for consolidation. Finish concrete in a dome shape above finish grade elevation to shed water. Do not attach fabric to posts until concrete has cured a minimum of 7 days.
- C. Locate corner posts at corners and at changes in direction. Use pull posts at all abrupt changes in grade and at intervals no greater than 500 feet. On runs over 500 feet, space pull posts evenly between corner or end posts. On long curves, space pull posts so that the strain of the fence will not bend the line posts.
- D. Install top rail continuously through post tops or extension arms, bending to radius for curved runs. Install expansion couplings as recommended by fencing manufacturers.
- E. Install bottom rails in one piece between posts and flush with post on fabric side using special offset fittings where necessary.
- F. Attach fabric to security side of fence. Maintain a 2 inch clearance above finished grade except when indicated otherwise. Thread stretcher bars through fabric using one bar for each gate and end post and 2 for each corner and pull post. Pull fabric tight so that the maximum deflection of fabric is 2 inches when a 30 pound pull is exerted perpendicular to the center of a panel. Maintain tension by securing stretcher bars to posts with metal bands spaced 15 inches oc. Fasten fabric to steel framework with wire ties spaced 12 inches oc for line posts and 24 inches oc for rails and braces. Bend back wire ends to prevent injury. Tighten stretcher bar bands, wire ties, and other fasteners securely.
- G. Position bolts for securing metal bands and hardware so nuts are located opposite the fabric side of fence. Tighten nuts and cut off excess threads so no more than 1/8 inch is exposed. Peen ends to prevent loosening or removal of nuts.
- H. Install gates plumb and level and adjust for full opening without interference. Install ground-set items in concrete for anchorage, as recommended by fence manufacturer. Adjust hardware for smooth operation and lubricate where necessary.
- I. Wire brush and repair welded and abraded areas of galvanized surfaces with one coat of cold galvanizing compound.
- J. Restore disturbed ground areas to original condition. Topsoil and seed to match adjacent areas.

**END OF SECTION**

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**SECTION 329200 - TURF AND GRASSES**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
1. Seeding.
  2. Hydroseeding.
  3. Sodding.

**1.2 DEFINITIONS**

- A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- B. Finish Grade: Elevation of finished surface of planting soil.
- C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- E. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- F. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

**1.3 ACTION SUBMITTALS**

**1.4 INFORMATIONAL SUBMITTALS**

- A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
- B. Product Certificates: For soil amendments and fertilizers, from manufacturer.
- C. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required initial maintenance periods.

**1.5 DELIVERY, STORAGE, AND HANDLING**

- A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
- B. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

## 1.6 PROJECT CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.
  1. Spring Planting: May1 through June 15.
  2. Fall Planting: September 1 through October 15.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

## 1.7 MAINTENANCE SERVICE

- A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:
  1. Seeded Turf: 60 days from date of planting completion.
    - a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

## PART 2 - PRODUCTS

### 2.1 GRASSES

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species: Trio Supreme mix of species by Preferred Seed, or approved equal.
  1. Sod – Full Sun: Kentucky bluegrass (*Poa pratensis*), a minimum of three cultivars.

### 2.2 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
  1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.
  2. Provide lime in form of ground dolomitic limestone or calcitic limestone.
- B. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, and with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.
- C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- D. Aluminum Sulfate: Commercial grade, unadulterated.
- E. Perlite: Horticultural perlite, soil amendment grade.
- F. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 sieve.

- G. Sand: Clean, washed, natural or manufactured, and free of toxic materials.

### **2.3 ORGANIC SOIL AMENDMENTS**

- A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
- B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture, with a pH range of 3.4 to 4.8.
- C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
- D. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

### **2.4 FERTILIZERS**

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 percent nitrogen and 10 percent phosphoric acid.
- B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
  2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- D. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
  2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

### **2.5 PLANTING SOILS**

- A. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 6 percent organic material content; free of stones 0.25 inch or larger in any dimension and other extraneous materials harmful to plant growth.

### **2.6 MULCHES**

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
- B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.

- C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
- D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
  - 1. Organic Matter Content: 50 to 60 percent of dry weight.
  - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- E. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.
- G. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

## **2.7 EROSION-CONTROL MATERIALS**

- A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.
- B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
  - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
  - 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
  - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
  - 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

### **3.2 PREPARATION**

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.



1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
  2. Protect grade stakes set by others until directed to remove them.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

### **3.3 TURF AREA PREPARATION**

- A. Limit turf subgrade preparation to areas to be planted.
- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 6 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
1. Apply fertilizer directly to subgrade before loosening.
  2. Spread planting soil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
- C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
  2. Loosen surface soil to a depth of at least 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 6 inches of soil. Till soil to a homogeneous mixture of fine texture.
    - a. Apply fertilizer directly to surface soil before loosening.
  3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
  4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
- D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.
- E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- F. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

### **3.4 PREPARATION FOR EROSION-CONTROL MATERIALS**

- A. Prepare area as specified in "Turf Area Preparation" Article.
- B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.
- C. Fill cells of erosion-control mat with planting soil and compact before planting.
- D. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.
- E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

### **3.5 SEEDING**

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
  - 1. Do not use wet seed or seed that is moldy or otherwise damaged.
  - 2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow seed at a total rate of 5 lb/1000 sq. ft.
- C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes exceeding 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.
- E. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

### **3.6 HYDROSEEDING**

- A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
  - 1. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 lb/acre.

### **3.7 SODDING**

- A. Time limit and option in first paragraph below are requirements of TPI's "Guideline Specifications to Turfgrass Sodding."
- B. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.
- C. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
  - 1. Lay sod across slopes exceeding 1:3.
  - 2. Anchor sod on slopes exceeding 1:6 with wood pegs[ or steel staples] spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.
- D. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

### **3.8 TURF RENOVATION**

- A. Renovate existing turf.
- B. Renovate existing turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
  - 1. Reestablish turf where settlement or washouts occur or where minor regrading is required.

2. Install new planting soil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.
- D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
- E. Mow, dethatch, core aerate, and rake existing turf.
- F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.
- G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.
- I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil. Install new planting soil to fill low spots and meet finish grades.
- J. Apply seed and protect with straw mulch as required for new turf.
- K. Water newly planted areas and keep moist until new turf is established.

### **3.9 TURF MAINTENANCE**

- A. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.
  1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
  2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

### **3.10 SATISFACTORY TURF**

- A. Turf installations shall meet the following criteria as determined by Owner's Representative:
  1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
- B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

### **3.11 CLEANUP AND PROTECTION**

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
- C. Remove nondegradable erosion-control measures after grass establishment period.

**3.12 MAINTENANCE SERVICE**

- A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
1. Seeded Turf: One year from date of planting completion.
    - a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.
  2. Sodded Turf: One year days from date of planting completion.

END OF SECTION 329200

## SECTION 329300 - PLANTS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Plants.
  - 2. Tree stabilization.
  - 3. Tree-watering devices.

#### 1.2 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than sizes indicated; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than sizes indicated.
- D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for type and size of plant required.
- E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
- F. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.
- G. Finish Grade: Elevation of finished surface of planting soil.
- H. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.
- I. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- J. Planting Area: Areas to be planted.
- K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- L. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
- M. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
- N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.
- O. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

### 1.3 COORDINATION

- A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
  - 1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

### 1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.
- B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
  - 1. Manufacturer's certified analysis of standard products.
  - 2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
- C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.
- D. Sample Warranty: For special warranty.

### 1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

### 1.7 QUALITY ASSURANCE

- A. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
- B. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
  - 1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
  - 2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

### 1.8 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.
- B. Bulk Materials:
  - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  - 3. Accompany each delivery of bulk materials with appropriate certificates.

- C. Deliver bare-root stock plants within 24 hours of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.
- D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
- E. Handle planting stock by root ball.
- F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.
- G. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
  - 1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.
- H. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.
- I. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
  - 1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.
  - 2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
  - 3. Do not remove container-grown stock from containers before time of planting.
  - 4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

## 1.9 FIELD CONDITIONS

- A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

## 1.10 WARRANTY

- A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
  - 1. Warranty Periods: From date of planting completion.
    - a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
  - 2. Include the following remedial actions as a minimum:
    - a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
    - b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
    - c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.

- d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

## PART 2 - PRODUCTS

### 2.1 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
  - 1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.
  - 2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.
- C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
- D. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

### 2.2 FERTILIZERS

- A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
  - 1. Size: 5-gram tablets.
  - 2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

### 2.3 MULCHES

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
  - 1. Type: Shredded hardwood bark.
  - 2. Size Range: 3 inches maximum, 1/2 inch minimum.
  - 3. Color: Natural. Confirm with Owner.
  - 4. Depth: 4".

### 2.4 WEED-CONTROL BARRIERS

- A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.



- 2.5 **Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd.**

## 2.6 PESTICIDES

- A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

## 2.7 TREE-STABILIZATION MATERIALS

- A. Trunk-Stabilization Materials:
1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.
  2. Wood Deadmen: Timbers measuring 8 inches in diameter and 48 inches long, treated with specified wood pressure-preservative treatment.
- B. Root-Ball Stabilization Materials:
1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated; stakes pointed at one end.
  2. Wood Screws: ASME B18.6.1.

## 2.8 TREE-WATERING DEVICES

- A. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

- A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.
1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
  2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
  3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
  4. Uniformly moisten excessively dry soil that is not workable or which is dusty.
- B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

### **3.3 PLANTING AREA ESTABLISHMENT**

- A. Placing Planting Soil: Place and mix planting soil in-place over exposed subgrade.
- B. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

### **3.4 EXCAVATION FOR TREES AND SHRUBS**

- A. Planting Pits and Trenches: Excavate circular planting pits.
  - 1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
  - 2. Excavate approximately three times as wide as ball diameter for balled and burlapped stock.
  - 3. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
  - 4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
  - 5. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
  - 6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
  - 7. Maintain supervision of excavations during working hours.
  - 8. or required under planting areas, excavate to top of porous backfill over tile.
- B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated.
- C. Obstructions: Notify Owner if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

### **3.5 TREE, SHRUB, AND VINE PLANTING**

- A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.
- B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
- C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
  - 1. Backfill: Planting soil C300.
  - 2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
  4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
    - a. Quantity: Two per plant.
  5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- D. Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
1. Backfill: Planting soil C300.
  2. Carefully remove root ball from container without damaging root ball or plant.
  3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
  4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
    - a. Quantity: Two per plant.
  5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- E. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

### **3.6 MECHANIZED TREE-SPADE PLANTING**

- A. Trees may be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.
- B. Use the same tree spade to excavate the planting hole as will be used to extract and transport the tree.
- C. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.
- D. Cut exposed roots cleanly during transplanting operations.
- E. Plant trees following procedures in "Tree, Shrub, and Vine Planting" Article.
- F. Where possible, orient the tree in the same direction as in its original location.

### **3.7 TREE, SHRUB, AND VINE PRUNING**

- A. Remove only dead, dying, or broken branches. Do not prune for shape.
- B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.
- C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.
- D. Do not apply pruning paint to wounds.

### **3.8 TREE STABILIZATION**

- A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated:

1. Upright Staking and Tying: Stake trees of 2- through 5-inch caliper. Stake trees of less than 2-inch caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least 18 inches below bottom of backfilled excavation and to extend at least 72 inches above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
- B. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings. Stake and guy trees more than 14 feet in height and more than 3 inches in caliper unless otherwise indicated.
- C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.

### **3.9 GROUND COVER AND PLANT PLANTING**

- A. Set out and space ground cover and plants other than trees, shrubs, and vines 18 inches apart in even rows with triangular spacing.
- B. Use planting soil for backfill.
- C. Dig holes large enough to allow spreading of roots.
- D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to a depth not less than two nodes.
- E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
- F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

### **3.10 PLANTING AREA MULCHING**

- A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 12 inches and secure seams with galvanized pins.
- B. Mulch backfilled surfaces of planting areas and other areas indicated.

### **3.11 EDGING INSTALLATION**

- A. Shovel-Cut Edging: Separate mulched areas from turf areas with a 45-degree, 4- to 6-inch-deep, shovel-cut edge.

### **3.12 INSTALLING SLOW-RELEASE WATERING DEVICE**

- A. Provide one device for each tree.
- B. Place device on top of the mulch at base of tree stem and fill with water according to manufacturer's written instructions.

### **3.13 PLANT MAINTENANCE**

- A. Maintain plantings by watering as required to establish healthy, viable plantings.

### **3.14 PESTICIDE APPLICATION**

- A. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

- B. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas according to manufacturer's written recommendations. Do not apply to seeded areas.
- C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

### **3.15 REPAIR AND REPLACEMENT**

- A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.
  - 1. Submit details of proposed pruning and repairs.
  - 2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
  - 3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.
- B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
  - 1. Provide new trees of same size as those being replaced for each tree.

### **3.16 CLEANING AND PROTECTION**

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.
- C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
- D. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.
- E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

### **3.17 MAINTENANCE SERVICE**

- A. Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
  - 1. Maintenance Period: 12 months from date of planting completion.
- B. Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
  - 1. Maintenance Period: 12 months from date of planting completion.

END OF SECTION 329300

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## SECTION 334100 - STORM UTILITY DRAINAGE PIPING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Pipe and fittings.
  - 2. Catch basins

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
  - 1. Catch basins. Include plans, invert locations and elevations, sections, details, frames, covers, and grates.

#### 1.3 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle catch basins according to manufacturer's written rigging instructions.

#### 1.4 PROJECT CONDITIONS

- A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
  - 1. Notify Owner no fewer than two days in advance of proposed interruption of service.
  - 2. Do not proceed with interruption of service without Owner's written permission.

### PART 2 - PRODUCTS

#### 2.1 PE PIPE AND FITTINGS

- A. Corrugated PE Drainage Pipe and Fittings NPS 3 to NPS 10: AASHTO M 252M, Type S, with smooth waterway for coupling joints.
  - 1. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.
- B. Corrugated PE Pipe and Fittings NPS 12 to NPS 60: AASHTO M 294M, Type S, with smooth waterway for coupling joints.
  - 1. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

#### 2.2 PVC PIPE AND FITTINGS

- A. PVC Gravity Sewer Piping:
  - 1. Pipe and Fittings: ASTM F 679, T-1 wall thickness, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.

#### 2.3 CATCH BASINS

- A. Standard Precast Concrete Catch Basins:
  - 1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
  - 2. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
  - 3. Riser Sections: 4-inch minimum thickness, and lengths to provide depth indicated.

4. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
  5. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
  6. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
  7. Steps: Individual FRP steps; wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 4 feet.
  8. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.
- B. Frames and Grates: NYSDOT type F2 cast frame with curb box with NYSDOT type G2 reticuline grate, H20 loading.
1. Size: Per the drawings.

### **PART 3 - EXECUTION**

#### **3.1 EARTHWORK**

- A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

#### **3.2 PIPING INSTALLATION**

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
- F. Install gravity-flow, nonpressure drainage piping according to the following:
1. Install piping pitched down in direction of flow.
  2. Install ABS sewer piping according to ASTM D 2321 and ASTM F 1668.
  3. Install PE corrugated sewer piping according to ASTM D 2321.
  4. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
  5. Install PVC profile gravity sewer piping according to ASTM D 2321 and ASTM F 1668.

#### **3.3 CATCH BASIN / MANHOLE INSTALLATION**

- A. Construct catch basins to sizes and shapes indicated.
- B. Set frames and grates to elevations indicated.



### **3.4 FIELD QUALITY CONTROL**

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
  - 1. Defects requiring correction include the following:
    - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    - c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    - d. Infiltration: Water leakage into piping.
    - e. Exfiltration: Water leakage from or around piping.
  - 2. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
  - 3. Reinspect and repeat procedure until results are satisfactory.

### **3.5 CLEANING**

- A. Clean interior of new piping of dirt and superfluous materials.
- B. All storm piping and structures shall be flushed clean with potable water upon completion of the work and before acceptance of work.

END OF SECTION 334100

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**SECTION 334201 – HYDRODYNAMIC SEPARATOR**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.
- B. New York State Standards and Specifications for Erosion and Sediment Control

**1.2 WORK OF THIS SECTION**

- A. Work covered in this section includes the installation of the storm water treatment device. All costs associated with the permits shall be included in the Contractor's bid.
- B. All Contractors and their subcontractors must agree to implement all applicable provisions of the Erosion Control Plans prior to commencement of any construction activity.

**1.3 QUALITY ASSURANCE**

- A. This item shall govern the furnishing and installation of the CDS® by Contech Engineered Solutions LLC, complete and operable as shown and as specified herein, in accordance with the requirements of the plans and contract documents.
- B. The Contractor shall furnish all labor, equipment and materials necessary to install the storm water treatment device(s) (SWTD) and appurtenances specified in the Drawings and these specifications.
- C. The manufacturer of the SWTD shall be one that is regularly engaged in the engineering design and production of systems deployed for the treatment of storm water runoff for at least five (5) years and which have a history of successful production, acceptable to the Engineer. In accordance with the Drawings, the SWTD(s) shall be a CDS® device manufactured by:

Contech Engineered Solutions LLC  
9025 Centre Pointe Drive  
West Chester, OH, 45069  
Tel: 1 800 338 1122

- D. All components shall be subject to inspection by the engineer at the place of manufacture and/or installation. All components are subject to being rejected or identified for repair if the quality of materials and manufacturing do not comply with the requirements of this specification. Components which have been identified as defective may be subject for repair where final acceptance of the component is contingent on the discretion of the Engineer.
- E. The manufacturer shall guarantee the SWTD components against all manufacturer originated defects in materials or workmanship for a period of twelve (12) months from the date the components are delivered to the owner for installation. The manufacturer shall upon its determination repair, correct or replace any manufacturer originated defects advised in writing to the manufacturer within the referenced warranty period. The use of SWTD components shall be limited to the application for which it was specifically designed.
- F. The SWTD manufacturer shall submit to the Engineer of Record a "Manufacturer's Performance Certification" certifying that each SWTD is capable of achieving the specified removal efficiencies listed in these specifications. The certification shall be supported by independent third-party research.
- G. No product substitutions shall be accepted unless submitted 10 days prior to project bid date, or as directed by the Engineer of Record. Submissions for substitutions require review and approval by the Engineer of Record, for hydraulic performance, impact to project designs, equivalent treatment

performance, and any required project plan and report (hydrology/hydraulic, water quality, stormwater pollution) modifications that would be required by the approving jurisdictions/agencies. Contractor to coordinate with the Engineer of Record any applicable modifications to the project estimates of cost, bonding amount determinations, plan check fees for changes to approved documents, and/or any other regulatory requirements resulting from the product substitution.

## PART 2 - PRODUCTS

### 2.1 HOUSING UNIT

- A. Housing unit of stormwater treatment device shall be constructed of pre-cast or cast-in-place concrete, no exceptions. Precast concrete components shall conform to applicable sections of ASTM C 478, ASTM C 857 and ASTM C 858 and the following:
1. Concrete shall achieve a minimum 28-day compressive strength of 4,000 pounds per square-inch (psi);
  2. Unless otherwise noted, the precast concrete sections shall be designed to withstand lateral earth and AASHTO H-20 traffic loads;
  3. Cement shall be Type III Portland Cement conforming to ASTM C 150;
  4. Aggregates shall conform to ASTM C 33;
  5. Reinforcing steel shall be deformed billet-steel bars, welded steel wire or deformed welded steel wire conforming to ASTM A 615, A 185, or A 497.
  6. Joints shall be sealed with preformed joint sealing compound conforming to ASTM C 990.
  7. Shipping of components shall not be initiated until a minimum compressive strength of 4,000 psi is attained or five (5) calendar days after fabrication has expired, whichever occurs first.

### 2.2 INTERNAL COMPONENTS

#### 2.2 Internal Components and appurtenances shall conform to the following:

1. Screen and support structure shall be manufactured of Type 316 and 316L stainless steel conforming to ASTM F 1267-01;
2. Hardware shall be manufactured of Type 316 stainless steel conforming to ASTM A 320;
3. Fiberglass components shall conform to the ASTM D-4097

#### 2.3 Access system(s) conform to the following:

1. Manhole castings shall be designed to withstand AASHTO H-20 loadings and manufactured of cast-iron conforming to ASTM A 48 Class 30.

## PART 3 - EXECUTION

- 3.1 **The contractor shall exercise care in the storage and handling of the SWTD components prior to and during installation. Any repair or replacement costs associated with events occurring after delivery is accepted and unloading has commenced shall be borne by the contractor.**
- 3.2 **The SWTD shall be installed in accordance with the manufacturer's recommendations and related sections of the contract documents. The manufacturer shall provide the contractor installation instructions and offer on-site guidance during the important stages of the installation as identified by the manufacturer at no additional expense. A minimum of 72 hours notice shall be provided to the manufacturer prior to their performance of the services included under this subsection.**
- 3.3 **The contractor shall fill all voids associated with lifting provisions provided by the manufacturer. These voids shall be filled with non-shrinking grout providing a finished**

**surface consistent with adjacent surfaces. The contractor shall trim all protruding lifting provisions flush with the adjacent concrete surface in a manner, which leaves no sharp points or edges.**

- 3.4 The contractor shall removal all loose material and pooling water from the SWTD prior to the transfer of operational responsibility to the Owner.**

#### PART 4 - PERFORMANCE

- A. The SWTD shall be sized to either achieve an 80 percent average annual reduction in the total suspended solid load or treat a flow rate designated by the jurisdiction in which the project is located. Both methods should be sized using a particle size distribution having a mean particle size ( $d_{50}$ ) of 125 microns unless otherwise stated.
- B. The SWTD shall be capable of capturing and retaining 100 percent of pollutants greater than or equal to 2.4 millimeters (mm) regardless of the pollutant's specific gravity (i.e.: floatable and neutrally buoyant materials) for flows up to the device's rated-treatment capacity. The SWTD shall be designed to retain all previously captured pollutants addressed by this subsection under all flow conditions. The SWTD shall be capable of capturing and retaining total petroleum hydrocarbons. The SWTD shall be capable of achieving a removal efficiency of 92 and 78 percent when the device is operating at 25 and 50 percent of its rated-treatment capacity. These removal efficiencies shall be based on independent third-party research for influent oil concentrations representative of storm water runoff ( $20 \pm 5$  mg/L). The SWTD shall be greater than 99 percent effective in controlling dry-weather accidental oil spills.
- C. The SWTD shall be designed with a sump chamber for the storage of captured sediments and other negatively buoyant pollutants in between maintenance cycles. The minimum storage capacity provided by the sump chamber shall be in accordance with the volume listed in Table 1. The boundaries of the sump chamber shall be limited to that which do not degrade the SWTD's treatment efficiency as captured pollutants accumulate. The sump chamber shall be separate from the treatment processing portion(s) of the SWTD to minimize the probability of fine particle re-suspension. In order to not restrict the Owner's ability to maintain the SWTD, the minimum dimension providing access from the ground surface to the sump chamber shall be 16 inches in diameter.
- D. The SWTD shall be designed to capture and retain Total Petroleum Hydrocarbons generated by wet-weather flow and dry-weather gross spills and have a capacity listed in Table 1 of the required unit.
- E. The SWTD shall convey the flow from the peak storm event of the drainage network, in accordance with required hydraulic upstream conditions as defined by the Engineer. If a substitute SWTD is proposed, supporting documentation shall be submitted that demonstrates equal or better upstream hydraulic conditions compared to that specified herein. This documentation shall be signed and sealed by a Professional Engineer registered in the State of the work. All costs associated with preparing and certifying this documentation shall be born solely by the Contractor.
- F. The SWTD shall have completed field tested following TARP Tier II protocol requirements

END OF SECTION 334201

